



GROUNDWATER ALLOCATION PLAN

SWAN GROUNDWATER AREA



WATER RESOURCE ALLOCATION AND PLANNING SERIES

WATER AND RIVERS COMMISSION REPORT NO. WRAP 12

1997



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Summary

The Swan Groundwater Area was proclaimed in 1975 to enable better management of the groundwater resources in the area. This was necessary because of the declining water levels in the confined Leederville aquifer and the possibility of increasing groundwater salinity.

Groundwater allocation in the Swan Groundwater Area has been previously described by the Metropolitan Region Planning Authority (1984), Banyard (1985), Hooper (1986) and Hopkins and Richardson (1990).

The revisions in this current Allocation Plan are necessary because of changes in the boundary of the groundwater area and of the subarea boundaries contained within it.

This Allocation Plan recommends that the Bullsbrook Groundwater Area, for which there has been no previous groundwater allocation plan, be added to the Swan Groundwater Area. This will approximately double its size. Other area and boundary changes include:

- the excision of the urban area south of Toodyay Road and its addition to the Perth Groundwater Area and
- the shifting of the eastern boundary, north of Toodyay Road, eastwards to include the entire Swan Valley Planning Area, as defined in the *Swan Valley Planning Act 1995*.

To assist with the management of the groundwater resources, eight new subareas have been established. The boundaries of the subareas coincide, where possible, with hydrogeological and cadastral boundaries.

The groundwater resources of the Swan Groundwater Area are contained in four major aquifers: the superficial Mirrabooka, Leederville and Yarragadee aquifers.

The *superficial aquifer* has the largest allocation limit, of about 18.6 million kL/a (kilolitres per annum), and currently about 76% of this has been allocated throughout the area. The aquifer has an average saturated thickness of about 40 m and is mainly sandy west of Ellen Brook and the Swan River, where it forms the southeastern part of the Gnangara Mound groundwater flow-system. In the east, the superficial

aquifer of the Swan-Helena groundwater flow-system is pre-dominantly clayey, with thin gravelly deposits locally occurring adjacent to the Darling Scarp. There the groundwater resource is relatively small.

Where the superficial aquifer comprises Bassendean Sand, rainfall recharge rates are high compared to those areas of Guildford Clay. Groundwater in the superficial aquifer is generally fresh throughout the Swan Groundwater Area however, in areas of shallow watertable, salinity may be higher owing to concentration of salts by evaporation. Higher salinities may also occur in clayey areas (e.g. along the Swan River), which inhibit rainfall infiltration, resulting in high evaporation rates and concentration of salts.

The *Mirrabooka aquifer* (previously known, informally, as the Lancelin aquifer) is a semi-confined and locally confined aquifer in hydraulic continuity with the overlying superficial aquifer. It occurs in the western half of the area, where it reaches a maximum thickness of about 100 m. The Mirrabooka aquifer comprises the Poison Hill Greensand Molecap Greensand, and Mirrabooka Member (Osborne Formation). It consists of unconsolidated sandstone and silty sandstone with interbedded shale.

The Mirrabooka aquifer has a relatively small replenishable groundwater resource, with an allocation limit of about 3.6 million kL/a. However, its low salinity makes it an important water resource, particularly in areas where the overlying superficial aquifer contains brackish water. The resource of the Mirrabooka aquifer is currently about 42% allocated.

The *Leederville aquifer* is a multilayer groundwater-flow system consisting of discontinuous interbedded sandstones, siltstones and shales of the Henley Sandstone Member (Osborne Formation) and the Pinjar, Wanneroo and Mariginiup Members (Leederville Formation). The aquifer is confined where it is overlain



by Kardinya Shale Member (Osborne Formation) and elsewhere by shale beds within the aquifer. Near the Darling Scarp the Leederville aquifer is directly beneath, and in direct hydraulic connection with, the thin overlying superficial aquifer.

The total allocation limit for the Leederville aquifer is about 5.4 million kL/a, of which about 93% has been allocated. Of an average thickness of about 300 m it is subjected to large rates of groundwater abstraction for the irrigation of vineyards in the Swan Valley. This is contributing to a general regional decline in the potentiometric water levels, particularly where the aquifer is confined above by shale. To limit further decline, no additional allocation is permitted in areas of confinement in the Swan Groundwater Area.

The *Yarragadee aquifer* contains brackish to saline groundwater, and allocation limits have not been set for it.

The groundwater resources of the Swan Groundwater Area are utilised for a variety of activities, including the maintenance of the local environment. The superficial aquifer is hydraulically connected to a number of important wetlands within the area, including some of international significance. In places, increased groundwater demand for developments such as horticulture is in competition with the needs of the environment. Groundwater abstraction is limited to ensure that certain environmental conditions are met in the Swan Groundwater Area and adjacent areas. For example, the internationally significant wetlands associated with Twin Swamps Wildlife Sanctuary (western swamp tortoise), and others with proposed water-level maintenance criteria (East Gngangara Environmental Water Provisions Plan), need to be maintained and protected from water-level drawdown effects and deterioration of water quality, due to excessive groundwater abstraction.

In the Swan Groundwater Area, most abstracted groundwater is used for irrigated agriculture, in keeping with the dominantly rural setting and historical

importance of the area, particularly for viticulture. A large volume of groundwater is also used for recreational purposes, tourism and parks and gardens. Preservation of the rural character of the Swan Valley, situated within the Swan Groundwater Area, is important to the State, and is guided by a number of government land-planning policies, including the *Swan Valley Planning Act*. This Act stipulates that the Water and Rivers Commission should manage the groundwater resources in the primary production area with the objective of promoting further development of viticulture and horticulture.

Further agricultural development (e.g. horticulture, viticulture) in the Swan Groundwater Area, particularly in the Ellen Brook surface water catchment, requires careful planning to ensure these developments do not significantly add to the nutrient loading of the Swan River. Pollution from fertilisers applied in the Ellen Brook catchment causes most of the increase in toxic algal blooms in the upper reaches of the Swan River.

Due to the current level of groundwater abstraction, environmental constraints and groundwater management practices, there is limited potential for additional groundwater allocation for developments in the Swan Groundwater Area. Limited availability, poor quality at some localities, and competition between the environment and irrigated agriculture, enforce the need for groundwater management to protect the environment as well as existing and future users of this resource.

The essential principles of the Groundwater Allocation Plan: Swan Groundwater Area 1997 were approved by:

- The Swan Groundwater Advisory Committee on 25 July, 1997
- The Water Resources Allocation Committee on 28 July, 1997
- The Board of the Water and Rivers Commission on 21 August, 1997



1. Introduction

1.1 Location

The Swan Groundwater Area is within the local government authority boundary of the Shire of Swan. It covers about 270 km² (Fig. 1), mostly on the Swan Coastal Plain. The area extends from about 3 km south of the Muchea townsite to just north of the urban areas of Guildford and Midland. The crest of the Darling Scarp forms the eastern boundary. To the west, it has a common boundary with the Gnangara and Mirrabooka Groundwater Areas.

1.2 Swan Groundwater Area

The Swan Valley has a long history of groundwater abstraction for irrigated agriculture. The Swan Groundwater Area was proclaimed in 1975, under the *Rights In Water and Irrigation Act 1914* to enable better management of this resource.

To facilitate better management of the groundwater resources within the Swan Groundwater Area, this allocation plan adopts the following changes to the extent of the area:

- the addition of the Bullsbrook Groundwater Area to the previous Swan Groundwater Area;
- the inclusion of the region of the Swan Valley Planning Area; and
- the excision of the urban area south of Toodyay Road and its addition to the Perth Groundwater Area.

These changes are with the Government for gazettal. However, they have been incorporated within this Allocation Plan, the resultant region being called the Swan Groundwater Area as before.

1.3 Groundwater overview

Eight subareas have been established within the Swan Groundwater Area to facilitate management and allocation of groundwater (Fig. 1). The boundaries of the subareas coincide, where possible, with hydrogeological and cadastral boundaries.

Fresh groundwater in the Swan Groundwater Area is found in three main aquifers: the superficial, Mirrabooka, and Leederville aquifers.

The superficial aquifer has the most groundwater available for licensed allocation in the Swan Groundwater Area. It is, however, not found in abundant quantities everywhere. From the Gnangara Mound flow system west of Ellen Brook and the Swan River, areas of Bassendean Sand generally have abundant supplies of groundwater. Further to the east, supplies are more restricted due to clay soils and the thin mantle material associated with the Darling Plateau.

The semi-confined Mirrabooka aquifer, which exists mostly in areas west of Ellen Brook and the Swan River, has limited quantities of low salinity groundwater.

Groundwater abstraction from the Leederville aquifer takes place over most of the Groundwater Area. However, where the aquifer is confined, water levels are falling and no additional allocation can be made.

Below the Leederville aquifer, the Yarragadee aquifer contains large quantities of brackish to saline groundwater which is of limited general use.

Some parts of the Swan Groundwater Area are currently serviced by the Water Corporation's metropolitan scheme water supply. However, except for the Bullsbrook townsite, the northern part of the Groundwater Area (north of Warbrook Road) is not serviced by the scheme, and water for domestic purposes is sourced from private wells.

1.4 Water and Rivers Commission's role

The Water and Rivers Commission is responsible for equitably allocating the State's water resources and managing their use to support sustainable development and conservation of the environment.



Groundwater allocation and conservation are administered in accordance with the *Rights In Water and Irrigation Act* and the *Water Agencies (Powers) Act 1984*. Under the *Rights In Water and Irrigation Act*, the right to use, flow and control groundwater is reserved in the Crown. This Act requires the compulsory licensing of supply from artesian wells throughout the State. In addition, supplies from non-artesian wells within specific areas, proclaimed under the Act as Groundwater Areas, require licensing. Provision exists for exemption of stock and domestic groundwater supplies from licensing, if considered appropriate.

Regulatory controls are designed:

- to encourage the responsible development of groundwater resources and limit abstraction from the aquifer to a level which can be sustained over the longterm;
- to allocate resources for beneficial private and public purposes and to meet the environmental requirements of the area,
- to enable the resources to be shared in an equitable manner, and
- to protect present and future sources of groundwater for public water supplies and for private use, where appropriate.

Groundwater licence administration in the Swan Groundwater Area is a major responsibility of the Swan Regional Office of the Water and Rivers Commission in Welshpool. All applications for groundwater well licences are forwarded to this office. The Swan Region obtains specialist advice on groundwater matters from the Allocation Branch of the Water and Rivers Commission in the Hyatt Centre, East Perth.

Groundwater allocation is carried out by:

- observing Water and Rivers Commission State-wide groundwater allocation policies;
- using local groundwater monitoring data from the Commission's network of wells;

- seeking advice from other Divisions of the Commission, other State departments, local government, and the Swan Groundwater Advisory Committee; and
- using information supplied by consultants working on behalf of licensees as part of licence requirements.

1.5 Objectives of the Allocation Plan

A previous assessment of the groundwater resources in the Swan Groundwater Area by the Geological Survey of Western Australia (GSWA, Davidson, 1992) indicated that the 1990 Swan Groundwater Area Management Plan (Hopkins & Richardson 1992) required amendment, particularly in relation to subarea boundaries and allocation limits. Monitoring data from wells in some subareas showed little response to abstraction despite the fact that the allocation limits had been exceeded. Hence, a re-evaluation of the hydrogeology and the groundwater availability was necessary to enable better utilisation of the resource.

This Allocation Plan utilises recent groundwater resource assessments to better estimate the groundwater available for allocation from each of the aquifers.

The intention of this plan is to state the allocation policies of the Water and Rivers Commission for managing groundwater use in the Swan Groundwater Area. It also provides information on hydrogeology and groundwater availability and recommends a monitoring program.

Taken into account in this plan are issues of particular importance to the Swan Valley that influence the use of the groundwater resources.

1.6 Principles of groundwater allocation and licensing

The policies and procedures of groundwater licensing in Western Australia are detailed in the report entitled 'General Principles and Policies for Groundwater Licensing in Western Australia' (Ventriss 1990), and in reports published by the Water and Rivers



Commission (WRC 1996) which outline standards, procedures and work instructions associated with groundwater well licensing.

Groundwater licence allocations are aimed at ensuring equitable use of the State's groundwater resources, while protecting the long-term security of those resources and having regard for the economic, social and environmental consequences.

Groundwater is a valuable naturally-occurring resource that should be used efficiently to avoid wastage. Applicants for groundwater licenses should be made aware of this principle, and those planning to use large quantities of groundwater should demonstrate that water conservation has been considered and will be implemented where possible.

Allocation of the groundwater resource, including regulatory controls on abstraction, is based on the following objectives:

1. To abstract groundwater at a sustainable rate and ensure that the use of the resource benefits the community (Primary Objective).
2. To comply with statutory policies on environmental protection.
3. To ensure that, where possible, a sufficient quantity of groundwater is available to enterprises dependent upon a continuous supply of good quality water.
4. To encourage efficiency in groundwater use through improvements in methods of agriculture and irrigation, and to encourage development that is consistent with the regional planning and landuse objectives of the region.



2. Social environment

2.1 History

An excellent history of the Swan Valley (District) is given by M. J. Bourke in the book *On the Swan* (1987).

Radiocarbon dating of charcoal found with stone artefacts in a clay pit in the Upper Swan, indicates Aboriginal settlement from 40 000 years ago. European settlement of the Swan Valley began in about 1830.

The area is one of the earliest agricultural (horticulture and viticulture) regions of the State. The fertile soils associated with the alluvial sediments of the Swan River were recognised by early settlers as suitable for horticulture. During the twentieth century, viticulture has developed into a significant industry which gives the Swan Valley much of its character. The availability of clay (Guildford Clay) suitable for the manufacture of clay products (e.g. bricks, tiles) for the Perth market, was realised early during the settlement of the area.

The Swan Valley is regarded as one of the most important agricultural, recreational and tourist assets of the Perth Metropolitan Area. Retaining this asset has become an important objective of the Government and, therefore, an essential consideration for the Swan Groundwater Area Allocation Plan.

Land was first granted in the Bullsbrook Region in 1844, with the first major settlement taking place in the 1860s. The name 'Bullsbrook' is believed to have been derived from Lieutenant Bull, an early settler in the area. Bullsbrook townsite is situated between the Midland Railway and Ellen Brook, and was gazetted in 1939.

Pearce Air Force Base, established in 1935, was named after Sir George Pearce, who had been the Minister for Defence. Between the Great Northern Highway and Chittering Road, the area of Bullsbrook East has been developed to provide housing for the Royal Australian Air Force (RAAF) personnel and as a business centre for the surrounding rural area.

Other population centres in the Swan Groundwater Area include the Vines Resort, and a number of Special Rural Zones. The proposed extension of the Ellenbrook subdivision will cross into the Swan Groundwater Area, as will the proposed Albion townsite and rural villages identified in the *Swan Valley Planning Act*.

2.2 Land planning

Current land zoning in the Swan Groundwater Area is shown on Figure 2. The following land planning documents and legislation policies apply to the area:

- *Metroplan* (1990) resulted from 'The Corridor Plan Review, Planning for the Future of the Perth Metropolitan Region' (1987), which proposed areas in the Swan Valley for urban expansion. *Metroplan* (1990) also reaffirmed the contents of the Swan Valley Policy (Planning) Area (1985) document.
- *Metropolitan Region Scheme (MRS) Amendment 950/33* and *The North-East Corridor Structure Plan (1994)* are based on *Metroplan* (1990) and the Shire of Swan Recommended Draft Structure Plan (1992). The documents provide a framework for the development of the North-East Corridor and a guide to planning. Figure 2 represents the current land zoning in the Swan Groundwater Area based on the MRS.
- The Shire of Swan operates under a number of local policy documents concerning land planning in the Swan Valley. These documents include:
 - 1) *Shire of Swan Town Planning Scheme No. 9* (1985, amended 1988),
 - 2) *Shire of Swan Recommended Draft Structure Plan* (1992),
 - 3) *Bullsbrook Structure Plan* (1991),
 - 4) *Bullsbrook Rural Strategy* (1992), and
 - 5) *Pearce Rural Strategy* (draft).



- *The Swan Valley Planning Act* gives legislative powers to help preserve the rural character of the Swan Valley. The Government of Western Australia adopted a policy in 1985, known as the Swan Valley Policy. Its purpose was to maintain and revitalise the special character of the Swan Valley, which depends on (1) viticulture, (2) tourism, (3) recreational industries and (4) activities that conserve and enhance the unique resources of the Swan Valley (e.g. rural character and natural environment), and develop other natural resources such as clay deposits for brick manufacture.

The Swan Valley Planning Area, as defined in the *Swan Valley Planning Act*, is divided into four planning subareas pertaining to different landuses (Fig. 3). As part of the regular planning process, proposed projects in the area may require approval from the Swan Valley Planning Committee, in addition to other regulatory agencies, before development can proceed.

- *Ellen Brook (Draft) Interim Horticulture Strategy* (EPA 1994) is the first stage of a coordinated plan to reduce nutrient discharge to Ellen Brook from urban, irrigated agriculture and industrial sources. Associated with irrigated agriculture, the level of phosphorus loss to waterways is dependent on crop type, soil type and fertiliser history (Lantzke 1997). Ellen Brook is a major contributor of phosphorus to the Swan-Canning Estuary (Deeley et al. 1993). The widespread algal blooms in the upper reaches of the Swan River are predominantly caused by large nutrient (mainly phosphorus) input from the Ellen Brook surface water catchment (Fig. 3).

Objectives of the Interim Horticultural Strategy are:

- 1) to ensure that horticultural areas are situated so as to reduce the risk of excessive nutrient discharge via surface and groundwater to Ellen Brook;
- 2) to discourage horticultural enterprises utilising inappropriate technologies which may increase nutrient load to Ellen Brook;

- 3) to protect the quality of potable groundwater resources within the catchment;
- 4) to rationalise the environmental impact assessment of horticultural proposals in Ellen Brook catchment; and
- 5) to promote best management practices for horticulture in the catchment.

The Interim Horticultural Strategy has no statutory powers, and should only be used as a guide to the development of horticultural projects.

Agriculture Western Australia is currently producing a report called 'Land-Use Planning for Sustainable Horticulture in the Ellen Brook Catchment', which will provide an improved method for evaluating the environmental acceptability of projects in the catchment area.

- The draft *East Gnangara Environmental Water Provisions Plan* (Water and Rivers Commission) will provide an overall approach to the management of groundwater allocations on the eastern side of the Gnangara Mound. It will allocate water between the environment, public water supply and private users. A main aim of the project is to ensure that important environmental areas are allocated water that will enable their protection. This is achieved through the determination of Environmental Water Requirements and Environmental Water Provisions. These are environmental criteria expressed as minimum water levels.

- *The Basic Raw Materials Policy Statement for Perth Metropolitan Region* (DPUD 1992) identifies priority resource areas containing naturally occurring raw materials such as sand, clay and rock, from which future requirements of the region are likely to be met. In a priority resource area, the protection of the resource for extraction takes priority over other developments that might jeopardise extraction options.

In the Swan Groundwater Area there are priority resource areas at Ellenbrook, for sand, and in the Upper Swan, extending north of Warbrook Road, for clay.



3. Physical environment

3.1 Climate

The Swan Groundwater Area has a Mediterranean-type climate with mild wet winters and hot dry summers. The average annual rainfall at Bullsbrook is about 700 mm, with January (6 mm) and June (150 mm) being the driest and wettest months respectively. The average annual rainfall increases towards the south, and West Swan receives about 800 mm. Precipitation increases towards the southwest, with Perth having a long-term annual average of 870 mm.

Figure 4 shows annual rainfall histograms for Bullsbrook (Pearce Airbase), Midland (West Swan) and Belmont (Perth Airport). Histograms of mean monthly rainfall for Bullsbrook, West Swan and Perth are given in Figure 5.

In terms of temperature, February has the highest mean daily minimum and maximum temperatures (17.7°C and 33.2°C respectively) and July the lowest (8.5°C and 17.6°C).

3.2 Geomorphology

Three geomorphological provinces occur in the Swan Groundwater Area. They are the Swan Coastal Plain, Dandaragan Plateau and Darling Plateau (Fig. 6). The following description on geomorphology of the area has been taken from Davidson (1995).

The Swan Coastal Plain is bounded to the east by the Darling Scarp, which rises steeply to more than 200 m above sea level. The scarp represents the eastern boundary of marine erosion. The Swan Coastal Plain consists of a series of distinct landforms, roughly parallel to the coast. The most easterly landform comprises the colluvial slopes that form the foothills of the Darling and Dandaragan Plateaus and which represent dissected remnants of a sand-covered, wave-cut platform known as the Ridge Hill Shelf.

To the west of the colluvial slopes lies the Pinjarra Plain, a piedmont and valley flat alluvial plain consisting predominantly of clayey alluvium that has

been transported by rivers and streams from the Darling and Dandaragan Plateaus. Further west, the Bassendean Dune System forms a gently undulating aeolian sand plain. The dunes probably accumulated as shoreline deposits and coastal dunes during interglacial periods of high sea level, and originally consisted of mostly lime sand with quartz sand and minor fine-grained, black, heavy-mineral concentrations. The carbonate material has been completely leached, leaving dunes consisting entirely of quartz sand.

3.3 Geology

The Swan Groundwater Area covers part of the eastern-central margin of the Perth Basin and part of the western margin of the Darling Plateau, comprising colluvium and Precambrian crystalline rocks east of the Darling Fault. The Mesozoic strata within the Perth Basin, to the west of the Darling Fault, have been gently folded to form the Swan Syncline, and superimposed upon these strata is a veneer of late Tertiary-Quaternary sediments, referred to as the superficial formations. On the Dandaragan Plateau, between the Gingin Scarp and the Darling Fault, Cretaceous units outcrop in some of the valleys and deeply incised drainages (GSWA 1990).

The stratigraphic units within the Perth Basin, to a depth of about 1000 m, are summarised in Table 1 and a generalised geological section of the Swan Groundwater Area is shown in Figure 7. A more detailed description of the geology is given in Davidson (1995).

Quaternary/late Tertiary sediments

Superficial formations is a collective term used to describe the late Tertiary to Quaternary sediments and comprise, in order of deposition, Ascot Formation, Yoganup Formation, Guildford Clay, Gnangara Sand and Bassendean Sand. They collectively range in thickness to a maximum of 80 m, and unconformably overlie a gentle westward-sloping erosional surface of older sediments. The superficial formations consist mainly of sand, silt and clay in varying proportions. In the eastern half of the area the sediments are more clayey than those in the western part, which are predominantly sandy.



TABLE 1
STRATIGRAPHIC SEQUENCE IN THE SWAN GROUNDWATER AREA
 (after Davidson 1995)

Age	(10 ⁶ years)	Stratigraphy	Symbol	Maximum thickness (m)	Lithology	Aquifer	
CAINOZOIC	Quaternary-Late Tertiary	Superficial formations	Bassendean Sand	Qd	80	Sand and subordinate silt and clay	Superficial aquifer
			Gnangara Sand	Qn	30	Sand, gravel and subordinate clay	
			Guildford Clay	Qg	35	Clay with subordinate sand and gravel	Local confining bed
			Yoganup Formation	Ty	10	Sand, silt, clay and pebbles	
			Ascot Formation	Ta	25	Limestone, sand, shells and clay	
MESOZOIC	Cretaceous	Coolyena Group	Poison Hill Greensand	Kcp	90	Sand, silty, clayey and glauconitic	Mirrabooka aquifer
			Gingin Chalk	Kcg	40	Chalk, sandy and glauconitic	
			Molecap Greensand	Kcm	80	Sand, clayey and glauconitic	
			Osborne Formation	Kco	180	Sandstone, siltstone and shale	
			Mirrabooka Member	Kcom	160	Sandstone, siltstone and shale	
	Cretaceous-Jurassic	Warnbro Group	Henley Sandstone Member	Kcoh	100	Sand, silty, clayey and glauconitic	Leederville aquifer
			Leederville Formation	Kwl	600	Sandstone, siltstone and shale	
			Pinjar Member	Kwlp	150	Sandstone, siltstone and shale	
			Wanneroo Member	Kwlv	450	Sandstone, siltstone and shale	
			Mariginiup Member	Kwlm	250	Sandstone, siltstone and shale	
			Parmelia Formation	Kp	>287	Sandstone, siltstone and shale	Yarragadee aquifer
			Carnac Member	Kpc		Shale and siltstone	
	Otorowiri Member	Kpo		Shale and siltstone			
	Jurassic	146	Yarragadee Formation	Jy	>2000	Sandstone, siltstone and shale	

~~~~~ unconformity



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### **Cretaceous sediments**

Cretaceous sediments in the Swan Groundwater Area occur in the Swan Syncline, with sediments dipping westwards. These include the Poison Hill Greensand, Molecap Greensand, the Osborne Formation, the Leederville Formation, and the South Perth Shale.

The Poison Hill Greensand and Molecap Greensand are components of the Mirrabooka aquifer, and the Leederville aquifer contains the Henley Sandstone Member of the Osborne Formation and the members of Leederville Formation (refer Chapter 4).

Important aquitards include the Kardinya Shale separating the Mirrabooka aquifer from the Leederville aquifer and the South Perth Shale between the Leederville and Yarragadee aquifers.

### **Jurassic sediments**

The *Yarragadee Formation* underlies all of the Swan Groundwater Area west of the Darling Fault and is overlain by the South Perth Shale. It is a component of the Yarragadee aquifer.

## **3.4 Environment**

The health of wetlands and the flora and fauna within reserves of the Swan Groundwater Area is dependent on groundwater. Most of the wetlands in the area are hydraulically connected to the watertable, and are sensitive to variations in watertable elevations. Groundwater abstraction can result in the lowering of the watertable, and should therefore be controlled to prevent unnatural drying out of wetlands and consequent endangering of the local flora and fauna.

Most of the native flora that existed in the Swan Groundwater Area have been cleared for pastoral and horticultural (including viticulture) purposes. However, there are areas of important remnant vegetation, particularly within Bushplan Reserves (previously termed System 6 Reserves) and surrounding some of the wetlands.

A comprehensive fauna survey of the Gngangara Mound (WA Museum 1978) included a large part of the Swan Groundwater Area. The survey found 12 mammal species in the area, 70 amphibian and reptile species, 17 of which were rare, and numerous birds. Storr et al. (1978) provide a complete list of birds found in the area.

The wetlands sustain an environment suitable for the existence of frogs and waterfowl, including ducks, geese, ibis and heron. Tortoises and gilgies are also present in some wetlands (Jasinska & Knott 1994). The western swamp tortoise, one of Australia's most endangered species, is present only in the Ellen Brook and Twin Swamps Reserves. The Department of Conservation and Land Management is responsible for maintaining the water levels in the wetlands. This may involve the addition of water pumped from a nearby groundwater well (i.e. artificial maintenance).

### **3.4.1 Statutory environmental protection**

Two key documents relating to statutory environmental protection in the Swan Groundwater Area are:

- the *Environmental Protection Authority 1983 System 6 Reserves* (Red Book) (recently renamed Bushplan Reserves), and
- the *Environmental Protection Authority Swan Coastal Plain Lakes Environmental Protection Policy* (EPA 1993a, Appendix 2); commonly called the Lakes EPP Policy.

### **Bushplan Reserves**

Certain vegetation areas (including wetlands) on the Swan Coastal Plain are protected from degradation by the Conservation Reserve System recommended by the Environmental Protection Authority (EPA) in the 1983 (System 6, Red Book) publication, which was endorsed in principle by the Government in March 1984. The EPA considers areas (Bushplan Reserves) recommended in the Red Book as potentially significant for conservation, and carefully scrutinises any development that is likely to pose a threat to the environment of these areas.

Bushplan Reserves in the Swan Groundwater Area include the following areas:

- Reserve C1654, which is north of Bullsbrook East townsite at the intersection of Great Northern Highway and Morrissey Road. This area has unique swamp vegetation.
- Land associated with Pearce Aerodrome, which has a rare vegetation system.
- Reserves A27620 and A27621. These are the Ellen Brook and Twin Swamps Wildlife Sanctuaries, established for the preservation of fauna (especially the western swamp tortoise).



- The Swan River from Guildford to Walyunga National Park, part of which is within the Swan Groundwater Area.
- Jane Brook, part of which (north of Toodyay Road) is within the Swan Groundwater Area.

### **Swan Coastal Plain Lakes Environmental Protection Policy 1992 (Lakes EPP)**

The EPA's Swan Coastal Plain Lakes Environmental Protection Policy was gazetted in December 1992. This policy prohibits unauthorised filling, mining, drainage into or out of, and effluent discharge into, specific wetlands identified in the policy (EPA 1993a). A development is unlikely to receive EPA approval if it involves any of these prohibitions. Breach of the policy can result in prosecution under Part V of the *Environmental Protection Act 1986*. Wetlands identified under this policy (Appendix 2) have the highest level of protection under the Act.

Additional statutory protection is likely to exist following the completion of the Western Swamp Tortoise EPP, the Swan Canning EPP and the East Gngangara Environmental Water Provisions Plan (see Recommendations, Chapter 12).

### **3.4.2 Non-statutory protection policies**

**Ellen Brook Interim Horticulture Strategy.** Specific environmental policy applying to the Swan Groundwater Area is contained in the 'Ellen Brook Interim Horticulture Strategy' (EPA 1994). The Interim Horticultural Strategy sets out that:

- light horticultural activities (e.g. grape vines, potted nurseries) are acceptable throughout the catchment provided they are restricted to gravel and loamy soils which are not subjected to waterlogging;
- medium horticultural activities (e.g. orchards, garden nurseries) are restricted to areas of heavier textured soils; i.e. not in areas of grey and white sands, which are more permeable; and
- intensive horticultural activities (e.g. market gardens, turf farms, golf courses) utilising conventional management techniques are generally not suitable developments in the Ellen Brook catchment.

This strategy, having no statutory authority, should be regarded as a guide to development.

### **Water and Rivers Commission Conservation Category wetlands**

The *Lakes EPP* does not include all wetlands of high conservation value. The policy applies to more permanently inundated lakes. The boundary of these lakes usually includes areas of open water only, and may not protect the fringing vegetation.

To protect wetlands of high conservation value not included in *Lakes EPP*, the Water and Rivers Commission has mapped, evaluated and classified all wetlands on the Swan Coastal Plain (Hill et al. 1995, Appendix 2). This report evaluated wetlands as either (1) Conservation, (2) Resource Enhancement, or (3) Multiple Use Category wetlands. Those wetlands with a Conservation Category status are considered in groundwater allocation policy for the Swan Groundwater Area.



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## 4. Hydrogeology

Groundwater pervades the superficial formations beneath the Swan Coastal Plain and the underlying geological formations of the Perth Basin. It originates mainly from direct rainfall recharge on the coastal plain, with a small component being derived from local runoff from the Darling and Dandaragan Plateaus. Groundwater in the deeper, confined aquifers also flows into the area from the north.

Groundwater in the Quaternary superficial formations is contained in a regional unconfined aquifer system. The superficial aquifer may be in local hydraulic connection with some underlying Mesozoic formations. The Mesozoic formations also form confined aquifer systems. The confined aquifer systems are bounded to the east near the Darling Fault and extend several kilometres offshore to the west.

The geological formations have been grouped into four distinct aquifers, each being assigned the name of the major geological unit contributing to it. The stratigraphic sequence and the relationship of the aquifer are summarised in Table 1. In descending order they are :

- *Superficial aquifer*: a major unconfined aquifer comprising the Quaternary-Tertiary Bassendean Sand, Gnangara Sand, Guildford Clay, Yoganup Formation, and Ascot Formation.
- *Mirrabooka aquifer*: a locally important semi-confined aquifer comprising the Cretaceous Poison Hill Greensand, Gingin Chalk, Molecap Green and the Mirrabooka Member of the Osborne Formation.
- *Leederville aquifer*: a major aquifer, mostly confined, comprising the Cretaceous Osborne Formation (Henley Sandstone Member) and Leederville Formation (Pinjar Member, Wanneroo Member and Mariginiup Member).
- *Yarragadee aquifer*: a major confined aquifer comprising the Cretaceous Parmelia Formation and the Jurassic Yarragadee Formation.

The Yarragadee aquifer is not considered in detail in this report because private groundwater abstraction is

not economically viable due to its depth below ground surface. Furthermore groundwater from the Yarragadee aquifer is brackish to saline.

The following general description of the hydrogeology of the Swan Groundwater Area is taken from reports by Allen (1981) and Davidson (1995).

### 4.1 Superficial aquifer

Groundwater in the superficial aquifer is contained in sand and clay which have an accumulated average saturated thickness of about 40 m. It is a complex unconfined aquifer system. Water levels in the superficial aquifer impact directly on the health of the wetlands in the area.

#### Groundwater recharge and discharge

Recharge to the superficial aquifer is between 10 and 30% of the mean annual rainfall. The greatest recharge occurs in areas of Bassendean Sand and the least in clayey areas (Davidson 1992). Recharge also depends on the density of vegetation cover and the extent of urbanisation. For example, the urban development at Ellenbrook is likely to increase recharge and raise groundwater levels. Stormwater runoff, shed from large areas of hard surface (e.g. roofs, roads) is concentrated to collection basins where leakage to the watertable is common. In some areas, the superficial aquifer is also recharged by upward leakage from the Mirrabooka and Leederville aquifers.

Groundwater from the superficial aquifer discharges to the underlying Mirrabooka aquifer, or Leederville aquifer, by leakage in areas where there are downward potentiometric levels and where confining beds are absent. The superficial aquifer also discharges into Ellen Brook, Henley Brook and the Swan River.

#### Groundwater flow

To the west of Ellen Brook and the Swan River, the superficial aquifer forms part of the Gnangara Mound groundwater flow-system. The Gnangara Mound is a vast shallow groundwater resource to the north of Perth. In the Swan Groundwater Area, groundwater flow is to



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the east and southeast and discharge occurs into Ellen Brook, Henley Brook and the Swan River (Fig. 8).

The Swan-Helena groundwater flow-system occurs in a small area bounded by Ellen Brook and the Swan River in the west and the Darling Scarp in the east. Groundwater flows westward, discharging into Ellen Brook and the Swan River. Apart from the colluvial slopes of the Darling Scarp, the area is underlain by sediments of Guildford Clay.

#### **Groundwater salinity**

Groundwater salinity is generally less than 1000 mg/L TDS throughout the Swan Groundwater Area (Fig. 9). In some areas, groundwater may be more saline at the watertable owing to the concentration of salts by evaporation. The groundwater is also more saline in clay-rich areas, as the clayey sediments inhibit infiltration, resulting in high evaporation and concentration of salts. Groundwater salinity is often high at the discharge boundaries formed by the drainages and down-gradient of wetlands, where evaporation has concentrated dissolved salts.

## **4.2 Mirrabooka aquifer**

The Mirrabooka aquifer is a locally important semi-confined aquifer. It occurs in the western half of the Swan Groundwater Area and is in general hydraulic continuity with the overlying superficial aquifer. It has a maximum thickness of about 100 m and consists of sandstones, silty sandstones and interbedded shales of Poison Hill Greensand, Molecap Greensand and Mirrabooka Member.

#### **Groundwater recharge and discharge**

The Mirrabooka aquifer is recharged by leakage from the superficial aquifer, which is estimated to be 4% of rainfall. Along the eastern extent of the Mirrabooka aquifer (Fig. 8), groundwater discharges by upward leakage into the superficial aquifer.

#### **Groundwater flow**

Groundwater flow in the Mirrabooka aquifer is southeastwards, subparallel to that of the superficial aquifer (Fig. 8).

#### **Groundwater salinity**

The groundwater salinity is generally less than 500 mg/L TDS (Fig. 10) and in some areas it is less than that of

the overlying superficial aquifer. The Mirrabooka aquifer is a particularly important resource of fresh groundwater in those areas where the groundwater of the superficial aquifer is brackish and further abstraction from the underlying Leederville aquifer is not permitted (e.g. South Swan Subarea).

## **4.3 Leederville aquifer**

The Leederville aquifer is a major aquifer in the Swan Groundwater Area. It is mostly a confined multilayer aquifer system consisting of discontinuous interbedded sandstones, siltstones and shales of the Henley Sandstone Member (Osborne Formation) and the Pinjar, Wanneroo and Mariginiup Members (Leederville Formation).

The aquifer overlaps the Darling Fault south of the Dandaragan Plateau. It is unconfined in areas east of Ellen Brook and the Swan River, where it directly underlies the superficial aquifer. With increasing depths, however, it becomes confined by discontinuous interbeds of siltstone and shale within the aquifer (Figs. 7 and 8). The aquifer has an average thickness of about 300 m in the Swan Groundwater Area.

#### **Groundwater recharge and discharge**

The Leederville aquifer (west of the Swan River and Ellen Brook) is recharged by throughflow from the Gingin area to the north, where there is direct leakage from the superficial aquifer. Recharge has been estimated to be 3% of mean annual rainfall (McCrea & Colman 1993). In the east of the Swan Groundwater Area, where the upper part of the Leederville aquifer is in hydraulic connection with the overlying superficial aquifer, recharge occurs by downward leakage.

The Leederville aquifer discharges to the superficial aquifer in areas where the Kardinya Shale has been eroded and there is an upward hydraulic gradient (Fig. 8). Downward leakage to the Yarragadee aquifer occurs where the confining beds of the South Perth Shale are thin or absent and a downward hydraulic gradient exists.

#### **Groundwater flow**

West of Swan River and Ellen Brook, groundwater flow is southerly. To their east the flow is westwards, subparallel to that of the overlying superficial aquifer.



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### **Groundwater salinity**

Groundwater is generally fresher at the intake areas, and salinity increases with depth and distance from these areas (Fig. 11). The Leederville aquifer has been divided into an upper (Henley Sandstone and Pinjar Members) and a lower (Wanneroo and Mariginiup Members) zone based on groundwater salinity distribution. In each zone the salinity shows a gradual increase with depth, from less than 500 to greater than 3000 mg/L TDS.

## **4.4 Yarragadee aquifer**

The Yarragadee is a major multilayer confined aquifer. It is more than 2 000 m thick and consists of interbedded sandstones, siltstones and shales. Over most of the Swan Groundwater Area, the Yarragadee aquifer consists of the Yarragadee Formation. In the north, the Parmelia Formation is present and forms a component of the Yarragadee aquifer. The aquifer is mostly confined by the overlying South Perth Shale, although, in the northern part of the area where the South Perth Shale is absent, it is confined by shale interbeds within the overlying Leederville Formation.

### **Groundwater recharge and discharge**

Groundwater recharge to the Yarragadee aquifer is by downward leakage from the Leederville aquifer in areas where the South Perth Shale is absent and a downward

hydraulic gradient exists. Groundwater from the Yarragadee aquifer discharges to the Leederville aquifer in areas where the South Perth Shale is absent and where upward potentiometric levels exist. However, most groundwater throughflow discharges offshore, possibly over a series of saltwater wedges, into the overlying strata.

### **Groundwater flow**

Groundwater flows southeastwards in the northern part of the Swan Groundwater Area, but gradually changes direction to flow southwestwards in the southern part. The relatively flat potentiometric surface suggests that groundwater movement is very slow.

### **Groundwater salinity**

Groundwater in the Yarragadee aquifer generally has salinities in excess of 2500 mg/L TDS. However, recent drilling results have indicated fresher groundwater (800 mg/L TDS) near Beechboro Road (Fig. 12). There is therefore a possibility that a freshwater zone, within the Yarragadee aquifer, could extend into the western part of the Swan Groundwater Area. Groundwater salinity in the aquifer increases in an easterly direction.

Groundwater from the Yarragadee aquifer is unlikely to be utilised for irrigation because of the high cost of drilling deep wells and the high salinity, but it may be useful for some industrial purposes.



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## 5. Groundwater monitoring

The monitoring network in the Swan Groundwater Area consists mainly of wells drilled during regional drilling programs. These wells drilled to various depths, were designed to monitor water quality and water level change within the local and regional aquifer systems and to provide geological and hydrogeological information.

The location of the existing and proposed monitoring wells in the Swan Groundwater Area is shown in Figures 13-19. The wells, being monitored are grouped into a number of programs (series) described below.

### 5.1 Existing monitoring network

#### **Artesian Monitoring (AM Series)**

The AM series of wells was completed in 1985. They were part of the exploratory drilling program to assess the groundwater resources of the confined aquifers in the Perth region. This program was commenced in 1961 by the Geological Survey of WA. At most locations two wells were drilled, one with a slotted interval in the middle of the Leederville aquifer and the other with a slotted interval approximately 100 metres beneath the top of the Yarragadee aquifer.

#### **Gnangara Mound Groundwater Monitoring (GN, GD Series)**

These wells were drilled during the 1960s to investigate the groundwater resources of the Gnangara Mound (superficial aquifer) and determine the suitability of the groundwater resource for abstraction for scheme water supply purposes.

#### **Lexia Observation Wells (L Series)**

These wells were drilled by the Water Authority between 1983 and 1986 to investigate the hydrogeology at three stratigraphic levels. Four east-west lines of wells were drilled, spaced about 2.5 km apart, with individual well spacing of about 1 km. Wells having numbers suffixed with the letter 'A' were drilled to monitor the potentiometric level at the base of the superficial aquifer. Those with the suffix 'C' are shallow wells, drilled to monitor watertable fluctuations. Those ending with '2' are screened deeper, in the Mirrabooka aquifer.

#### **Mirrabooka Production Observation Wells (M Series)**

Investigations to determine the potential for groundwater abstraction from the Mirrabooka aquifer in the area commenced in the 1960s, and the first production wells started operation in 1971. Although the Mirrabooka production wells are located between 2.5 and 10 km west of the Swan Groundwater Area, some groundwater monitoring wells associated with the scheme are located within it (South Swan Subarea).

#### **Mirrabooka Monitoring Wells (MM Series)**

These wells were drilled to provide baseline groundwater data for the Mirrabooka Wellfield and to enable determination of aquifer characteristics. The wells are now used to provide information on the aquifer response to abstraction.

#### **Net Recharge Project (NR Series)**

In 1981 the Water Authority, in conjunction with the CSIRO, began a study on groundwater recharge processes in the Gnangara Water Reserve. The project estimated rates of net recharge in the unsaturated zone at selected sites near the crest of the Gnangara Mound and within an area of vegetation.

#### **Pacminex Exploratory Wells (PB Series)**

These wells were drilled as part of a groundwater resource investigation of the Quaternary and Cretaceous sediments at the proposed Pacminex Alumina Refinery site. Some of these wells, located near the Vines Resort, are being monitored.

#### **Swan Groundwater Area Series**

Drilling of these wells was initiated after the area was proclaimed in the 1970s. In 1985, nests of wells were constructed at five sites to monitor the potentiometric levels in the superficial and Leederville aquifers. At two of these sites, wells were drilled into the Mirrabooka aquifer. There are also a number of privately owned wells which are part of this series. The private wells are used for monitoring variations in groundwater salinity.



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### **GSWA Well Census**

Between the late 1960s and early 1970s, the Geological Survey of WA (GSWA) carried out a groundwater sampling program of selected private wells in the Swan Valley. Salinity and water level data obtained were used to assess the hydrogeology of the Swan Valley (Allen 1981). To assess changes within the groundwater flow systems in the area, the Water Authority resampled some of these wells in January 1992.

Data from these wells have recently (July 1996) been stored into the State Water Resources Information System (SWRIS) database. It is recommended that these wells be incorporated into the regular groundwater monitoring program for the Swan Groundwater Area.

### **GNM Series**

As part of the East Gngangara Environmental Water Provisions Plan, a number of wells (GNM series) were drilled to depths just below the watertable to enable assessment of the impacts of groundwater abstraction and other landuse activities on water levels in the east Gngangara Mound area. The GNM wells, some of which are located in the Swan Groundwater Area, are used in particular to assess the effect of groundwater abstraction on the vegetation, wetland water levels and groundwater quality. The monitoring data will be used in annual and triennial reports to the Environmental Protection Authority.

Comprehensive chemical analysis is also undertaken for wetlands identified in the East Gngangara Environmental Water Provisions Plan and by the Department of Conservation and Land Management for wetlands associated with the Twin Swamps and Ellen Brook Reserves.

### **Seepage monitoring**

Water levels in wells upstream of Edgcombe and Egerton Springs will be monitored monthly once access issues are resolved. Comprehensive water chemistry will also be tested annually. This program is part of the east Gngangara Mound monitoring program (GNM Series).

## **5.2 Current monitoring program**

The current groundwater monitoring program is detailed in Table 2. Data from the monitoring wells are stored in a computer database called SWRIS. This

report used SWRIS to generate tables and figures of groundwater monitoring data. Data from the monitoring program are presented in Chapter 10.

## **5.3 Monitoring results - water levels**

Groundwater level changes, as recorded over the past 20 years, are summarised in Figures 20-24.

### **Superficial aquifer**

Raised groundwater levels during the winter months commonly cause localised flooding within the Swan Groundwater Area. The amplitude in watertable elevations generally ranges from 1 to 2 m between the winter and summer months (Fig. 20). Some wells, however, show a continuing decline in summer water levels. This could be due to groundwater abstraction near the wells, as declining summer water levels generally recover after winter rains.

Figure 21 shows the changes in maximum and minimum water levels between 1986 and 1995. The end-of-winter water levels (maximum water levels) have changed little in the past 10 years (area in blue). The end of summer water levels, however, show a decline (area in red) in two localities:

1. North Swan Subarea, where substantial groundwater abstraction for recreational use is causing a decline in the local water levels;
2. South Swan Subarea, where there is substantial abstraction of groundwater for irrigated agriculture.

Declining water levels in summer may be causing stress on ecosystems and should be investigated.

The water levels in two monitoring wells located in the North Swan Subarea (L90a, L90c) have risen. This rise in the local watertable has probably resulted from the clearing of vegetation and the urban development at Ellenbrook.

### **Mirrabooka aquifer**

Hydrographs from monitoring wells in the Mirrabooka aquifer, in the North Swan Subarea, indicate variations of 1-2 m between the summer and winter water levels over the past 20 years (Fig. 22). In the South Swan Subarea, however, groundwater levels generally show declines over the past five years which are probably





**Table 2. Current groundwater monitoring program in the Swan Groundwater Area**

| Monitoring series                  | Aquifer                                  | Water level                                             | Salinity                                                                                                       |
|------------------------------------|------------------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| AM Series                          | Leederville<br>Yarragadee                | Quarterly/Monthly**                                     |                                                                                                                |
| GN, GD Series                      | Superficial                              | Quarterly/Monthly**                                     |                                                                                                                |
| L Series                           | Superficial<br>Mirrabooka                | Quarterly/Monthly**<br>Quarterly                        |                                                                                                                |
| M Series                           | Superficial                              | Quarterly                                               |                                                                                                                |
| MM Series                          | Superficial                              | Quarterly                                               |                                                                                                                |
| NR Series                          | Superficial                              | Quarterly/Monthly**                                     |                                                                                                                |
| PB Series                          | Superficial<br>Mirrabooka<br>Leederville | Monthly                                                 |                                                                                                                |
| Swan Series                        | Superficial<br><br>Leederville           | Quarterly (Water & Rivers<br>Comm. wells)<br>Quarterly+ | Quarterly/3 yearly (private wells)<br><br>Quarterly#                                                           |
| GSWA Census                        | Superficial<br>Mirrabooka<br>Leederville | 1969-1971<br>1969-1971<br>1969-1971                     | Irregular Periods (1969-1971,1992)<br>Irregular Periods (1969-1971,1992)<br>Irregular Periods (1969-1971,1992) |
| GNM Series<br>(wells and wetlands) | Superficial                              | Monthly wells<br>and wetlands                           | Annual comprehensive analysis -<br>Wetlands EPP173, Lexia 186, Lexia 86                                        |

+ *Water and Rivers Commission wells only.*

# *private wells only. Some done quarterly, others every 3 years.*

\*\* *Monthly = AM31, AM31A, AM35, AM35A; GN24; L80A&C, L90A&C; L170A&C, NR11C.*

due to abstraction from the Water Corporation Mirrabooka Groundwater Scheme to the west of the Swan Groundwater Area (Fig. 2). No large groundwater users (> 50 000 kL/a) draw from the Mirrabooka aquifer in the South Swan Subarea.

#### **Leederville aquifer**

Groundwater abstraction from the Leederville aquifer in Swan Groundwater Area is currently exceeding annual recharge, causing declining potentiometric levels where the aquifer is confined (Fig. 23). Assuming no new abstraction from this aquifer, the potentiometric surface will reach an equilibrium over time from induced additional groundwater throughflow (Davidson 1992).

In the South Swan Subarea, the declining potentiometric level may be partly due to groundwater abstraction from wells drilled into the Leederville aquifer within the Mirrabooka Wellfield to the west, as well as groundwater abstraction from the Leederville aquifer in this subarea by private licensees.

The decline of potentiometric levels in the Leederville aquifer confirms the comments from a number of landowners in the Swan Groundwater Area that some wells and/or pumps in the Leederville aquifer have required periodic lowering over time.

At the recharge areas, east of Ellen Brook and the Swan River, hydrographs of monitoring wells in the Leederville aquifer do not show declining potentiometric levels. Here, the aquifer is unconfined in its upper part and gets direct groundwater recharge from the overlying superficial aquifer.

#### **Yarragadee aquifer**

Declining potentiometric levels in the Yarragadee aquifer occur in the northern Perth region, including the Swan Groundwater Area (Fig. 24). This is due to the annual groundwater abstraction from the Yarragadee aquifer in the Perth region (primarily for public water supply) being nearly twice the estimated current annual recharge (Davidson 1995). The four monitoring wells screened in the Yarragadee aquifer in the Swan Groundwater Area show this decline to range from 0.5 to 1.0 m/a since about 1980.



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## 5.4 Monitoring results - salinity

In the past, groundwater salinity has not been regularly monitored from aquifers in the Swan Groundwater Area. Recommended changes to the monitoring program include more regular salinity monitoring (Chapter 5.6).

There is no evidence of groundwater salinity increasing on a regional scale for the aquifers in the Swan Groundwater Area (Figs. 9-12). However, there are examples of well-owners replacing superficial wells due to increasing salinity. One such area where salinity in the superficial aquifer appears to be rising is along the eastern boundary of the North and South Swan Subareas (Fig. 9). There are likely to be other areas in the Swan Groundwater Area where increasing salinity is occurring, but due to insufficient monitoring data, these areas are not depicted in Figure 9. Increasing salinity is most likely to be occurring in areas of heavy soils (e.g. Guildford Clay) where groundwater is generally already of marginal quality.

## 5.5 Maintenance of existing monitoring wells

A number of the monitoring wells need to be replaced due either to recent land developments or age. The screens of some wells are blocked and the wells should be redeveloped to ensure that data collected are reliable. Table 3 contains a list of existing monitoring wells in the Swan Groundwater Area that require maintenance.

Manolini's well (Fig. 17) should be inspected to determine if measurements can continue (motor seized). If the Swan Research Station is sold, the new owners should be approached for permission to continue monitoring this site.

## 5.6 Recommended changes to monitoring program

*The Swan Valley Planning Act* indicates that the Government places a high level of importance on the maintenance of the horticultural (including viticultural) activities in the area. This is particularly important considering the occurrence of groundwater of varying

salinities, both spatially and with depth, and the requirement of large quantities of fresh groundwater for irrigation in the Swan Groundwater Area. For this reason, a number of changes and additions are proposed to the monitoring program. These include the better utilisation of existing wells and the addition of new wells. The proposed program (Appendix 3) will ensure that the necessary data can be collected for a reliable assessment of the aquifers within the Swan Groundwater Area.

It is recommended that three new superficial aquifer monitoring wells be constructed. Two wells are proposed in the Cockman Bluff Subarea and a third in the Radar Subarea. These wells will supplement the existing monitoring wells.

Private wells of 5/85, Yukich, No.107 Angelo and Morris (Fig. 17) should be removed from the monitoring program, as these have been abandoned. It is recommended that the private wells of the GSWA census be included in the program for regular monitoring.

Included in the recommended changes to the monitoring program is expanded monitoring of groundwater chemistry. This includes monitoring of groundwater salinity and some comprehensive chemical analysis (McCrea 1997). As the area has a history of groundwater with variable salinity, particularly in the superficial aquifer, it is important to have current groundwater salinity data to enable the assessment of any trends. This will assist the better management and preservation of the region's horticultural/viticultural developments. Comprehensive analysis is recommended for selected wells (Fig.17) near Ellen Brook to provide data on possible nutrient input to the watercourse. Comprehensive groundwater chemistry analysis is also recommended for wells downflow of the Ellenbrook urban development to assess possible nutrient input to Henley Brook.

While recommended changes to the monitoring program include an increase in groundwater chemistry sampling, the frequency of water level measurements has been reduced for some series of wells.



**Table 3. Maintenance Program for current monitoring wells in the Swan Groundwater Area**

| <b>Station No.</b> | <b>Project</b> | <b>Name</b> | <b>Problem</b>            | <b>Action</b>                        |
|--------------------|----------------|-------------|---------------------------|--------------------------------------|
| G61611085          | Gnangara Mound | GD15        | Will be abandoned         | Replace                              |
| G61611176          | Lexia          | L52         | Blocked, screen collapsed | Airlift & clean, may need resleeving |
| G61611171          | Lexia          | L242        | Blocked                   | Airlift & clean                      |
| G61611054          | Lexia          | L60A        | May be abandoned          | Request developer to protect well    |
| G61611053          | Lexia          | L60C        | May be abandoned          | Request developer to protect well    |
| G61611051          | Mirrabooka     | MM64        | Abandoned                 | Redrill to north                     |
| G61619604          | Swan           | 4/85        | Blocked                   | Airlift & clean                      |



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## 6. Groundwater availability

The quantity of groundwater available for allocation from the superficial aquifer in the Swan Groundwater Area is dependent on the amount of rainfall recharge and the environmental requirements for the preservation of wetlands in the area.

A computer model called the Perth Urban Water Balance Model (PUWBM), part of the Perth Urban Water Balance Study, was developed in 1985 to better predict water levels of the superficial and Mirrabooka aquifers due to different abstraction rates in the Perth region. The Water and Rivers Commission, as part of the East Gngangara Environmental Water Provisions Plan, has subsequently upgraded this model to estimate the available groundwater resources for allocation in the subareas located on the Gngangara Mound (Fig. 25). The PUWBM was developed in two sections, north and south of the Swan River. It simulates the movement of groundwater through the subsurface strata, and consists of two parts: a recharge model and a groundwater flow model, which complement each other.

The recharge model simulates processes occurring in the unsaturated zone (from the land surface to the watertable). Parameters considered include rainfall, infiltration rates, evaporation, transpiration and the percolation of water downwards under the influence of gravity. The spatial input data for the recharge model are organised into cells (500 m x 500 m) covering the entire Perth region. Each cell has a range of attributes associated with it, including ground level, soil moisture content, landuse codes, and the year of planting if the dominant use of the land in the cell is silviculture.

The groundwater flow model simulates the movement of groundwater in the saturated zone. This is basically horizontal flow. Mathematically, this is described using a finite element approach, in which data are organised into a triangular mesh with the potentiometric level defined at each of the nodes. Variable resolution can be secured by using triangles of different sizes, depending on the degree of interest on the area.

The model runs in monthly steps, taking into account the different time-variable inputs such as rainfall,

evaporation and rates of abstraction. For each time step for each cell, the recharge processes are modelled, resulting in an estimate of the volume of water that will be added to the saturated zone. The amount of water added changes the potentiometric level at the different nodes. The potentiometric level differences induce the horizontal flow within the saturated zone. The upgraded potentiometric levels at the nodes are substituted as new levels for the recharge model for further computations.

The computer model was calibrated by modifying a number of different factors, including the hydraulic conductivity, to simulate, as closely as possible, the actual potentiometric levels in the monitoring wells. Special attention was given to areas such as wetlands.

In recent years the PUWBM has been upgraded to include a number of parameters that were not originally considered. The model for the areas north of the Swan River now incorporates most of these changes, but the model for the south of Perth has yet to be upgraded.

Modelling has indicated that there is an additional, limited quantity of groundwater available for allocation from the superficial and Mirrabooka aquifers in the North and South Swan, Neaves and Radar Subareas.

The deeper Leederville aquifer has not been modelled in these four subareas, but, due to declining potentiometric levels, there are no groundwater supplies for *additional* allocation from this aquifer.

### 6.1 Superficial aquifer

Any large increase in abstraction of groundwater from the North Swan Subarea is constrained by the proposed development of the Water Corporation's Lexia Groundwater Scheme to the west (Fig. 2). The Lexia wellfield will be drawing groundwater from the Gngangara Mound groundwater flow-system, upgradient of the Swan Groundwater Area. The Water Corporation plans to abstract about 10.5 million kL/a from the superficial and Mirrabooka aquifers for the scheme.



In the Swan Groundwater Area, the allocation limits (Table 4) of groundwater abstraction from the superficial aquifer for the subareas located on the Gngangara Mound were determined from results of computer modelling (upgraded PUWBM) carried out for the East Gngangara Environmental Water Provisions Plan (draft, Water and Rivers Commission).

Factors that will influence the rate of rainfall recharge to these areas, such as the urbanisation of large areas and the drilling of a significant number of domestic wells, have been taken into account when optimising the model. As domestic wells are no longer licensed in the Swan Groundwater Area (Chapter 9.3), their number can only be estimated by survey (e.g. Water Authority 1995).

Results of computer modelling indicate that, in the North and South Swan Subareas, current allocations have nearly reached the maximum available from the superficial aquifer. Supplies are also small where aquifers are thin, such as east of the Darling Fault. The potential for additional groundwater allocation from the superficial aquifer is greater north of Warbrook Road, in the Neaves, Radar and Cockman Bluff Subareas.

For subareas to the east of the Gngangara Mound, where the PUWB Model did not apply, groundwater allocation limits were calculated using rainfall recharge estimates from Davidson (1992). For these areas 25% rainfall recharge has been adopted for areas of Bassendean Sand and 10% recharge for areas of Guildford Clay. The superficial aquifer recharge has been reduced by 4% to account for discharge by leakage to the underlying Mirrabooka aquifer (Davidson 1992) and by an additional 2% to account for leakage to the Leederville aquifer where the aquifers are hydraulically connected. Annual rainfall was taken as 800 mm for subareas south of Warbrook Road and 700 mm for subareas north of Warbrook Road.

East of the Darling Fault, no allocation limit has been set and a 'take-what-you-can-get' policy applies. Here, the superficial aquifer is thin and generally low-yielding, and groundwater abstraction will have little regional impact.

## 6.2 Mirrabooka aquifer

The Mirrabooka aquifer is in hydraulic continuity with the overlying superficial aquifer, and occurs in parts

**Table 4. Groundwater allocation for the superficial aquifer in the Swan Groundwater Area (million kilolitres per annum)**

| Subarea       | Total Area (km <sup>2</sup> ) | Area of Mostly          |                         | Allocation Limit | Current Allocation | Unallocated Resource | Salinity mg/L TDS |
|---------------|-------------------------------|-------------------------|-------------------------|------------------|--------------------|----------------------|-------------------|
|               |                               | Sand (km <sup>2</sup> ) | Clay (km <sup>2</sup> ) |                  |                    |                      |                   |
| North Swan    | 45                            | 22.5                    | 22.5                    | 3.3*             | 3.1                | 0.2                  | <500              |
| South Swan    | 46                            |                         | 45.7                    | 4.3*             | 4.0                | 0.3                  | 500-1000          |
| Central Swan  | 21                            |                         | 21.0                    | 1.9              | 1.7                | 0.2                  | 500-1000          |
| East Swan     | 32                            |                         |                         |                  | 0.8                | No limit             | >1000             |
| Neaves        | 24                            | 24.0                    |                         | 3.8              | 3.2                | 0.6                  | <500              |
| Radar         | 44                            | 14.0                    | 30.0                    | 3.4              | 1.4                | 2.1                  | <500              |
| Cockman Bluff | 33                            |                         | 33.0                    | 1.9              | 0.7                | 1.2                  | <500              |
| Bandy Spring  | 26                            |                         |                         |                  | 0.3                | No limit             | >1000             |
| <b>Total</b>  | <b>271</b>                    | <b>61.5</b>             | <b>209.5</b>            | <b>18.6</b>      | <b>14.1**</b>      | <b>4.6</b>           |                   |

\* set by computer modelling to protect environmentally significant wetlands.

\*\* total, excluding East Swan and Bandy Spring Subareas.



**Table 5. Groundwater allocation for the Mirrabooka aquifer in the Swan Groundwater Area (million kilolitres per annum)**

| Subarea       | Total Area | Annual Groundwater Recharge | Allocation Limit | Current Allocation | Unallocated Resource | Salinity mg/L TDS |
|---------------|------------|-----------------------------|------------------|--------------------|----------------------|-------------------|
| North Swan    | 18         | 0.5                         | 0.3*             | 0.2                | 0.1                  | <500              |
| South Swan    | 46         | 2.0                         | 1.6*             | 1.2                | 0.4                  | <500              |
| Central Swan  | 21         |                             | No aquifer       |                    |                      |                   |
| East Swan     | 32         |                             | No aquifer       |                    |                      |                   |
| Neaves        | 24         | 0.5                         | 0.5              | 0                  | 0.5                  | -                 |
| Radar         | 44         | 1.2                         | 1.2              | 0.1                | 1.1                  | <500              |
| Cockman Bluff | 33         |                             | No aquifer       |                    |                      |                   |
| Bandy Spring  | 26         |                             | No aquifer       |                    |                      |                   |
| <b>Total</b>  | <b>271</b> | <b>4.2</b>                  | <b>3.6</b>       | <b>1.5</b>         | <b>2.1</b>           |                   |

\* set by computer modelling to protect environmentally significant wetlands.

**Table 6. Groundwater allocation for the Leederville aquifer in the Swan Groundwater Area (million kilolitres per annum)**

| Subarea       | Allocation Limit | Current Allocation | Unallocated Resource | Salinity mg/L TDS   |
|---------------|------------------|--------------------|----------------------|---------------------|
| North Swan    | 1.6#             | 1.6                | 0.0                  | Variable with depth |
| South Swan    | 2.5#             | 2.5                | 0.0                  |                     |
| Central Swan  | 0.8              | 0.4                | 0.4                  |                     |
| East Swan     | No limit         | 0.6                | Small                |                     |
| Neaves        | 0.0#             | 0.0                | 0.0                  |                     |
| Radar         | 0.2#             | 0.2                | 0.0                  |                     |
| Cockman Bluff | 0.3#             | 0.3                | 0.0                  |                     |
| Bandy Spring  | No limit         | 0.1                | Small                |                     |
| <b>Total</b>  | <b>5.4</b>       | <b>5.0+</b>        | <b>0.4</b>           |                     |

# limit set to current abstraction- i.e. no further allocation permitted.

+ total not including East Swan and Bandy Spring Subareas.



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of the North Swan, South Swan, Neaves and Radar Subareas (Fig. 8). The upper unconfined part of the aquifer is recharged by downward leakage from the superficial aquifer. However, discontinuous layers of clay within the aquifer may result in it being semi-confined, and upward potentiometric levels may develop, causing groundwater discharge to the superficial aquifer in some areas.

Where groundwater modelling has shown that there is still potential to allocate additional groundwater from the Mirrabooka aquifer, a leakage component of 4% net rainfall recharge has been applied.

The total allocation limit for the groundwater resources of the Mirrabooka aquifer in the Perth region is about 11 million kL/a (Davidson 1992). It is estimated that half of this resource (5.5 million kL/a) flows to the eastern side of the Gnangara Mound. Of this, about 1.9 million kL/a is abstracted from the Mirrabooka aquifer by the Water Corporation in the Mirrabooka Groundwater Area to the west. The remaining 3.6 million kL/a is available for allocation in the Swan Groundwater Area.

### 6.3 Leederville aquifer

Wells in the Leederville aquifer are usually higher yielding and less vulnerable to contamination from surface sources than those in the superficial aquifer. The Leederville aquifer is therefore preferred by a large number of users.

Annual rainfall recharge north of the Swan River is estimated at 23 million kL/a (Davidson 1995). However, about 37 million kL/a is currently abstracted north of the Swan River. Of this, some 5.7 million kL/a (15%) is being abstracted from the Leederville aquifer in the Swan Groundwater Area. Declining potentiometric levels in monitoring wells confirm that the aquifer is overallocated, with little potential for additional groundwater allocation. The allocation limits for subareas where the potentiometric level is

declining have been set at the current allocated amount, with no additional allocation permitted.

In the Swan Groundwater Area, the potentiometric level is declining in all subareas except East Swan, Bandy Spring, and Central Swan.

Groundwater abstraction from the Leederville aquifer is permitted in East Swan and Bandy Spring Subareas because potentiometric levels are not declining and the aquifer is thin and generally low-yielding. In addition, abstraction will have little effect on the water levels on a regional scale because the subareas are east of the Darling Fault. The potentiometric level is also not declining in the Central Swan Subarea where the Leederville aquifer is unconfined. Additional groundwater abstraction from the Leederville aquifer is therefore also permitted from the Central Swan Subarea.

It is fortuitous that some water is available from the Leederville aquifer in the Central Swan Subarea, as the superficial aquifer is nearly totally allocated and the subarea is in the Swan Valley Planning Area B (*Swan Valley Planning Act*) (Fig. 3), where expansion of the horticulture/viticulture industry is encouraged.

### 6.4 Yarragadee aquifer

Although there is no known abstraction from the Yarragadee aquifer in the Swan Groundwater Area, elsewhere in the northern Perth region, abstraction from this aquifer is about twice the estimated annual recharge (approximately 12 million kL/a). Consequently, as reflected in monitoring wells in the Yarragadee aquifer in the Swan Groundwater Area, the potentiometric level is declining at rates of about 0.3 m/year (Davidson 1995).

Due to the regional trend of declining potentiometric levels of the Yarragadee aquifer, abstraction from this aquifer in the Swan Groundwater Area is not generally permitted.



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# 7. Groundwater use

## 7.1 Private abstraction

The total allocation limit for all aquifers combined in the Swan Groundwater Area is approximately 27.6 million kL/a. Of this total, 67% is from the superficial aquifer, 13% from the Mirrabooka aquifer and the remaining 20% from the Leederville aquifer.

Discounting subareas east of the Darling Fault where no allocation limit applies (East Swan and Bandy Spring subareas), some 20.6 million kL/a or 75% of the total allocation limit has been licensed.

Groundwater abstraction is heavily concentrated in the North and South Subareas (Table 7). These two subareas account for 56% of the total groundwater drawn; however, they only cover about one-third of the total groundwater area.

Table 8 gives statistics for a number of activities utilising groundwater in the Swan Groundwater Area. In keeping with the dominantly rural setting, about 76% of all licensed groundwater abstraction is for irrigated agriculture (pasture/lucerne/turf 32%, vegetables/fruit/flowers 24%, viticulture 20%). The only other major category of use is for tourism/recreation, which accounts for about 18% of all abstraction.

Of the activities described above, viticulture has the lowest water usage per hectare, using an average of approximately 4150 kilolitres of groundwater per hectare of irrigation. Irrigation for tourism and recreation, which are also preferred landuse activities in the Swan Valley Planning Area, utilises more than twice the volume of groundwater per hectare than viticulture.

When comparing activities listed in Table 8 between subareas, it is apparent that:

- Pasture/lucerne/turf besides concentrated use in North and South Swan subareas, the remaining irrigation is evenly distributed over most of the other subareas;

- Vegetables/fruit/flowers 40% of all irrigation exists in the Neaves subarea;
- viticulture 75% of all irrigation exists in the South Swan Subarea; and
- Tourism/recreation nearly 50% of irrigation exists in the North Swan Subarea, largely utilised by the Vines Country Club.

From the total amount of groundwater currently allocated to each individual subarea, Table 9 shows how the water is distributed between different activities within each. Observations include:

- For the Cockman Bluff, East Swan, and Bandy Spring Subareas, about 60% or more of all groundwater allocated is for pasture/lucerne/turf;
- In the Central Swan Subarea, groundwater is allocated fairly evenly for irrigated agriculture (the first three activities) plus tourism/recreation;
- Less than 1% of groundwater is allocated to viticulture within the Neaves and Radar Subareas;
- Nearly half of all irrigation in the South Swan subarea is for Viticulture; and
- Most groundwater in the North Swan Subarea is allocated to just a few licences abstracting large amounts of groundwater for tourism/recreation and pasture/lucerne/turf activities.

Currently, most domestic and stock usage is licensed south of Warbrook Road (in the 'old' Swan Groundwater Area). It will not be necessary to renew these licences in the future because most domestic and stock groundwater usage will be exempt from licensing over the entire Swan Groundwater Area (Chapter 9.3). This will save the significant administrative costs involved in processing a large number of applications for very small groundwater allocations. In future, information on the amount of domestic groundwater usage from the unlicensed wells may be obtained by a well survey.





**Table 7. Summary of current groundwater usage from aquifers in subareas of the Swan Groundwater Area (million kilolitres per annum)**

| Subarea       | Superficial  | Mirrabooka | Leederville | Total        | %  |
|---------------|--------------|------------|-------------|--------------|----|
| Bandy Spring  | (0.3)        | n/a        | (0.1)       | (0.4)        | 2  |
| Cockman Bluff | 0.7          | n/a        | 0.3         | 1.0          | 4  |
| Central Swan  | 1.7          | n/a        | 0.4         | 2.1          | 10 |
| East Swan     | (0.7)        | n/a        | (0.6)       | (1.3)        | 6  |
| Neaves        | 3.2          | 0.0        | 0.0         | 3.2          | 14 |
| North Swan    | 3.1          | 0.2        | 1.6         | 4.9          | 22 |
| Radar         | 1.4          | 0.1        | 0.2         | 1.7          | 8  |
| South Swan    | 4.0          | 1.2        | 2.5         | 7.7          | 34 |
| <b>TOTAL</b>  | <b>14.1+</b> | <b>1.5</b> | <b>5.0+</b> | <b>20.6+</b> |    |

+ total not including East Swan and Bandy Spring Subareas.

**Table 8. Licensed groundwater usage statistics for various activities in the Swan Groundwater Area**

| Activity                 | Number of Licenses | Hectares Irrigated | Allocation (million kilolitres per annum) | Allocation (%) |
|--------------------------|--------------------|--------------------|-------------------------------------------|----------------|
| Pasture/Lucerne/Turf     | 323                | 759                | 6.8                                       | 32             |
| Vegetables/Fruit/Flowers | 413                | 537                | 5.2                                       | 24             |
| Viticulture              | 350                | 1061               | 4.4                                       | 20             |
| Tourism/Recreation*      | 1054               | 424                | 3.9                                       | 18             |
| Animals                  | 310                | 2                  | 0.7                                       | 3              |
| Other+                   | 413                | 52                 | 0.6                                       | 3              |
| <b>TOTAL#</b>            | <b>2863</b>        | <b>2835</b>        | <b>21.6</b>                               | <b>100</b>     |

\* includes garden usage.

+ includes industry/domestic/domestic garden usage.

# includes Bandy Spring and East Swan Subareas.

**Table 9. Per cent usage for various activities from licensed groundwater allocations within subareas of the Swan Groundwater Area**

| Subarea       | Pasture<br>Lucerne<br>Turf | Vegetable<br>Fruit<br>Flowers | Viticulture | Tourism | Animals | Other | Total (%) |
|---------------|----------------------------|-------------------------------|-------------|---------|---------|-------|-----------|
| Bandy Spring  | 68                         | 15                            | 0           | 12      | 0       | 5     | 100       |
| Cockman Bluff | 61                         | 19                            | 2           | 13      | 4       | 1     | 100       |
| Central Swan  | 25                         | 29                            | 20          | 18      | 6       | 2     | 100       |
| East Swan     | 59                         | 10                            | 13          | 12      | 3       | 3     | 100       |
| Neaves        | 26                         | 67                            | 0           | 4       | 3       | 0     | 100       |
| North Swan    | 34                         | 11                            | 11          | 38      | 3       | 3     | 100       |
| Radar         | 42                         | 17                            | 0           | 20      | 10      | 11    | 100       |
| South Swan    | 20                         | 18                            | 45          | 12      | 1       | 4     | 100       |



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Rural activities (e.g. horticulture) displaced by urban expansion along the North-West Corridor (City of Wanneroo) may relocate to parts of the Swan Groundwater Area. Radar and Cockman Bluff Subareas have the best potential to support these activities, as they have the largest volume of unallocated groundwater. However, developments may experience environmental constraints within the Ellen Brook Catchment.

## **7.2 Public water supply**

There are no public water supply wellfields in the Swan Groundwater Area. However, the area south of Warbrook Road is serviced by the reticulated water supply scheme from Water Corporation wellfields and dams located outside the Groundwater Area. North of Warbrook Road, a water main located along the Great

Northern Highway supplies water to Bullsbrook East townsite and a number of properties which are located along the pipeline.

The nearest Water Corporation wellfield, the Mirrabooka Groundwater Scheme, is located to the west of the Swan Groundwater Area (Fig. 2). The proposed Lexia Scheme, which in the future may service the Ellenbrook urban area, will also be located outside the Swan Groundwater Area. It is likely that the Lexia Scheme will also contribute to the water supply of other proposed urban developments in the North-East Corridor. These developments may also be serviced by a proposed smaller Bullsbrook Groundwater Scheme which may be located north of Warbrook Road in the Swan Groundwater Area. Currently, this proposed scheme is not well defined.



## 8. Groundwater licensing process

### 8.1 Application for a groundwater licence

The process of issuing a groundwater well licence begins when an application on a prescribed form is received at a Water and Rivers Commission office. Such an application is required under the following circumstances:

- the well is defined as artesian under the *Rights in Water and Irrigation Act*; and
- the property on which the non-artesian well is to be situated is within a Groundwater Area proclaimed under the *Rights in Water and Irrigation Act*.

In either of the above circumstances, an applicant must gain approval, in the form of a groundwater well licence, to start to construct, enlarge, deepen, alter or draw water from any artesian or non-artesian well.

A person in breach of these requirements is liable to a fine.

There are circumstances where some groundwater usage is exempted from the provisions of licensing from non-artesian (unconfined) aquifers in specified Groundwater Areas proclaimed under the *Rights in Water and Irrigation Act* (Chapter 9.3).

### 8.2 The approval process

Applications for a groundwater well licence in the the Groundwater Area are made to the Swan Regional Office of the Water and Rivers Commission. In many cases, the Regional Office can directly approve and issue a groundwater well licence if the licence conforms to appropriate policies given in the Swan Groundwater Area Allocation Plan (1997). However, before a groundwater licence is issued, all other necessary planning (e.g. Swan Shire) and environmental (e.g. Department of Environmental Protection) approvals must have been granted. It is the licensee's responsibility to ensure all necessary approvals have been granted.

In addition, the applicant may be required to submit to the Water and Rivers Commission either a copy of the Certificate of Title or a copy of a Lease Agreement for the property where the development is to occur.

A Letter of Intent may be issued by the Water and Rivers Commission to a groundwater licence applicant, before granting all other necessary approvals, if the proposed abstraction complies with policies in the Swan Groundwater Area Allocation Plan (1997). This letter does not authorise the applicant to proceed with abstraction of groundwater, but rather gives an assurance that a groundwater well licence will be forthcoming if all other necessary approvals from authorities are granted.

If an applicant is refused a groundwater well licence following the assessment procedure, or objects to a licence condition imposed by the Water and Rivers Commission, the applicant can within 30 days of notification of refusal, or the imposing of conditions, appeal to the Minister for Water Resources. The Minister is then required to direct an inquiry into the matter. A three-person inquiry panel, having heard all the evidence, makes a recommendation to the Minister. The Minister is not obliged to follow the recommendation. There can be no further appeal by either party. *However, in all circumstances the appeal is discussed informally with the applicant to attempt a solution that would avoid a formal appeal and inquiry.*

### 8.3 Swan Groundwater Advisory Committee

Groundwater Advisory Committees are constituted (*Water and Rivers Commission Act 1995*) to assist with the administration of groundwater licensing in critical management areas. These committees consider licence applications and advise the Water and Rivers Commission on water allocations, issuing of licences and associated conditions.

The committees consist of government officers from departments relevant to the management considerations in individual control areas, and private individuals



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representing local landholders and interested groups. A senior Water and Rivers Commission officer is appointed by the Board to chair the committee.

The Swan Groundwater Advisory Committee was formed in 1982. The main role of the committee is to advise on policy and groundwater allocation issues in the Swan Groundwater Area.

Issues considered essential for a groundwater allocation plan in general, and of particular importance to the Swan Valley, were identified at a special Swan Groundwater Advisory Committee meeting (workshop) on 26 August 1994. These issues are listed in Appendix 1, and to a large extent have been incorporated into this allocation plan. The workshop recommended that, while the composition of the Swan Groundwater Advisory Committee changes periodically, it should generally consist of:

- environmental representation (e.g. Shire environmental officer);
- community representation, to ensure local knowledge is considered;
- persons with specific expertise in agriculture (including horticulture); and
- direct representation from the local area and industry, e.g. grape growers, agistment vested interest groups (e.g. tourism).

The workshop recommended that a representative of the Swan Valley Planning Committee be a non-voting

member of the Advisory Committee. It was also considered advantageous to have a member of the Advisory Committee present at the Planning Committee meetings. This allocation plan supports these recommendations and advises they be implemented as soon as possible.

## 8.4 Water Resource Allocation Committee

The Water Resource Allocation Committee (WRAC) is a committee of the Water and Rivers Commission, constituted under the *Water and Rivers Commission Act*. It consists of: the Director of Policy and Planning and the Director of Regional Services at the Water and Rivers Commission, and the Deputy Chairman of the Water and Rivers Commission Board.

The water resource functions of the committee are:

- to guide the Water and Rivers Commission, through the Director of Policy and Planning Division, on the development of its policies and operations in relation to the allocation and management of the use of water resources across the State, and
- consider surface water diversion and groundwater abstraction licence applications that the Water and Rivers Commission proposes to refuse, and recommend refusal or other appropriate action to the Board of the Water and Rivers Commission.

WRAC reviews groundwater allocation plans and, following approval, forwards them to the Board of the Water and Rivers Commission for endorsement.



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# 9. General allocation guidelines and policies

The general groundwater allocation guidelines and policies that apply to the Swan Groundwater Area are discussed in this chapter, and the specific policies pertaining to the subareas are discussed in Chapter 10.

Guidelines and policies are divided into five sections:

1. Groundwater allocation.
2. Licensing conditions.
3. Domestic groundwater use.
4. Environmental protection.
5. Landuse.

Each policy has a policy number which can be referred to in correspondence relating to it. The policy number is prefixed with the letters *SWA*, identifying it with the Swan Groundwater Area, e.g. *SWA-1*, *SWA-2*.

Policies stated in subarea Factsheets follow the same format except they include the letter 's' to identify them as a subarea policy, e.g. *SWA-1s*.

Future amendment to a policy should be suffixed with a letter *a,b,c*, ... e.g. *SWA-1* to *SWA-1/a*, *SWA-1s* to *SWA-1s/a*.

Texts not identified with a policy number are groundwater allocation guidelines and represent advice on allocation issues.

Groundwater allocation policies and guidelines for a groundwater area may change with time. A list of any amendments to allocation policies and guidelines stated in Chapters 9 and 10 of the Swan Groundwater Area Allocation Plan can be obtained from the Water and Rivers Commission, Swan Regional Office.

## 9.1 Groundwater allocation

### 9.1.1 Issue of groundwater well licences

- *SWA-1*

*In accordance with the Swan Groundwater Advisory Committee Recommendation No. 70/94, the Water and Rivers Commission may issue groundwater licences without referral to the Swan Groundwater Advisory Committee when they comply with current allocation plan policies, and development approvals from the relevant State and Local Government departments have been obtained by the licensee.*

Issues to be referred to the Swan Groundwater Advisory Committee should deal mainly with matters of groundwater allocation policy in the Swan Groundwater Area.

- *SWA-2*

*The Swan Regional Office of the Water and Rivers Commission can directly approve and issue a groundwater well licence if it conforms to the appropriate policies given in the Swan Groundwater Area Allocation Plan 1997.*

- *SWA-3*

*Before a groundwater licence is issued, all other necessary development and environmental approvals must have been granted. In addition, the applicant may be required to submit to the Water and Rivers Commission either a copy of the Certificate of Title or a copy of a Lease Agreement for the property where the development is to occur. It is the licensee's responsibility to ensure all necessary approvals have been granted.*



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A Letter of Intent may be issued by the Water and Rivers Commission to a groundwater licence applicant prior to granting of all other necessary approvals, if the proposed groundwater abstraction complies with policies in the Swan Groundwater Area Allocation Plan. This letter does not authorise the applicant to proceed with obtaining groundwater, but gives an assurance that a groundwater well licence will be forthcoming if all other necessary approvals from authorities are granted.

- *SWA-4*

*All new groundwater well licences will be issued for a two-year period. Following this period, providing the licensee has met licence conditions, including satisfactory progress with development, the licence may be renewed for a period up to a maximum of 10 years.*

### 9.1.2 Priority use of groundwater

A number of environmentally significant wetlands, including those identified in the East Gngangara Environmental Water Provisions Plan (WRC, draft), are found in the Swan Groundwater Area. Some of these wetlands have statutory protection (Section 3.4). Policies on groundwater allocation have been developed to protect the ecosystems of environmentally important wetlands.

The Swan Valley has been identified as a major area for horticultural/viticultural pursuits. Local statutory protection for these pursuits is provided by the *Swan Valley Planning Act*. Groundwater allocation policies should support the priority uses identified for this area.

To meet the demands of the general community, the availability of groundwater for community use (e.g. schools, playing fields) is normally given a higher priority than for private uses. Exceptions may include private use for horticulture/viticulture in areas of the *Swan Valley Planning Act* and where there will be a large economic benefit (e.g. employment) to the region.

- *SWA-5*

*The order of 'priority beneficial use' for groundwater in the Swan Groundwater Area is:*

(1) *environment;*

- (2) *uses identified under the Swan Valley Planning Act for subareas that occur in the Swan Valley Planning Area; and*
- (3) *community and private use.*

### 9.1.3 Aquifers

The Swan Groundwater Area has four aquifers. General policies, listed below, have been developed for these aquifers that apply throughout the Groundwater Area. Policies specific to subareas are listed in Chapter 10.

#### Superficial aquifer

The superficial aquifer west of the Swan River and Ellen Brook forms part of the Gngangara Mound groundwater flow-system and represents a large groundwater resource. East of the Swan River and Ellen Brook, the aquifer is a part of the Swan-Helena groundwater flow-system, is generally thinner and contains less groundwater for allocation.

The superficial aquifer has the largest replenishable groundwater resource in the Groundwater Area. It is recharged directly by rainfall. Preference should be given to allocating groundwater from this rather than from the deeper aquifers. Greater infiltration, and thus recharge, can be induced by lowering the watertable by increasing abstraction. This must, however, be managed.

It is also recognised that, particularly in the North and South Swan Subareas, groundwater allocation from the superficial and Mirrabooka aquifers should be managed to protect the wetlands in a manner that addresses the water level maintenance criteria proposed in the East Gngangara Environmental Water Provisions Plan.

- *SWA-6*

*Groundwater will be allocated from the superficial aquifer in preference to the deeper aquifers if available, environmentally acceptable and of suitable quality.*

#### Mirrabooka aquifer

The Mirrabooka aquifer, present in part of the Swan Groundwater Area, has limited available groundwater resources, but these areas of low salinity. Additional abstraction from this aquifer should be limited (South Swan Subarea, SWA-6s). Only those developments that require low salinity groundwater should be directed to utilise this resource.



### **Leederville aquifer**

The Leederville aquifer is fully allocated in subareas where it occurs as a confined aquifer. In these areas and to the west of the Swan Groundwater Area, abstraction has resulted in declining potentiometric levels. However, these levels are not declining in areas adjacent to the Darling Fault where the aquifer is semi-confined, or in its upper part, where it is unconfined. In some of these areas, additional groundwater may be allocated if proponents can demonstrate that the water in the overlying superficial aquifer is unsuitable for use (SWA-3s).

The Swan Regional Office of the Water and Rivers Commission should keep the Water Allocation Branch informed of groundwater licences issued from the Leederville aquifer in Central Swan, East Swan and Bandy Spring Subareas.

### **Yarragadee aquifer**

Because the Yarragadee aquifer is deep and contains brackish groundwater, demand for abstraction is likely to remain small. Allocation will be considered on a case-by-case basis.

- *SWA-7*  
Any proposed abstraction from the Yarragadee aquifer should be referred to the Water Allocation Branch of the Water and Rivers Commission for assessment.

### **9.1.4 Reallocation of groundwater**

The shifting of the subarea boundaries and the re-assessment of the groundwater resources in the Swan Groundwater Area has increased availability in some areas. Applications for a groundwater well licence that were previously refused on the basis of insufficient groundwater availability may now be reconsidered.

An application for a groundwater licence will only be reconsidered for a project that is in the same context of the original application and in keeping with current planning policy (e.g. *the Swan Valley Planning Act*). Preference will be given to applicants who require groundwater for improving the economic viability of existing projects (e.g. expanding) rather than those establishing new projects.

### **9.1.5 Areas east of the Darling Fault**

The Swan Groundwater Area includes some areas east of the Darling Fault where sediments are thin and groundwater availability is small. In the Bandy Springs and East Swan subareas, no allocation limits have been set and most groundwater applications will be granted with an allocation linked to the requirements of the project. However, existing allocations must be considered before issuing new licences, to limit possible interference due to pumping. Environmental constraints may also affect allocations in some areas.

### **9.1.6 Allocation limits**

Groundwater is allocated to ensure long-term sustainability of the groundwater resources for existing users, in terms of both quality and quantity.

- *SWA-8*  
Groundwater allocation totals for aquifers in respective subareas of the Swan Groundwater Area should not exceed the Total Allocation Limit for each subarea.

When the groundwater resources of a subarea become 90% allocated, additional allocation should be generally directed to improve the economic viability of existing projects. Where possible, proponents of new projects, requiring large groundwater supplies should be discouraged from locating in such subareas, and encouraged to establish the projects where greater resources are available.

## **9.2 Licensing conditions**

A number of conditions are normally applied to a groundwater well licence. These can be of a general nature, or specific to a particular licence. Licensing conditions specific to subareas are listed in the Fact Sheets (Chapter 10). The following condition applies to all licences :

- *SWA-9*  
All licences shall stipulate an annual groundwater allocation, including those in subareas where there is no Total Allocation Limit (i.e. a 'take-what-you-can-get' policy applies).



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### 9.2.1 Cement grouting

When a well is drilled through the superficial aquifer into the underlying aquifer, inter-aquifer groundwater flow may occur, resulting in a deterioration of groundwater quality. These wells should be cement grouted, at the owner's expense (see *SWA-5s*), to prevent the intermixing of groundwater from the aquifers. Grouting also assists in stabilising the well and increasing its life by reducing casing corrosion.

East of the Darling Fault, cement grouting is not required because it is difficult to distinguish the contact between the superficial and Leederville aquifers, which are hydraulically connected.

Construction of a well requiring cement grouting (i.e. in the Mirrabooka and Leederville aquifers) must be done by an individual who holds a Class 2 Water Well Driller's Certificate issued by the Western Australian Branch of the Australian Drilling Industry Association (ADIA 1996).

Collapsed and abandoned wells require 'sealing off' to prevent potential future aquifer contamination. In all cases, it is preferable to seal the well with cement poured down the well casing. Local soil materials may not satisfactorily seal the well because of upwards potentiometric levels in some areas of the Swan Groundwater Area.

- *SWA-10*  
*The casing of collapsed or abandoned wells must be sealed, at the owners expense, in a manner satisfactory to the Water and Rivers Commission.*

### 9.2.2 Hydrogeological assessment

In locations with limited hydrogeological data, applicants requiring large quantities of water may be asked to carry out hydrogeological assessments, including groundwater monitoring, to investigate the sustainability of available resources.

- *SWA-11*  
*In support of a groundwater well licence application, proponents of proposals to abstract groundwater may be required to submit to the Water and Rivers Commission a report assessing the possible local and regional impacts of such abstraction on the*

*hydrology, the environment and other groundwater users. This report is to be completed by a professional in the field of hydrogeology, employed at the applicant's expense.*

Typically, these reports are required for proposed projects requiring equal to or greater than 500,000 kL/a of groundwater. However, they may be required for projects requiring lesser amounts, particularly in environmentally sensitive areas.

### 9.2.3 Metering

A metering policy has been adopted throughout the State for large groundwater users.

- *SWA-12*  
*Groundwater allocations equal-to or greater than 500 000 kL/a require the metering of groundwater abstraction as a condition of license. Meters are installed and maintained at the licensee's expense. The abstraction volume is reported periodically to the Water and Rivers Commission.*

In some cases, the Commission may direct licensees to install meters where allocations are less than 500,000 kL/a.

### 9.2.4 Water-use efficiency

Groundwater is a basic requirement for many developments in the Swan Groundwater Area. There is already a large amount of groundwater abstraction in a number of subareas, of which some have limited potential for additional allocation.

Existing and potential applicants for groundwater licences should be made aware that groundwater is an important resource and should be used efficiently. Those planning to use large volumes of groundwater may be required to demonstrate that water conservation methods have been considered and will be implemented where possible.

While it is possible to 'gain back' some allocated groundwater by improved irrigation efficiency, this potential is not believed to be large in the Swan Groundwater Area, as most irrigators are already using efficient irrigation systems.

Use of higher salinity groundwater should be considered for projects that do not require low salinity water.





- *SWA-13*  
Groundwater should be used efficiently, utilising appropriate best practice techniques of the irrigation industry.

Advice can be sought from Agriculture WA and the Irrigation Association of Australia.

### 9.3 Domestic groundwater use

There have been different policies concerning the exemption from licensing of wells abstracting groundwater for domestic and stock purposes in the 'old' Swan and Bullsbrook Groundwater Areas. Generally, south of Warbrook Road in the 'old' Swan Groundwater Area, all domestic and stock wells were licensed. North of Warbrook Road in the former Bullsbrook Groundwater Area, groundwater abstraction from the superficial aquifer for domestic and stock use was exempt from licensing.

The new uniform policy for the whole of the Swan Groundwater Area is:

- *SWA-14*  
Groundwater abstraction is generally exempt from licensing where abstraction is for domestic or stock purposes and from the superficial aquifer, and abstraction is less than or equal to 1 500 kL/a.

## 9.4 Environmental Protection

### 9.4.1 Wetlands

Most wetlands in the Swan Groundwater Area are hydraulically connected to the watertable, and groundwater abstraction can affect the water level in the wetlands (refer to Chapter 3.4).

- *SWA-15*  
Groundwater will be managed in the Swan Groundwater Area, recognising statutory environmental protection criteria, including :
  - (1) *Bushplan Reserves (previously termed System 6 Reserves)*
  - (2) *EPP Lakes; and*
  - (3) *water level maintenance criteria (when legislated) for wetlands within and adjacent to*

*the Swan Groundwater Area as identified in the East Gngangara Environmental Water Provisions Plan.*

- *SWA-16*

*An application for a groundwater well licence should be referred to the Water Allocation Branch of the Water and Rivers Commission for assessment if:*

- (1) *exceeding 1 500 kL/a within 500 m of; or*
- (2) *greater than 15 000 kL/a within 1 km of:*
  - *Bushplan Reserves (previously termed System 6 Reserves)*
  - *EPP Lakes*
  - *wetlands identified in the East Gngangara Environmental Water Provisions Plan*
  - *Conservation Category Wetlands.*

Appendix 2 shows the location of these wetlands.

### 9.4.2 Ellen Brook catchment

Existing and future landuse activities in the Ellen Brook catchment (Fig. 3) must be aimed at reducing nutrient runoff to Ellen Brook, Henley Brook, and the Swan River.

There are no statutory policies relating to the preferred development in the Ellen Brook catchment. However, preference will be given to projects that demonstrate minimal nutrient export from the development site. It is the responsibility of the developer to provide the necessary data to demonstrate this condition.

The Department of Environmental Protection (DEP) has, under Section 38 of the *Environmental Protection Act*, directed the Water and Rivers Commission to refer all new agricultural proposals within the Ellen Brook catchment to the DEP for their assessment. The DEP will review each proposal on a case-by-case basis and determine if the proposal warrants more detailed environmental impact assessment. The assessment of these proposals will ensure that potential environmental impacts on Ellen Brook and the Swan River, due to nutrient export, are minimised. The Swan Groundwater Area Allocation Plan policy on agricultural proposals within the Ellen Brook catchment reflects this directive from the DEP (Chapter 10 *SWA-2s*).



Appendix 4 contains the Horticultural Development Application Form required by the DEP for assessment of proposed agricultural projects in the Ellen Brook catchment. This form is also used by the Water and Rivers Commission to assess applications in other environmentally sensitive areas.

## 9.5 Landuse

### 9.5.1 Swan Valley Planning Area

Groundwater in the Swan Valley Planning Area (Fig. 3) should be allocated in accordance with the *Swan Valley Planning Act*.

This is particularly important if the proposal is located in Area B (Fig. 3) of the Swan Valley Planning Area. Item 2 of the Planning Objectives for Area B (page 8 of the Act) states that:

‘The planning objective for any proposed development in Area B ...*(is) the provision of (ground)water for viticulture and horticulture and the discouragement of other activities that have high water demands*’.

Therefore, the Water and Rivers Commission as manager of the water resources of the State, has a direct

responsibility to enforce the planning objectives in Area B, as defined by the *Swan Valley Planning Act*.

A general guideline of acceptable new activities in Area B is presented in a proposed list of high, medium and low priority uses as follows:

| High Priority               | Medium Priority | Low Priority               |
|-----------------------------|-----------------|----------------------------|
| Viticulture                 | Market garden   | Golf course                |
| Tourism                     | Plant nursery   | Turf farm                  |
| Equine pursuits             | Pasture         | Industry                   |
| Livestock                   | Recreation      | Poultry/piggery production |
| Orchard                     |                 |                            |
| Special Rural Zone activity |                 |                            |
| Clay brick                  |                 |                            |
| Priority                    |                 |                            |
| Resource area               |                 |                            |

*Note: descending lists not in order of priority*

### 9.5.2 Special Rural Zones

Special Rural Zones do not have a pre-set limit to groundwater abstraction. Applications for groundwater use on Special Rural Zones are treated in the same manner as other types of landuse. If groundwater is available for the proposed allocation in a subarea and the project is consistent with the zoning, then the application for groundwater use can be considered.



# 10. Management by subareas (Subarea Fact Sheets)

## Bandy Springs Subarea Fact Sheet

### Description

Area: 26.33 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Ridge Hill Shelf Unit of the Swan Coastal Plain along foothills of Darling Scarp. Crystalline rocks of the Darling Plateau in the southeast. Subarea is east of Darling Fault and in Ellen Brook Catchment. Groundwater supplies small. 'Take-what-you-can-get' policy applies to the superficial and Leederville aquifers.

### General Hydrogeology

Superficial Aquifer: Groundwater supplies are site-specific, occurring in perched aquifers, colluvial material, saprolite and fracture zones in bedrock. Yields likely to be small. Groundwater salinity may be marginal to brackish.  
 Mirrabooka Aquifer: Not present.  
 Leederville Aquifer: Extends east of the fault several kilometres, outcropping in places. Aquifer thin and yield likely to be small.

### Groundwater Resources

Volume Groundwater in Million Kilolitres per Annum

| Aquifer                | Superficial | Mirrabooka | Leederville        |
|------------------------|-------------|------------|--------------------|
| Groundwater Quality    | Marginal    |            | No monitoring data |
| Total Allocation Limit | No Limit*   |            | No Limit*          |
| Current Allocations    | 0.3         |            | 0.1                |
| Unallocated Resources  | Small*      |            | Small*             |

\* 'take-what-you-can-get' policy applies.

### Summary of Groundwater Monitoring Data

| Aquifer     | Wells | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|-------|-------------------------------------------------|-----------------------|
| Superficial | EE8a+ | 93.2-96.0                                       | 2659                  |
|             | EE8b+ | 98.4-101.1                                      | No monitoring data    |
| Mirrabooka  | None  |                                                 |                       |
| Leederville | None  |                                                 |                       |

+ disused wells.



## **Bandy Springs Subarea Fact Sheet (cont.)**

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea

- *SWA-1s*  
*A 'take-what-you-can-get' policy applies to groundwater allocation from the superficial and (limited) Leederville aquifers subject to environmental constraints and avoiding interference with neighbouring supply.*
- *SWA-2s*  
*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection.*
- *SWA-3s*  
*Groundwater may be allocated from the Leederville aquifer if a supply cannot be satisfactorily obtained from the superficial aquifer.*

### ***Recommendations***

- The 'take-what-you-can-get' policy needs triennial review and may require modification if significant mutual interference conflicts are occurring.
- In January of each year, the Swan Regional Office of the Water and Rivers Commission is to report to the Policy and Planning Division on the allocation total for all new groundwater licences in the Bandy Spring Subarea issued from the Leederville aquifer during the previous year.



## Central Swan Subarea Fact Sheet

### Description

Area: 21.26 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Swan Coastal Plain, mostly Pinjarra Plain Unit. Most of the subarea is in the Swan Valley Planning Area. Superficial aquifer often marginal quality. Additional abstraction from Leederville aquifer permitted.

### General Hydrogeology

Superficial Aquifer: May be low yielding due to Guildford Clay. Is part of the Swan-Helena Flow System flowing from east to west. The seasonal level of the watertable appears similar over time. Groundwater salinity may exceed 1 000 mg/L TDS.

Mirrabooka Aquifer: Absent

Leederville Aquifer: Flow is from east to west. Aquifer generally unconfined, with direct recharge from the superficial aquifer. The seasonal level of the potentiometric surface appears similar over time. Groundwater salinity is variable with depth, but is likely to be less than 1 1 000 mg/L at the top of the aquifer.

### Groundwater Resources

#### Volume Groundwater in Million Kilotres per Annum

| Aquifer                | Superficial | Mirrabooka     | Leederville        |
|------------------------|-------------|----------------|--------------------|
| Groundwater Quality    | Variable    | Aquifer Absent | No monitoring data |
| Total Allocation Limit | 1.9         |                | 0.8                |
| Current Allocations    | 1.7         |                | 0.4                |
| Unallocated Resources  | 0.2         |                | 0.4                |

### Summary of Groundwater Monitoring Data

| Aquifer     | Wells           | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|-----------------|-------------------------------------------------|-----------------------|
| Superficial | 2/87            | 20.1-22.5,                                      | No monitoring data    |
|             | 4/87            | 17.5-19.6                                       | No monitoring data    |
|             | Private: No. 68 | No monitoring data                              | 488                   |
|             | No. 72          | No monitoring data                              | 1102                  |
|             | Carne           | No monitoring data                              | 1163                  |
|             | Nielson         | No monitoring data                              | 697                   |
|             | Thomas          | No monitoring data                              | 745                   |
|             | Upper Swan      |                                                 |                       |
|             | Primary School  | No monitoring data                              | 880-789               |
|             | EE9+            | 11.0-14.4                                       | 264                   |
| Superficial | 5/85+           | 10.5-11.6                                       | No monitoring data    |
|             | Davies+         | No monitoring data                              | 464                   |
|             | Mirrabooka      | Aquifer Absent                                  |                       |
| Leederville | 4/85            | 5.6-7.5                                         | No monitoring data    |
|             | 6/85            | 6.0-9.6                                         | No monitoring data    |
|             | 1/87            | 18.9-21.2                                       | No monitoring data    |
|             | 3/87            | 17.4-20.9                                       | No monitoring data    |

+ disused wells.

(cont.)



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## Central Swan Subarea Fact Sheet (cont.)

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea.

- *SWA-2s*  
*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*
- *SWA-3s*  
*Groundwater may be allocated from the Leederville aquifer if a supply cannot be satisfactorily obtained from the superficial aquifer.*
- *SWA-4s*  
*The Water and Rivers Commission is to manage groundwater resources in Area B (Fig. 3) of the Swan Valley Planning Area in accordance with the Swan Valley Planning Act planning objective calling for the provision of (ground)water for viticulture and horticulture and the discouragement of other activities that have high water demands.*
- *SWA-5s*  
*Any well drilled below the bottom of the superficial aquifer must be pressure cement grouted by a Class 2 or 3 certified driller.*

### ***Recommendations***

- The recommended groundwater monitoring program (Appendix 3) includes undertaking annual groundwater salinity measurements for a number of existing superficial and Leederville aquifer monitoring wells that are currently only measured for waterlevel.
- Yearly and three-yearly salinity sampling of some private wells is recommended, including some former GSWA wells which previously had no regular monitoring schedule.
- ‘Once off’ salinity sampling of well 6/85 in the Leederville aquifer is recommended.
- In January of each year, the Swan Regional Office of the Water and Rivers Commission is to report to the Policy and Planning Division on the allocation total for all new groundwater licences in the Central Swan Subarea issued for the Leederville aquifer during the previous year.



## Cockman Bluff Subarea Fact Sheet

### Description

Area: 33.04 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Mostly Swan Coastal Plain with east and west of Brand/Great Northern Highways being Ridge Hill Shelf and Pinjarra Plain Units respectively. Small area of Dandaragan Plateau along Darling Fault in far north. Subarea contains Pearce Airbase and Bullsbrook East townsite. Ellen Brook runs along western boundary. Subarea is in Ellen Brook Catchment. Although the Leederville aquifer may be unconfined in places, no additional groundwater may be allocated from the Leederville aquifer - abundant groundwater is still available from the superficial aquifer.

### General Hydrogeology

Superficial Aquifer: Materials generally thin (colluvial materials - Ridge Hill Shelf) and low-yielding (Guildford Clay - Pinjarra Plain). Part of Swan-Helena Flow System flowing from east to west.  
 Mirrabooka Aquifer: Only present to around 1 km east of Ellen Brook.  
 Leederville Aquifer: In hydraulic connection with superficial aquifer. Leederville Formation often close to the land surface and may outcrop in places. Flow is from east to west.

### Groundwater Resources

#### Volume Groundwater in Million Kilotres per Annum

| Aquifer                | Superficial | Mirrabooka     | Leederville        |
|------------------------|-------------|----------------|--------------------|
| Groundwater Quality    | Fresh       | Aquifer Absent | No monitoring data |
| Total Allocation Limit | 1.9         |                | 0.3*               |
| Current Allocations    | 0.7         |                | 0.3                |
| Unallocated Resources  | 1.2         |                | 0.0                |

\* Allocation limit set to amount of current allocation.

### Summary of Groundwater Monitoring Data

| Aquifer     | Wells               | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|---------------------|-------------------------------------------------|-----------------------|
| Superficial | GD19                | 38.1-40.1                                       | 570                   |
|             | GD18+               | 45.1-47.1                                       | 400                   |
| Mirrabooka  | Aquifer Absent      |                                                 |                       |
| Leederville | No monitoring wells |                                                 |                       |

+ disused well.

(cont.)



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## Cockman Bluff Subarea Fact Sheet (cont.)

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea.

- *SWA-2s*

*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*

- *SWA-5s*

*Any well drilled below the bottom of the superficial aquifer must be pressure cement grouted by a Class 2 or 3 certified driller.*

- *SWA-7s*

*No groundwater is to be allocated from the Leederville aquifer for new wells in new projects. Allocation of groundwater from the Leederville aquifer for existing wells in new projects (e.g. change of property ownership, change of purpose) will be assessed on a 'case by case' basis (refer to Policy and Planning Division). No additional groundwater is to be allocated from the Leederville aquifer to wells in existing projects. Replacement wells in the Leederville aquifer are permitted for existing projects for the same allocation, provided use of the unconfined aquifers is not viable.*

### ***Recommendation***

- Construction of two new groundwater-monitoring wells in the superficial aquifer is recommended (Fig. 13) to record waterlevels and salinity variations. More monitoring data are required because (1) there is currently only one monitoring well in the Subarea (GD19), and (2) protection of the superficial aquifer is critical because it is the only aquifer with groundwater available for additional allocation in the subarea.





## East Swan Subarea Fact Sheet

### **Description**

Area: 31.52 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Swan Coastal Plain sediments - Guildford Clay to the west changing eastwards to Ridge Hill Shelf Unit along foothills of the Darling Range. Eastern boundary includes areas of crystalline rock of the Darling Plateau. Part of subarea is in Swan Valley Planning Area and Ellen Brook Catchment. Subarea is east of the Darling Fault. Groundwater supplies are small. 'Take-what-you-can-get' policy applies to the superficial and Leederville aquifers.

### **General Hydrogeology**

Superficial Aquifer: Limited yields from Guildford Clay (low permeability). Yields also small along foothills and plateau, where groundwater supplies are site-specific, occurring in colluvial material, unconsolidated lateritic materials, weathered mantle material and fracture zones in bedrock.  
 Mirrabooka Aquifer: Not present.  
 Leederville Aquifer: Extends around 1.5 km east of fault, thin and low-yielding.

### **Groundwater Resources**

#### Volume Groundwater in Million Kilotres per Annum

| Aquifer                      | Superficial   | Mirrabooka     | Leederville        |
|------------------------------|---------------|----------------|--------------------|
| Groundwater Quality          | Variable      | Aquifer Absent | No monitoring data |
| Total Allocation Limit       | No Limit*     |                | No Limit*          |
| Current Allocations          | 0.7           |                | 0.6                |
| <b>Unallocated Resources</b> | <b>Small*</b> |                | <b>Small*</b>      |

\* 'take-what-you-can-get' policy applies.

### **Summary of Groundwater Monitoring Data**

| Aquifer     | Wells                   | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|-------------------------|-------------------------------------------------|-----------------------|
| Superficial | GD13                    | 10.8-13.2                                       | 450                   |
|             | GD15*                   | No monitoring data                              | No monitoring data    |
|             | <u>Private</u> : Katich | No monitoring data                              | 540-1259              |
|             | Worthington             | No monitoring data                              | 140-205,              |
|             | Wilson,                 | 20.9-22.6                                       | 740-917               |
|             | McShane                 | No monitoring data                              | 1500                  |
|             | Scott                   | No monitoring data                              | 511-818               |
|             | No. 76 Yeo              | No monitoring data                              | No monitoring data    |
|             | Seven Pillar 28         | No monitoring data                              | 399-430               |
|             | Manolini                | No monitoring data                              | 2467-2658             |
| Mirrabooka  | Utoria 26+              | No monitoring data                              | 527-1422              |
|             | Aquifer Absent          |                                                 |                       |
| Leederville | Stone                   | No monitoring data                              | 3510                  |
|             | Gerrard                 | No monitoring data                              | 1180-1410             |
|             | Prnich                  | No monitoring data                              | 690-840               |
|             | Wilson                  | No monitoring data                              | 740-1314              |

\* to be destroyed by road widening - will be replaced.

+ disused well.

(cont.)



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## East Swan Subarea Fact Sheet (cont.)

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea.

- *SWA-1s*  
*A 'take-what-you-can-get' policy applies to groundwater allocation from the superficial and (limited) Leederville aquifers subject to environmental constraints and avoiding interference with neighbouring supply.*
- *SWA-2s*  
*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*
- *SWA-3s*  
*Groundwater may be allocated from the Leederville aquifer if a groundwater supply cannot be satisfactorily obtained from the superficial aquifer.*
- *SWA-4s*  
*The Water and Rivers Commission is to manage groundwater resources in Area B (Fig. 3) of the Swan Valley Planning Area in accordance with the Swan Valley Planning Act planning objective calling for the provision of (ground)water for viticulture and horticulture and the discouragement of other activities that have high water demands.*

### ***Recommendations***

- The recommended groundwater monitoring program (Appendix 3) includes undertaking annual groundwater salinity measurements for some existing superficial aquifer monitoring wells that are currently only measured for water-level.
- Three yearly salinity sampling of some private wells is recommended for former GSWA wells that previously had no regular monitoring schedule.
- The “take-what-you-can-get” policy needs triennial review and may need modification if significant mutual interference conflicts are occurring.
- In January of each year, the Swan Regional Office of the Water and Rivers Commission is to report to the Policy and Planning Division on the allocation total for all new groundwater licenses in the East Swan Subarea issued for the Leederville aquifer during the previous year.



## Neaves Subarea Fact Sheet

### Description

Area: 24.20 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Swan Coastal Plain - Bassendean Sand interfingered with Gngangara Sand. Subarea has abundant wetlands. No additional water to allocate from the Leederville aquifer. Subarea is in Ellen Brook Catchment.

### General Hydrogeology

Superficial Aquifer: Gngangara Groundwater Mound flow system, flowing in an easterly to southeasterly direction, discharging to Ellen Brook.  
 Mirrabooka Aquifer: Hydraulically connected to the superficial aquifer and likely to have a similar flow direction.  
 Leederville Aquifer: Aquifer is confined and flow direction is from north to south.

### Groundwater Resources

#### Volume Groundwater in Million Kilotres per Annum

| Aquifer                | Superficial | Mirrabooka         | Leederville        |
|------------------------|-------------|--------------------|--------------------|
| Groundwater Quality    | Fresh       | No monitoring data | No monitoring data |
| Total Allocation Limit | 3.8         | 0.5                | 0.0*               |
| Current Allocations    | 3.2         | 0.0                | 0.0                |
| Unallocated Resources  | 0.6         | 0.5                | 0.0*               |

\* Allocation limit set to amount of current allocation.

### Summary of Groundwater Monitoring Data

| Aquifer     | Wells  | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|--------|-------------------------------------------------|-----------------------|
| Superficial | GN 14  | 40.1-41.1                                       | 120                   |
|             | GN 21  | 62.3-63.8                                       | 170                   |
|             | NR2c   | 66.8-68.2                                       | No monitoring data    |
|             | NR4c   | 62.6-64.5                                       | No monitoring data    |
|             | NR11c  | 55.74-57.3                                      | No monitoring data    |
|             | L230a  | 46.1-48.5                                       | 204                   |
|             | L230c  | 52.3-50.6                                       | 96                    |
|             | L240a  | 44.9-43.5                                       | 350                   |
|             | L240c  | 46.8-48.5                                       | 81                    |
|             | L250a  | 42.8-44.1                                       | 226                   |
|             | L250c  | 41.4-42.8                                       | 200                   |
|             | L310a  | 55.0-56.4                                       | 183                   |
|             | L320a  | 43.0-44.6                                       | 152                   |
|             | L320c  | 45.4-46.8                                       | 204                   |
| Mirrabooka  | GNM14* | No monitoring data                              | No monitoring data    |
| Leederville | L242   | 43.1-44.5                                       | No monitoring data    |
| Yarragadee  | AM29a  | 18.9-46.9                                       | No monitoring data    |
|             | AM29   | No monitoring data                              | 3850                  |

\* and associated wetland.

(cont.)



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## Neaves Subarea Fact Sheet (cont.)

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea.

- *SWA-2s*

*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*

- *SWA-5s*

*Any well drilled below the bottom of the superficial aquifer must be pressure cement grouted by a Class 2 or 3 certified driller.*

- *SWA-7s*

*No groundwater is to be allocated from the Leederville aquifer for new wells in new projects. Allocation of groundwater from the Leederville aquifer for existing wells in new projects (e.g. change of property ownership, change of purpose) will be assessed on a 'case by case' basis (refer to Policy and Planning Division). No additional groundwater is to be allocated from the Leederville aquifer to wells in existing projects. Replacement wells in the Leederville aquifer are permitted for existing projects for the same allocation provided use of the unconfined aquifers is not viable.*

### ***Recommendations***

- The recommended groundwater monitoring program (Appendix 3) includes undertaking annual groundwater salinity measurements for some existing superficial and Mirrabooka aquifer monitoring wells which are currently only measured for waterlevel.
- 'Once off' salinity sampling of some AM wells in the Leederville and Yarragadee aquifers is recommended.



## North Swan Subarea Fact Sheet

### **Description**

Area: 45.14 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - From west to east, areas of Bassendean Sand interfingered with Gngangara Sand grade to Guildford Clay. Abundant wetlands in area. Much of the subarea will become urbanised, including the Ellenbrook sub-division. As a result, some large currently rural groundwater allocations will be recovered. The Vines Country Club exists in this subarea. Subarea is in Ellen Brook Catchment. Small area in Swan Valley Planning Area. No additional water to allocate from the Leederville aquifer. Artificial maintenance well operated by CALM for Twin Swamps Reserve (western swamp tortoise).

### **General Hydrogeology**

Superficial Aquifer: Gngangara Groundwater Mound flow system, flowing in an easterly to southeasterly direction, discharging into Ellen Brook.  
 Mirrabooka Aquifer: Hydraulically connected to the superficial aquifer and likely to have a similar flow direction.  
 Leederville Aquifer: Aquifer is confined and flow direction is from north to south.

### **Groundwater Resources**

#### Volume Groundwater in Million Kilotres per Annum

| Aquifer                | Superficial | Mirrabooka | Leederville        |
|------------------------|-------------|------------|--------------------|
| Groundwater Quality    | Fresh       | Fresh      | No monitoring data |
| Total Allocation Limit | 3.3         | 0.3        | 1.6*               |
| Current Allocations    | 3.1         | 0.2        | 1.6                |
| Unallocated Resources  | 0.2         | 0.1        | 0.0                |

\* Allocation limit set to amount of current allocation.

(cont.)



## North Swan Subarea Fact Sheet (cont.)

### *Summary of Groundwater Monitoring Data*

| Aquifer     | Wells                     | Maximum Range<br>of Potentiometric<br>Surface (m AHD) | Salinity (TDS) (mg/L) |                    |
|-------------|---------------------------|-------------------------------------------------------|-----------------------|--------------------|
| Superficial | PB1                       | 48.5-49.7                                             | No monitoring data    |                    |
|             | PB2                       | 48.1-50.1                                             | No monitoring data    |                    |
|             | PB3                       | 46.1-47.6                                             | No monitoring data    |                    |
|             | PB10                      | 33.2-37.4                                             | 232                   |                    |
|             | GD14                      | 22.2-24.6                                             | 117                   |                    |
|             | MM63                      | 28.8-30.0                                             | 230                   |                    |
|             | MM64                      | 35.1-37.6                                             | No monitoring data    |                    |
|             | L50A                      | 39.2-40.9                                             | 305                   |                    |
|             | L50C                      | 42.0-43.7                                             | 119                   |                    |
|             | L60A                      | 37.9-39.8                                             | 169                   |                    |
|             | L60C                      | 40.4-41.8                                             | 276                   |                    |
|             | L80A                      | 17.0-27.4                                             | 315                   |                    |
|             | L80C                      | 22.1-26.7                                             | No monitoring data    |                    |
|             | L90A                      | 15.8-19.9                                             | No monitoring data    |                    |
|             | L90C                      | 16.6-20.2                                             | 394                   |                    |
|             | L130A                     | 43.9-45.0                                             | 188                   |                    |
|             | L130C                     | 48.1-49.2                                             | 112                   |                    |
|             | L140A                     | 43.7-44.9                                             | 149                   |                    |
|             | L140C                     | 46.2-47.6                                             | 152                   |                    |
|             | L150A                     | 42.7-43.9                                             | 470                   |                    |
|             | L150C                     | 45.2-46.5                                             | 136                   |                    |
|             | L160A                     | 30.6-32.8                                             | 294                   |                    |
|             | L160C                     | 31.7-33.6                                             | 168                   |                    |
|             | L170A                     | 24.2-31.0                                             | 303                   |                    |
|             | L170C                     | 24.0-26.7                                             | 263                   |                    |
|             |                           | GNM15*                                                | No monitoring data    | No monitoring data |
|             |                           | GNM16*                                                | No monitoring data    | No monitoring data |
|             |                           | GNM17*                                                | No monitoring data    | No monitoring data |
|             |                           | Egerton                                               | No monitoring data    | No monitoring data |
|             |                           | Edgecombe                                             | No monitoring data    | No monitoring data |
|             |                           | <u>Private:</u> Yurisch                               | No monitoring data    | 371                |
|             |                           | No. 87                                                | No monitoring data    | 483                |
|             |                           | No. 29                                                | 6.5-19.5              | 510                |
|             | Shaw                      | No monitoring data                                    | 586                   |                    |
|             | No.87 Swan Res. Station   |                                                       | No monitoring data    |                    |
|             | Multiplex 2               | No monitoring data                                    | 475                   |                    |
|             | Multiplex 3               | No monitoring data                                    | 1085                  |                    |
|             | Morris+                   | No monitoring data                                    | 1231                  |                    |
| Mirrabooka  | PB19                      | 36.5-39.5                                             | No monitoring data    |                    |
|             | L52                       | 37.5-39.9                                             | No monitoring data    |                    |
|             | L132                      | 43.6-44.7                                             | 148                   |                    |
|             | L142                      | 43.5-44.5                                             | No monitoring data    |                    |
| Leederville | PB12                      | 10.1-25.4                                             | No monitoring data    |                    |
|             | <u>Private:</u> Multiplex | No monitoring data                                    | 340-368               |                    |
|             | Kendall                   | No monitoring data                                    | 400-362               |                    |
|             | Okmazich                  | No monitoring data                                    | 360-463               |                    |
|             | Swan Res. Station         | No monitoring data                                    | 390-420               |                    |

\* and associated wetland.

+ disused well.

(cont.)



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## North Swan Subarea Fact Sheet (cont.)

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea .

- *SWA-2s*

*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*

- *SWA-4s*

*The Water and Rivers Commission is to manage groundwater resources in Area B (Fig. 3) of the Swan Valley Planning Area in accordance with the Swan Valley Planning Act planning objective calling for the provision of (ground)water for viticulture and horticulture and the discouragement of other activities that have high water demands.*

- *SWA-5s*

*Any well drilled below the bottom of the superficial aquifer must be pressure cement grouted by a Class 2 or 3 certified driller.*

- *SWA-7s*

*No groundwater is to be allocated from the Leederville aquifer for new wells in new projects. Allocation of groundwater from the Leederville aquifer for existing wells in new projects (e.g. change of property ownership, change of purpose) will be assessed on a 'case by case' basis (refer to Policy and Planning Division). No additional groundwater is to be allocated from the Leederville aquifer to wells in existing projects. Replacement wells in the Leederville aquifer are permitted for existing projects for the same allocation provided use of the unconfined aquifers is not viable.*

### ***Recommendations***

- The recommended groundwater monitoring program (Appendix 3) includes undertaking annual groundwater salinity measurements for a number of existing superficial and Mirrabooka aquifer monitoring wells which are currently only measured for waterlevel.
- Three-yearly salinity sampling of some private wells in all aquifers except Yarragadee is recommended, including some former GSWA wells which previously had no regular monitoring schedule.
- Monthly water-level sampling is recommended to remain for some Lexia and Pacminex wells (near the Vines urban area) while downgrading monitoring from monthly to quarterly is appropriate for other wells in less sensitive areas which have shown little change in seasonal water-level trends over time.
- 'Once off' sampling of wells L52, L132 and L142 should be done for salinity.



## Radar Subarea Fact Sheet

### Description

Area: 44.42 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Gngangara Sand interfingered with Guildford Clay, the latter becoming more dominant near Ellen Brook. Is in Ellen Brook Catchment, Ellen Brook running along eastern boundary. Much of area seasonally waterlogged. No additional water to allocate from the Leederville aquifer.

### General Hydrogeology

Superficial Aquifer: Gngangara Mound flow system flows in an easterly to southeasterly direction, discharging to Ellen Brook.  
 Mirrabooka Aquifer: Hydraulically connected to the superficial aquifer and likely to have a similar flow direction.  
 Leederville Aquifer: Aquifer is confined and groundwater flow direction is from north to south.

### Groundwater Resources

#### Volume Groundwater in Million Kilolitres per Annum

| Aquifer                | Superficial | Mirrabooka         | Leederville |
|------------------------|-------------|--------------------|-------------|
| Groundwater Quality    | Fresh       | No monitoring data | Variable    |
| Total Allocation Limit | 3.4         | 1.2                | 0.2*        |
| Current Allocations    | 1.4         | 0.1                | 0.2         |
| Unallocated Resources  | 2.0         | 1.1                | 0.0         |

\*Allocation Limit set to amount of Current Allocation

### Summary of Groundwater Monitoring Data

| Aquifer     | Wells                    | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|--------------------------|-------------------------------------------------|-----------------------|
| Superficial | GD16                     | 29.3-32.0                                       | 260                   |
|             | GD17                     | 28.5-31.7                                       | No monitoring data    |
|             | GN24                     | 59.8-62.0                                       | 80                    |
|             | L260a                    | 33.6-35.4                                       | 298                   |
|             | L260c                    | 35.0-36.3                                       | 125                   |
|             | L270a                    | 28.3-31.5                                       | 306                   |
|             | L270c                    | 30.0-31.8                                       | 266                   |
|             | L280a                    | 28.0-25.8                                       | 330                   |
|             | L280c                    | 27.9-25.6                                       | 1090                  |
|             | L330a                    | 38.7-40.1                                       | 252                   |
|             | L330c                    | 38.6-39.9                                       | 148                   |
|             | L340a                    | 33.2-34.9                                       | 357                   |
|             | L340c                    | 33.2-34.7                                       | 364                   |
|             | L330a                    | No monitoring data                              | No monitoring data    |
|             | L330c                    | No monitoring data                              | No monitoring data    |
|             | L350a                    | 28.4-30.6                                       | 281                   |
|             | L350c                    | 28.1-30.0                                       | 261                   |
| Mirrabooka  | No. 91+                  | No monitoring data                              | 610                   |
|             | No wells                 |                                                 |                       |
| Leederville | AM26a                    | 31.3-41.3                                       | 437                   |
|             | A26b                     | 27.2-41.9                                       | 2066                  |
|             | <u>Private</u> :Gladinia | No monitoring data                              | 290-420               |
| Yarragadee  | AM26                     | 25.7                                            | No monitoring data    |

+ disused well.

(cont.)





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## **Radar Subarea Fact Sheet (cont.)**

### ***Specific Groundwater Licensing Policies***

Refer to Chapter 9 for general policies applying to this subarea.

- *SWA-2s*  
*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*
- *SWA-5s*  
*Any well drilled below the bottom of the superficial aquifer must be pressure cement grouted by a Class 2 or 3 certified driller.*
- *SWA-7s*  
*No groundwater is to be allocated from the Leederville aquifer for new wells in new projects. Allocation of groundwater from the Leederville aquifer for existing wells in new projects (e.g. change of property ownership, change of purpose) will be assessed on a 'case by case' basis (refer to Policy and Planning Division). No additional groundwater is to be allocated from the Leederville aquifer to wells in existing projects. Replacement wells in the Leederville aquifer are permitted for existing projects for the same allocation provided use of the unconfined aquifers is not viable.*

### ***Recommendations***

- Due to the large potential for additional allocation of groundwater from the superficial aquifer and a paucity of monitoring data in the center of the subarea, the construction of a new groundwater monitoring well in the superficial aquifer is recommended (Fig. 13).
- The recommended groundwater monitoring program (Appendix 3) also includes undertaking annual groundwater salinity measurements for some existing superficial aquifer monitoring wells which are currently only measured for waterlevel.
- 'Once off' salinity sampling of some AM wells in the Leederville and Yarragadee aquifers is recommended.



## South Swan Subarea Fact Sheet

### **Description**

Area: 45.73 km<sup>2</sup>  
 Local Government: Shire of Swan  
 Comments: Geomorphology - Gnangara Sand interfingered with Guildford Clay, the latter becoming more dominant near the Swan River. The Ellenbrook subdivision to the north is expected to increase groundwater recharge in the immediate area. The proposed Albion urban subdivision is west of Murray Road. Most of South Swan is in the Swan Valley Planning Area. Groundwater quality deteriorates in heavy soil areas. The Mirrabooka aquifer has priority use in this subarea. No additional water to allocate from the Leederville aquifer.

### **General Hydrogeology**

Superficial Aquifer: Gnangara Groundwater Mound flow system, flowing in an easterly to south-easterly direction, discharging to the Swan River. Well yields may be low due to clayey nature of sediments.  
 Mirrabooka Aquifer: Upward potentiometric levels cause discharge to superficial aquifer over much of area. Absent east of the Swan River. Likely to have a flow direction similar to superficial aquifer. Due to low yields and brackish groundwater in the superficial aquifer, most recharge to the Mirrabooka Aquifer is assigned for abstraction in the South Swan Subarea.  
 Leederville Aquifer: Aquifer is confined and flow direction is from north to south.

### **Groundwater Resources**

#### Volume Groundwater in Million Kilolitres per Annum

| Aquifer                | Superficial | Mirrabooka         | Leederville |
|------------------------|-------------|--------------------|-------------|
| Groundwater Quality    | Fresh       | No monitoring data | Fresh       |
| Total Allocation Limit | 4.3         | 1.6                | 2.5 *       |
| Current Allocations    | 4.0         | 1.2                | 2.5         |
| Unallocated Resources  | 0.3         | 0.4                | 0.0         |

\* Allocation limit set to amount of current allocation.

### **Summary of Groundwater Monitoring Data**

| Aquifer     | Wells | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|-------------|-------|-------------------------------------------------|-----------------------|
| Superficial | GD12  | 0.4-4.1                                         | 840                   |
|             | M81   | 18.6-20.8                                       | 400                   |
|             | M190  | 17.3-24                                         | 420                   |
|             | M290  | 5,28.1-30.8                                     | 170                   |
|             | MM45  | 9.8-13.5                                        | No monitoring data    |
|             | MM48  | 16.6-18.6                                       | No monitoring data    |
|             | MM48a | 16.3-15.0                                       | No monitoring data    |
|             | MM47  | 16.3-15.0                                       | No monitoring data    |
|             | MM47a | 16.6-13.5                                       | No monitoring data    |
|             | MM51a | 18.7-20.7                                       | 312                   |
|             | MM57  | 18.9-22.9                                       | No monitoring data    |
|             | M61   | 29.7-31.3                                       | No monitoring data    |
|             | 8/85  | No monitoring data                              | No monitoring data    |

(cont.)



## South Swan Subarea Fact Sheet (cont.)

### *Summary of Groundwater Monitoring Data (cont.)*

| Aquifer             | Wells              | Maximum Range<br>of Potentiometric<br>Surface (m AHD) | Salinity (TDS) (mg/L) |   |
|---------------------|--------------------|-------------------------------------------------------|-----------------------|---|
| Superficial (cont.) | 10/85              | No monitoring data                                    | No monitoring data    |   |
|                     | 11/85              | No monitoring data                                    | No monitoring data    |   |
|                     | 15/85              | No monitoring data                                    | No monitoring data    |   |
|                     | <u>Private:</u>    |                                                       |                       |   |
|                     | No. 45 Devenish    | 6.7-8.6                                               | 2218                  |   |
|                     | No. 96 Della       | 7.3-11.3                                              | 230                   |   |
|                     | Stone              | No monitoring data                                    | 605                   |   |
|                     | RulloA             | No monitoring data                                    | 1140-1295             |   |
|                     | Mews               | No monitoring data                                    | 230                   |   |
|                     | Schwinkowski       | No monitoring data                                    | 220-261               |   |
|                     | No 47              | No monitoring data                                    | 355-447               |   |
|                     | No. 71             | No monitoring data                                    | 696                   |   |
|                     | Bebich             | No monitoring data                                    | 739                   |   |
|                     | Sorgiovanni        | No monitoring data                                    | 871                   |   |
|                     | Bondi              | No monitoring data                                    | 818                   |   |
|                     | D'Angelo           | No monitoring data                                    | 632                   |   |
|                     | Yukich+            | No monitoring data                                    | 703                   |   |
|                     | No. 107+           | No monitoring data                                    | 450                   |   |
|                     | Mirrabooka         | 7/85                                                  | No monitoring data    | - |
|                     |                    | 14/85                                                 | No monitoring data    | - |
| 16/85               |                    | No monitoring data                                    | -                     |   |
| Taylor              |                    | No monitoring data                                    | 290-322               |   |
| Antunovich          |                    | No monitoring data                                    | 240-271               |   |
| Sarich              |                    | No monitoring data                                    | 290-377               |   |
| Leederville         | 6/85               | No monitoring data                                    | No monitoring data    |   |
|                     | 9/85               | No monitoring data                                    | No monitoring data    |   |
|                     | 12/85              | No monitoring data                                    | No monitoring data    |   |
|                     | 13/85              | No monitoring data                                    | No monitoring data    |   |
|                     | 5/87               | 8.5-10.7                                              | No monitoring data    |   |
|                     | 6/87               | 2.2-6.6                                               | No monitoring data    |   |
|                     | AM31a              | 4.1-26.5                                              | 600                   |   |
|                     | AM35               | 2.8-17.0                                              | 940                   |   |
|                     | Henley Pk Wines    | No monitoring data                                    | 370-240               |   |
|                     | Green Lendich      | No monitoring data                                    | 780-588               |   |
|                     | Swan Vly Tour Vill | No monitoring data                                    | 1100-633              |   |
|                     | Sandleford Wines   | No monitoring data                                    | 210-237               |   |
|                     | Buselich           | No monitoring data                                    | 320-424               |   |
|                     | Bignell            | No monitoring data                                    | 640-656               |   |
|                     | Rendall            | No monitoring data                                    | 410-1775              |   |
| Beros               | No monitoring data | 1030-945                                              |                       |   |
| Barrett             | No monitoring data | 850                                                   |                       |   |
| Rullo B             | No monitoring data | 470                                                   |                       |   |

+ *disused wells.*

(cont.)



## South Swan Subarea Fact Sheet (cont.)

### *Summary of Groundwater Monitoring Data (cont.)*

| Aquifer             | Wells         | Maximum Range of Potentiometric Surface (m AHD) | Salinity (TDS) (mg/L) |
|---------------------|---------------|-------------------------------------------------|-----------------------|
| Leederville (cont.) | Mateljan      | No monitoring data                              | 1190-1120             |
|                     | Dawson        | No monitoring data                              | 740-665               |
|                     | Stowe         | No monitoring data                              | 670-686               |
|                     | Simpson       | No monitoring data                              | 680                   |
|                     | Bowman        | No monitoring data                              | 610                   |
|                     | Lovreta       | No monitoring data                              | 560                   |
|                     | Rudez         | No monitoring data                              | 970                   |
|                     | Swan Ath Club | No monitoring data                              | 640-574               |
| Yarragadee          | AM31          | 18.7                                            | 3160                  |
|                     | AM35a         | 19.3                                            | 4650                  |

### *Specific Groundwater Licensing Policies*

Refer to Chapter 9 for general policies applying to this subarea

- *SWA-2s*

*Where the subarea is within the Ellen Brook Catchment (Fig. 3), all groundwater licence applications concerning developments with the potential of causing nutrient enrichment of groundwater / surface water must, after completion of a Horticultural Development Application Form (Appendix 4), be referred to the Department of Environmental Protection for assessment.*

- *SWA-4s*

*The Water and Rivers Commission is to manage groundwater resources in Area B (Fig. 3) of the Swan Valley Planning Area in accordance with the Swan Valley Planning Act planning objective calling for the provision of (ground)water for viticulture and horticulture and the discouragement of other activities that have high water demands.*

- *SWA-5s*

*Any well drilled below the bottom of the superficial aquifer must be pressure cement grouted by a Class 2 or 3 certified driller.*

- *SWA-6s*

*In the South Swan Subarea, due to brackish or low-yielding wells in the superficial aquifer and no additional allocations from the Leederville aquifer being permitted, the groundwater resource in the Mirrabooka aquifer has a priority allocation in the South Swan Subarea.*

- *SWA-7s*

*No groundwater is to be allocated from the Leederville aquifer for new wells in new projects. Allocation of groundwater from the Leederville aquifer for existing wells in new projects (e.g. change of property ownership, change of purpose) will be assessed on a 'case by case' basis (refer to Policy and Planning Division). No additional groundwater is to be allocated from the Leederville aquifer to wells in existing projects. Replacement wells in the Leederville aquifer are permitted for existing projects for the same allocation provided use of the unconfined aquifers is not viable.*

(cont.)



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## South Swan Subarea Fact Sheet (cont.)

### *Recommendations*

- Recommended groundwater monitoring program (Appendix 3) includes undertaking annual groundwater salinity measurements for a number of existing superficial and Mirrabooka aquifer monitoring wells which are currently only measured for waterlevel.
- Yearly and three yearly salinity sampling of some private wells in all aquifers except Yarragadee is recommended. These include some former GSWA wells which previously had no regular monitoring schedule.
- Monthly waterlevel sampling is recommended for superficial aquifer wells MM57, MM61, MM190 due to proximity to Ellenbrook subdivision or to Mirrabooka Wellfield. Other wells are to remain at quarterly sampling.
- 'Once off' salinity sampling of some wells in the Leederville and Yarragadee aquifers is also recommended.



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# 11. Conclusions

The Swan Groundwater Area Allocation Plan (1997) has been approved by the Swan Groundwater Advisory Committee (25 July, 1997), the Water Resources Allocation Committee (28 July, 1997), and the Board of the Water and Rivers Commission (21 August, 1997). The guidelines and policies contained in this Allocation Plan are the current practice for groundwater management and allocation in the Swan Groundwater Area.

## 11.1. Groundwater resource

### 11.1.1 Aquifers

The groundwater resources of the Swan Groundwater Area are contained in four aquifers: the superficial, Mirrabooka, Leederville and Yarragadee aquifers.

The unconfined superficial aquifer occurs throughout the area, has an average saturated thickness of about 40 m and is mainly sandy west of Ellen Brook and the Swan River, where it forms the southeastern part of the Gngangara Mound groundwater flow-system. In the east, the superficial aquifer of the Swan-Helena groundwater flow-system is predominantly clayey, with thin gravelly deposits occurring locally near to the Darling Scarp. The groundwater resource within the eastern area is relatively small.

The Mirrabooka aquifer is a semi-confined and locally confined aquifer, and is in general hydraulic continuity with the overlying superficial aquifer. It occurs in the western half of the area, where it reaches a maximum thickness of about 100 m. It consists of unconsolidated sandstone and silty sandstone with interbedded shale.

The Leederville aquifer is a multilayer groundwater flow-system consisting of discontinuous interbedded sandstones, siltstones and shales. In most areas the aquifer is confined, but near the Darling Scarp it is in direct hydraulic connection with the thin overlying superficial aquifer.

The confined Yarragadee aquifer, a major aquifer within the Perth Basin, is currently not utilised as a resource

because private groundwater abstraction is not economically viable. The water of the aquifer is brackish to saline.

### 11.1.2 Aquifer performance

#### Superficial aquifer

The water level in the superficial aquifer has generally stabilised over time. Large seasonal variations in water levels occur in wells located in areas of high groundwater abstraction. The watertable, however, recovers completely after the winter rainfall, provided it is not below average. Groundwater salinity in the superficial aquifer is generally less than 1000 mg/L TDS. Where the watertable is shallow or the soil is clayey (e.g. in parts of South Swan and Central Swan Subareas), groundwater salinity is commonly higher.

#### Mirrabooka aquifer

The potentiometric level of the Mirrabooka aquifer has remained stable over time. Groundwater salinity in the Mirrabooka aquifer may, in some areas, be lower than that of the overlying superficial aquifer and is usually less than 500 mg/L TDS.

#### Leederville aquifer

Potentiometric levels in the Leederville aquifer are stable in some areas and declining in others. Falling potentiometric levels have been observed in areas where there is a large volume of abstraction and the aquifer is confined (e.g. South Swan Subarea). Groundwater salinity in the Leederville aquifer generally increases with distance from the recharge areas and with depth. Two salinity zones are present.

#### Yarragadee aquifer

Potentiometric levels are declining in the Yarragadee aquifer, both regionally and within the Swan Groundwater Area. This trend is possibly due to groundwater abstraction from this aquifer in the Perth area exceeding the current throughflow. Potentiometric levels could continue to decline until additional leakage occurs (induced by falling levels) or abstraction is reduced.



## 11.2 Monitoring

### 11.2.1 Current program

A summary of the current groundwater monitoring program is shown in Table 10. Specific monitoring wells are shown in Figures 13-19.

Monitoring of the watertable levels in the Swan Groundwater Area is carried out by the Swan Regional Office of the Water and Rivers Commission. Most monitoring wells are in the Gngangara Mound groundwater flow-system to the west of Ellen Brook and the Swan River. Some monitoring wells were constructed in the Mirrabooka aquifer, mainly to monitor the effects of the Mirrabooka Groundwater Scheme, immediately to the west of the Swan Groundwater Area. Some of the Leederville and Yarragadee aquifer monitoring wells, which are part of a larger regional Artesian Monitoring Network, are also located in the Swan Groundwater Area.

A wetland monitoring program has recently commenced. It includes the measuring of water levels in wetlands and nearby GNM wells and measuring water quality in some wetlands. These are part of the proposed East Gngangara Environmental Water Provisions Plan.

The Department of Conservation and Land Management measures water levels and water quality in wetlands associated with the Twin Swamps and Ellen Brook Reserves.

Groundwater monitoring programs *specific to* the Swan Groundwater Area include:

- the Swan Series, which record water levels from Water and Rivers Commission wells in the unconfined and confined aquifers, and water quality from private wells, screened mainly in the superficial aquifer; and
- the GSWA Census wells, which have been used on an irregular basis for measurement of water quality from private wells screened mainly in the Leederville aquifer.

### 11.2.2 Limitations of current program

#### Superficial aquifer

Monitoring of groundwater salinity is not adequate in the area west of the Swan River and Ellen Brook. For example, there is only one wetland (EPP173) currently monitored north of Warbrook Road (formerly Bullsbrook Groundwater Area).

#### Mirrabooka aquifer

Additional monitoring of salinity is required in areas south of Warbrook Road.

#### Leederville aquifer

Some additional monitoring of salinity is required in the Central Swan Subarea, where additional allocations from the Leederville aquifer are permitted (Fig. 19).

### 11.2.3 Proposed monitoring program

Table 11 summarises the proposed groundwater monitoring program. The positions of proposed monitoring wells are given in Figures 13-19 and detailed in Appendix 3.

#### Superficial aquifer

In the superficial aquifer, the frequency of monitoring watertable levels in some wells has been reduced from

**Table 10. A summary of current groundwater monitoring in the Swan Groundwater Area.**

(Values represent number of 'groundwater level / groundwater quality' monitoring points)

| Aquifer     | North Swan | South Swan | Central Swan | East Swan | Neaves | Radar | Cockman Bluff | Bandy Spring | TOTAL  |
|-------------|------------|------------|--------------|-----------|--------|-------|---------------|--------------|--------|
| Superficial | 29/ 13     | 16/ 13     | 2/ 6         | 2/ 7      | 15/ 1  | 15/ 0 | 1/ 0          | 0/ 0         | 80/ 40 |
| Mirrabooka  | 4/ 0       | 3/ 3       |              |           | 1/ 0   | 0/ 0  |               |              | 8/ 3   |
| Leederville | 1/ 4       | 8/ 19      | 3/ 0         | 0/ 4      | 1/ 0   | 2/ 1  | 0/ 0          | 0/ 0         | 15/ 28 |
| Yarragadee  | 0/ 0       | 2/ 0       | 0/ 0         |           | 1/ 0   | 1/ 0  | 0/ 0          |              | 4/ 0   |



**Table 11. A summary of the proposed groundwater monitoring in the Swan Groundwater Area.**

(Values represent number of 'groundwater level / groundwater quality' monitoring points)

| Aquifer     | North Swan | South Swan | Central Swan | East Swan | Neaves | Radar | Cockman Bluff | Bandy Spring | TOTAL  |
|-------------|------------|------------|--------------|-----------|--------|-------|---------------|--------------|--------|
| Superficial | 29/ 19     | 16/ 23     | 2/ 9         | 2/ 9      | 15/ 6  | 16/ 8 | 3/ 3          | 0/ 0         | 83/ 77 |
| Mirrabooka  | 4/ 1       | 3/ 6       |              |           | 1/ 1   | 0/ 0  |               |              | 8/ 8   |
| Leederville | 1/ 5       | 8/ 19      | 3/ 3         | 0/ 4      | 1/ 0   | 2/ 1  | 0/ 0          | 0/ 0         | 15/ 32 |
| Yarragadee  | 0/ 0       | 2/ 0       | 0/ 0         |           | 1/ 0   | 1/ 0  | 0/ 0          |              | 4/ 0   |

monthly to quarterly. Monthly monitoring of water levels will continue (Fig. 13) for wells that show falling or rising water levels, are pump affected or are near environmentally sensitive areas (Fig. 20). Several new watertable monitoring wells are proposed for Cockman Bluff and Radar Subareas, where the number of monitoring wells is inadequate (Fig. 13). A significant increase in groundwater salinity monitoring is proposed, particularly in Water and Rivers Commission wells, west of the Swan River and Ellen Brook (Fig. 17). In this area, large groundwater abstraction occurs and more detailed salinity monitoring is needed.

#### **Mirrabooka aquifer**

Although no water level monitoring is currently carried out in the Mirrabooka aquifer north of Warbrook Road, construction of new monitoring wells is not proposed. The demand for the resource is not expected to be high, due to the availability of good quality groundwater from the overlying superficial aquifer in this area.

The Mirrabooka aquifer is a particularly important source of water supply in the South Swan Subarea, where the overlying superficial aquifer is mostly of marginal salinity and the deeper Leederville aquifer is fully allocated. With an increase in groundwater allocation expected from this aquifer, additional monitoring is required in the South Swan Subarea (Fig. 18) to check for a possible increase in salinity due to groundwater leakage from the overlying superficial aquifer. The groundwater salinity from each of the Mirrabooka aquifer monitoring wells located in the North Swan Subarea should be measured.

#### **Leederville aquifer**

The only subareas where additional groundwater allocations may be made are in Central Swan, East Swan and Bandy Spring. No new monitoring wells are proposed for the East Swan and Bandy Spring Subareas where there are no total allocation limits. In the Central Swan Subarea, the three monitoring wells are adequate. Regular monitoring of groundwater salinity in these wells is recommended (Fig. 19).

A single groundwater salinity measurement of AM Series wells in the Neaves, Radar, North Swan, and South Swan Subareas is required on a 'once off' basis.

#### **Yarragadee aquifer**

A single groundwater salinity measured for each Yarragadee aquifer AM Series monitoring well is required on a 'once off' basis.

#### **11.2.4 Well maintenance**

Two wells, GD15 and MM64, need replacing. New wells should be located next to the existing wells and screened at similar depths. Three wells, L52, L242 and 4/85, require re-developing by airlifting. A request should be made to the land developer near wells L60a and L60c to protect the wells to avoid damage during earthworks. If these wells are damaged, the developer should replace them.

### **11.3 The allocation limit**

#### **Superficial aquifer**

The total allocation limit for groundwater resources from the superficial aquifer in the Swan Groundwater





**Table 12. Groundwater allocation and availability for the superficial, Mirrabooka and Leederville aquifers in the Swan Groundwater Area.**

| Subarea       | Allocation limit*          |            |            | Current allocation |            |            | % Allocated |           |           |
|---------------|----------------------------|------------|------------|--------------------|------------|------------|-------------|-----------|-----------|
|               | S                          | M          | L          | S                  | M          | L          | S           | M         | L         |
| North Swan    | 3.3                        | 0.3        | 1.6        | 3.1                | 0.2        | 1.6        | 94          | 67        | 100       |
| South Swan    | 4.3                        | 1.6        | 2.5        | 4.0                | 1.2        | 2.5        | 93          | 69        | 100       |
| Central Swan  | 1.9                        | absent     | 0.8        | 1.7                | n/a        | 0.4        | 90          | n/a       | 50        |
| East Swan     | take-what-can-get policy** |            |            | 0.7+               | n/a        | 0.6+       | n/a         | n/a       | n/a       |
| Neaves        | 3.8                        | 0.5        | 0.0        | 3.2                | 0.0        | 0.0        | 84          | 0         | 100       |
| Radar         | 3.4                        | 1.2        | 0.2        | 1.4                | 0.1        | 0.2        | 38          | 8         | 100       |
| Cockman-Bluff | 1.9                        | absent     | 0.3        | 0.7                | n/a        | 0.3        | 37          | n/a       | 100       |
| Bandy-Spring  | take-what-can-get policy** |            |            | 0.3+               | n/a        | 0.1+       | n/a         | n/a       | n/a       |
| <b>TOTAL</b>  | <b>18.6</b>                | <b>3.6</b> | <b>5.4</b> | <b>14.1</b>        | <b>1.5</b> | <b>5.0</b> | <b>76</b>   | <b>42</b> | <b>93</b> |

Note: Units are (million kilolitres per year) S (Superficial) M (Mirrabooka) L (Leederville)

\* where present, aquifer may not extend over entire subarea.

\*\* Mirrabooka aquifer absent.

+ not included in total.

Area is 18.6 million kL/a (Table 12). Nearly 80% of this resource is contained in that part of the aquifer lying west of Ellen Brook and the Swan River (part of the Gnangara Mound). Supplies are small in clayey areas, and where the aquifer is thin east of Darling Fault.

#### **Mirrabooka aquifer**

In total, 3.6 million kL/a is available for allocation from the Mirrabooka aquifer in the Swan Groundwater Area.

#### **Leederville aquifer**

The total allocation limit for the Leederville aquifer is 5.4 million kL/a in the Swan Groundwater Area. There are two groundwater flow-systems within the Leederville aquifer, one flowing to the south, with its principal recharge area in the Gingin Groundwater Area, and a second system, flowing west, is recharged from the overlying superficial formation in the Bandy Springs, East Swan, Cockman Bluff and Central Swan Subareas.

#### **Yarragadee aquifer**

The groundwater resource of the Yarragadee aquifer was not assessed as part of this allocation plan, as the aquifer is unlikely to be used in the Swan Groundwater Area.

## **11.4 Potential for additional allocation**

### **Superficial aquifer**

Groundwater from the superficial aquifer is about 76% allocated. All subareas have some groundwater available for further allocation. Groundwater resources available for additional allocation mostly occur north of Warbrook Road, where demand has been less.

### **Mirrabooka aquifer**

Groundwater from the Mirrabooka aquifer is currently about 42% allocated. Subareas where the Mirrabooka aquifer is present (Neaves, Radar, North Swan and South Swan) have groundwater available for further allocation. In the South Swan Subarea, groundwater availability is particularly important because salinity is of marginal quality in the superficial aquifer and further abstraction from the underlying Leederville aquifer is not permitted.

### **Leederville aquifer**

Groundwater from the Leederville aquifer is about 93% allocated in the Swan Groundwater Area. Further allocation is permitted only in the Central Swan Subarea, and where the aquifer occurs to the east of



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the Darling Fault (East Swan and Bandy Spring Subareas) where a 'take-what-you-can-get' policy applies. Abstraction is permitted from the Leederville aquifer in these subareas because:

- the potentiometric surface is not declining; and
- abstraction from the Leederville aquifer will have little regional impact.

#### **Yarragadee aquifer**

Groundwater allocation was not assessed. Projects wishing to utilise this resource will be assessed on a case-by-case basis.

## **11.5 Allocation policies**

The main groundwater allocation policies of the four aquifers in the Swan Groundwater Area are:

### **1. Superficial Aquifer**

Groundwater will be allocated from the superficial aquifer in preference to deeper aquifers if available, environmentally acceptable and of suitable quality (Chapter 9, *SWA-6*).

### **2. Mirrabooka Aquifer**

The groundwater resource in the Mirrabooka aquifer has a priority allocation in the South Swan Subarea, as the superficial aquifer is low-yielding groundwater salinity is of marginal quality and additional

allocations from the Leederville aquifer are not permitted (Chapter 10, *SWA-6s*).

### **3. Leederville Aquifer**

The Leederville aquifer is fully allocated in subareas where it occurs under confined conditions. In these areas, and to the west of the Swan Groundwater Area, increased pumping has resulted in declining potentiometric levels. Where the aquifer is semi-confined or unconfined (along the Darling Fault), potentiometric levels are not declining.

Additional groundwater allocation is only permitted from the Leederville aquifer in the Central Swan Subarea, and where present, east of the Darling Fault in the East Swan and Bandy Spring Subareas. Proponents must initially demonstrate that the superficial aquifer is unsuitable (e.g. low yields, poor water quality) before consideration can be given to approving abstraction from the Leederville aquifer (Chapter 10, *SWA-3s*).

### **4. Yarragadee Aquifer**

Due to declining potentiometric levels and brackish groundwater quality, abstraction from the Yarragadee aquifer is to be discouraged.

Any proposed abstraction from the Yarragadee aquifer should be referred to the Water Allocation Branch of the Water and Rivers Commission for assessment (Chapter 9, *SWA-7*).



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## 12. Recommendations

1. When completed, the following projects may affect groundwater allocation policies in the Swan Groundwater Area. The Policy and Planning Division of the Water and Rivers Commission should periodically keep the Swan Groundwater Advisory Committee informed on results of these projects which may affect groundwater allocation in the Swan Groundwater Area:
  - (1) Swan Canning Cleanup Program (coordinated by the Swan River Trust)
  - (2) Swan/Canning Environmental Protection Policy (Department of Environmental Protection)
  - (3) Swan-Avon Integrated Catchment Management Projects (coordinated by the Swan River Trust)
  - (4) Ellen Brook Catchment Management Plan (coordinated by the Swan River Trust)
  - (5) East Gnangara Environmental Water Provisions Plan (Water and Rivers Commission)
  - 6) West Bullsbrook Management Strategy (Swan Shire)
  - (7) Land-Use Planning for Sustainable Horticulture in the Ellen Brook Catchment (Agriculture Western Australia)
  - (8) Other horticultural research and water/nutrient studies (Agriculture Western Australia).
2. An investigation along the lines of that carried out for the East Gnangara Environmental Water Provisions Plan should be undertaken for wetlands in the Neaves and Radar Subareas to determine if environmental maintenance conditions are warranted.
3. Declining summer water levels in the superficial aquifer in the North Swan Subarea may be causing ecosystem stress and should be investigated.
4. The validity of factors used in groundwater modelling (East Gnangara Environmental Water Provisions Plan), including the extent of urbanisation and private and public groundwater abstraction, should be triennially reassessed to incorporate significant changes. The computer modelling results should be periodically compared with data from monitoring wells to assess variations in computer predictions and calibration. If the computer predictions are found to be significantly different from data collected from monitoring wells, or if significant landuse changes have occurred, the model should be rerun and groundwater allocation policies, as they affect the Swan Groundwater Area, amended accordingly.
5. The performance of the Leederville aquifer should be triennially reviewed by the Water Allocation Branch of the Water and Rivers Commission. If potentiometric levels are declining in subareas where additional allocation is permitted (Central Swan, Bandy Spring and East Swan Subareas), further allocation may be restricted.
6. The composition of the Swan Groundwater Advisory Committee should include a representative of the Swan Valley Planning Committee as a non-voting member. It is also considered advantageous to have a member of the Advisory Committee present at the Planning Committee meetings.
7. Discussions should be held between the Swan Groundwater Advisory Committee and the Swan Valley Planning Committee concerning the issue that the *Swan Valley Planning Act* may not have sufficient safeguards to ensure the potential for continual expansion of the viticulture industry in the Swan Valley. The potential for further development of viticulture should be investigated, taking account of such factors as available land and groundwater resources.
8. The Water Resources Allocation Committee should advise the Ministry for Planning of the likely future situation where subareas in the Swan Valley Planning Area B will have no additional groundwater to allocate to the types of developments that have been given statutory protection under the *Swan Valley Planning Act*.
9. A streamlined procedure should be developed for the assessment of the environmental acceptability of proposed projects in the Ellen Brook catchment.



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# Glossary

|                                  |                                                                                                                                                                                 |                                |                                                                                                                              |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Abstraction                      | Pumping groundwater from an aquifer.                                                                                                                                            | Evapotranspiration             | A collective term for evaporation and transpiration.                                                                         |
| mAHD                             | Australian Height Datum. Height in metres above Mean Sea Level +0.026m at Fremantle.                                                                                            | Groundwater Area               | An area proclaimed under Section 26B of the Rights in Water and Irrigation Act.                                              |
| Allocation                       | The quantity of groundwater permitted to be abstracted by a well licence, usually specified in kilolitres/year (kL/a).                                                          | Hectare (ha)                   | 10 000 square metres or 2.47 acres.                                                                                          |
| Aquifer                          | A geological formation or group of formations able to receive, store and transmit significant quantities of water.                                                              | Kilolitre (kL)                 | 1000 litres, 1 cubic metre or 220 gallons.                                                                                   |
| Beneficial Use                   | The current or future uses for a water resource that have priority over other potential uses because of their regional significance to the community.                           | Potentiometric Level (surface) | An imaginary surface representing the total head of groundwater and defined by the level to which water will rise in a well. |
| Confined Aquifer                 | An aquifer that is confined that between shale and siltstone beds and therefore contain water under pressure.                                                                   | Recharge                       | The downwards movement of water that is added to the groundwater system.                                                     |
| Environmental Water Provisions   | Actual level (allocation) made after consideration of the economic and social requirements for the water. It may be equal to or less than the Environmental Water Requirements. | Saprolite                      | Transitional zone of weathering between bedrock and soil.                                                                    |
| Environmental Water Requirements | Water level that will maintain current ecological values.                                                                                                                       | Subarea                        | A subdivision of a Groundwater Area.                                                                                         |
| Evaporation                      | The vaporisation of water from a free-water surface above or below ground level, normally measured in millimetres.                                                              | Transpiration                  | The water used by plants in an area. Like evaporation, transpiration is normally measured in millimetres.                    |
|                                  |                                                                                                                                                                                 | Unconfined Aquifer             | An aquifer which has its upper boundary at atmospheric pressure.                                                             |
|                                  |                                                                                                                                                                                 | Watertable                     | The groundwater surface of an unconfined aquifer at which pressure is equal to atmospheric pressure.                         |
|                                  |                                                                                                                                                                                 | Wetland                        | A permanent or seasonal lake or swamp or permanently waterlogged soils or inundated land.                                    |



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# Appendix 1

## Summary of the Swan Groundwater Advisory Committee Workshop, 26 August 1994

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*Points raised during the workshop to develop a Groundwater Allocation Plan for the Swan (Bullsbrook) Groundwater Area — Shire of Swan Administration Centre, Friday 26 August 1994.*

### Swan Valley Policy Area

- Insufficient groundwater to support rural villages in Swan Valley Policy Area.

*Rural Villages are proposed in Central Swan and South Swan Subareas (Fig. 3). Most demand for groundwater is expected to be for irrigation of parks and gardens. Although it is likely that there is sufficient groundwater for such irrigation, a water sensitive design needs to be implemented in each Subarea.*

- Possible re-use of wastewater after on-site treatment.

*Although such a scheme could be initiated, it is not expected that water will be so limiting as to warrant the development cost.*

- Proposed road placements (highways) impact (dissect) some vineyards - need landowner input, discussion.

*The major amendment to the Metropolitan Region Scheme has been through a three month public comment period. The Amendment was passed by Parliament in December 1994.*

### Swan Groundwater Allocation Plan

- Allocation Plan should discuss what Committee should do - criteria for membership.

*See Chapter 8.3.*

- Change development clause in current (i.e. 1991 Management Plan) policy.

*See Chapter 10.1, SWA-4.*

- Include a section on irrigation efficiency.

*See Chapter 9.2.4, SWA-13.*

- Realign Swan Groundwater Area boundaries along the Swan Valley Planning Area.

*See Figure 3.*

- Degree of flexibility in allocations - possibility of overallocating areas - mining concept, requirement to deepen wells (economic consequences) - GSWA recommendations.

Only allocate to sustainable yield.

*See Chapter 9.1.6, SWA-8.*

### Guidelines for a Good Groundwater Allocation Plan

- Clear, easy-to-manage guideline.

As defined in Chapter 9. Groundwater Allocation Guidelines and Policies.

- Optimise, maximise groundwater usage in any particular area.

*Maximum allocation limits have been set for each aquifer in subareas west of the Darling Fault (Table 12). Usage is subject to constraints such as availability, effects on environment and planning policy.*

- User friendly, customer focused.

*Objectives applied in current Allocation Plan as seen for example in the subarea 'factsheets', Chapter 10.*

- Define allocation process.

*See Chapter 8.*

- Aid for Water and Rivers Commission policing of the groundwater resource.

Aided in the adoption of Groundwater Allocation Policies (Chapter 9).

- Reduce time-consuming communication between Head Office and Regions.

Aided in the adoption of Groundwater Allocation Policies (Chapter 9, e.g. SWA-2).

- Define priority (beneficial) use - short-term, long-term.

*See Chapter 9.1.2, SWA-5.*

- A good allocation plan will make the Advisory Committee largely unnecessary except for its role to monitor policy implementation.



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Groundwater allocation issues are addressed by the Swan Region with principal support from the Policy and Planning Division. Groundwater licences are issued by the Water and Rivers Commission without direct Advisory Committee involvement if the licence applications conform with all necessary conditions. Matters of groundwater allocation policy are referred to the Advisory Committee for action.

*See Chapter 9.1, SWA-1, SWA-2.*

- Groundwater allocation plan/policy supports Shire plan/policy supports Government plan/policy.

*See Chapter 2.2, Chapter 9.1 SWA-5.*

- Provide concise means of what the Swan Groundwater Advisory Committee is about, unambiguous.

*See Chapter 8.3.*

- Public information, availability, criteria for access to groundwater

*The Allocation Plan is a 'public' document and available for examination at Shire Offices, public libraries and at the Water and Rivers Commission (Head Office and Swan Region office). The Water and Rivers Commission will also produce a general summary of groundwater issues addressed in the Swan Groundwater Allocation Plan. The summary will be produced in a pamphlet which will be widely distributed throughout Swan Groundwater Area.*

- Identify current groundwater usage.

*See Chapter 7.*

- Priorities based on tangible long lasting value added.

*See Chapter 9.5.*

- Flexibility.

*See Chapter 9.5.*

- Terms of licences.

*See Chapter 9.2.*

- Grievance procedure, eg. appeals.

*See Chapter 8.2.*

- Establishes manageable guideline's.

*See Chapter 9.*

- Describes licensing

*See Chapter 8.*

- Contains data to support licensing activity.

*See Chapters 6, 7.*

- Fair and accountable framework over useable limited resource.

*See Chapter 9.*

#### **Swan Pamphlet-**

- To overcome some public criticism of committee membership (representation of community groups) a pamphlet could be published including a description of committee members and credentials.

This description is to be included in the Swan Groundwater Area Pamphlet.

**Groundwater Allocation Policies** - as defined on pages 9 and 10 of the *1991 Swan Groundwater Area Management Plan*.

*The comments/policies for the 1991 Management Plan have been addressed and amended in Chapters 9 and 10 of the current Allocation Plan.*

**Swan Groundwater Advisory Committee Objectives** as defined on pages 8 and 9 of the *1991 Swan Groundwater Area Management Plan*

*See Chapter 8.3.*

#### **Process for Groundwater Applications**

*See Chapter 8. A series of comprehensive reports on standards and procedures relating to groundwater well licensing have been published by the Water and Rivers Commission (1996).*

#### **Advisory Committee Membership - General Requirements**

*See Chapter 8.3.*

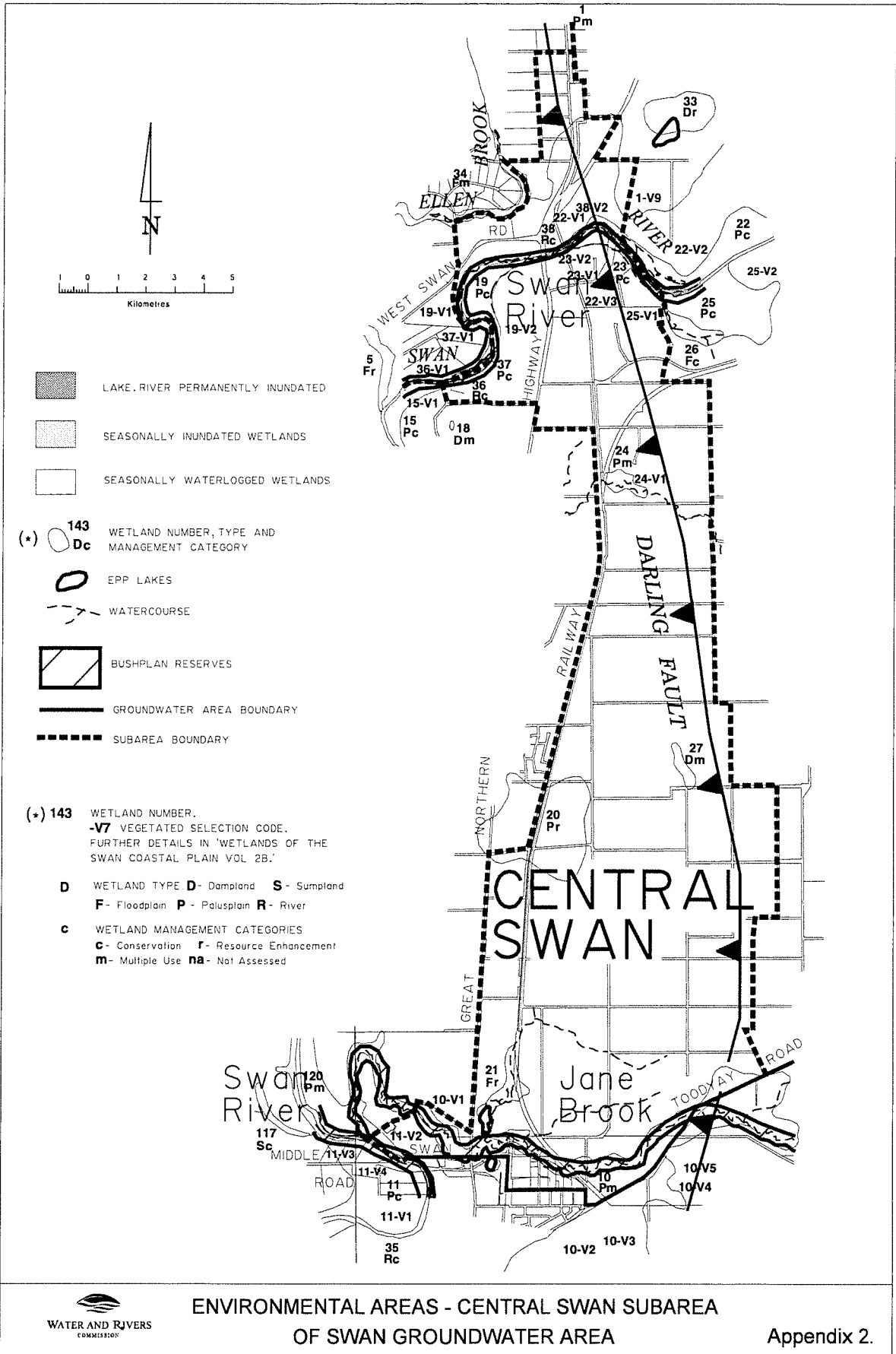
#### **Swan/Bullsbrook Groundwater Advisory Committee**

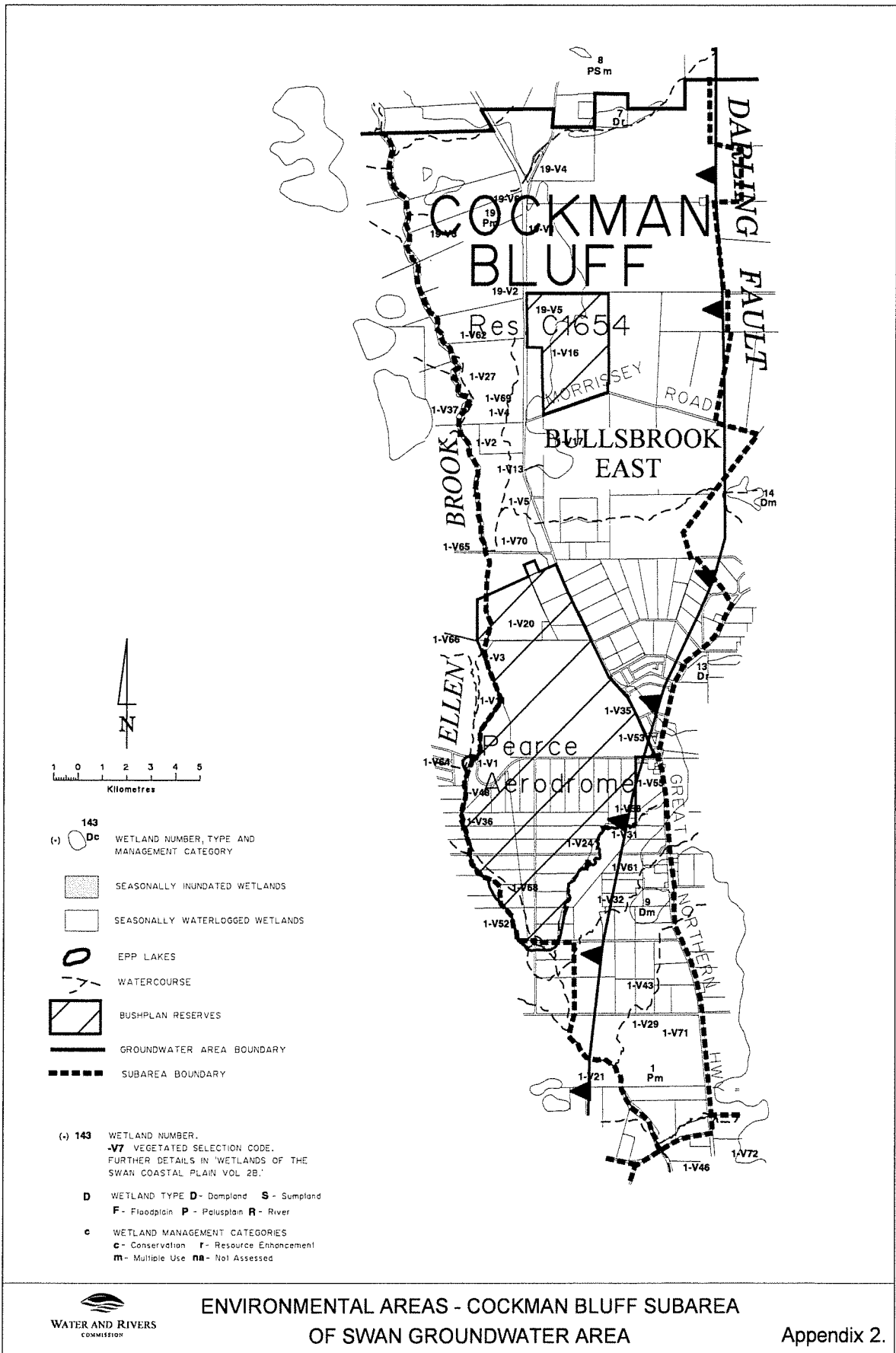
*See Chapter 8.3. The recommendations on the composition of the Swan Groundwater Advisory Committee are currently under consideration by the Water and Rivers Commission. It is expected that most of the recommendations will be adopted.*

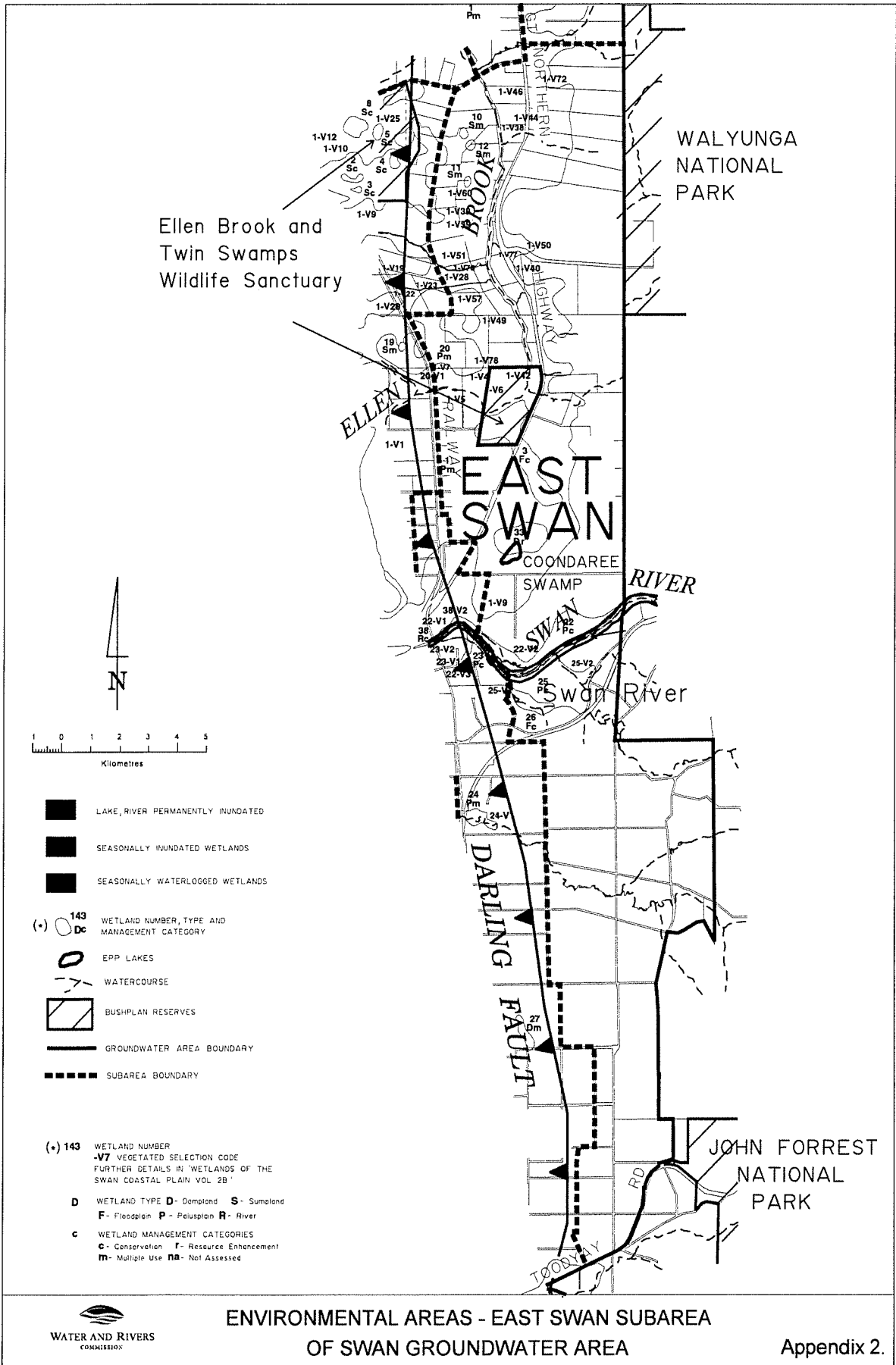






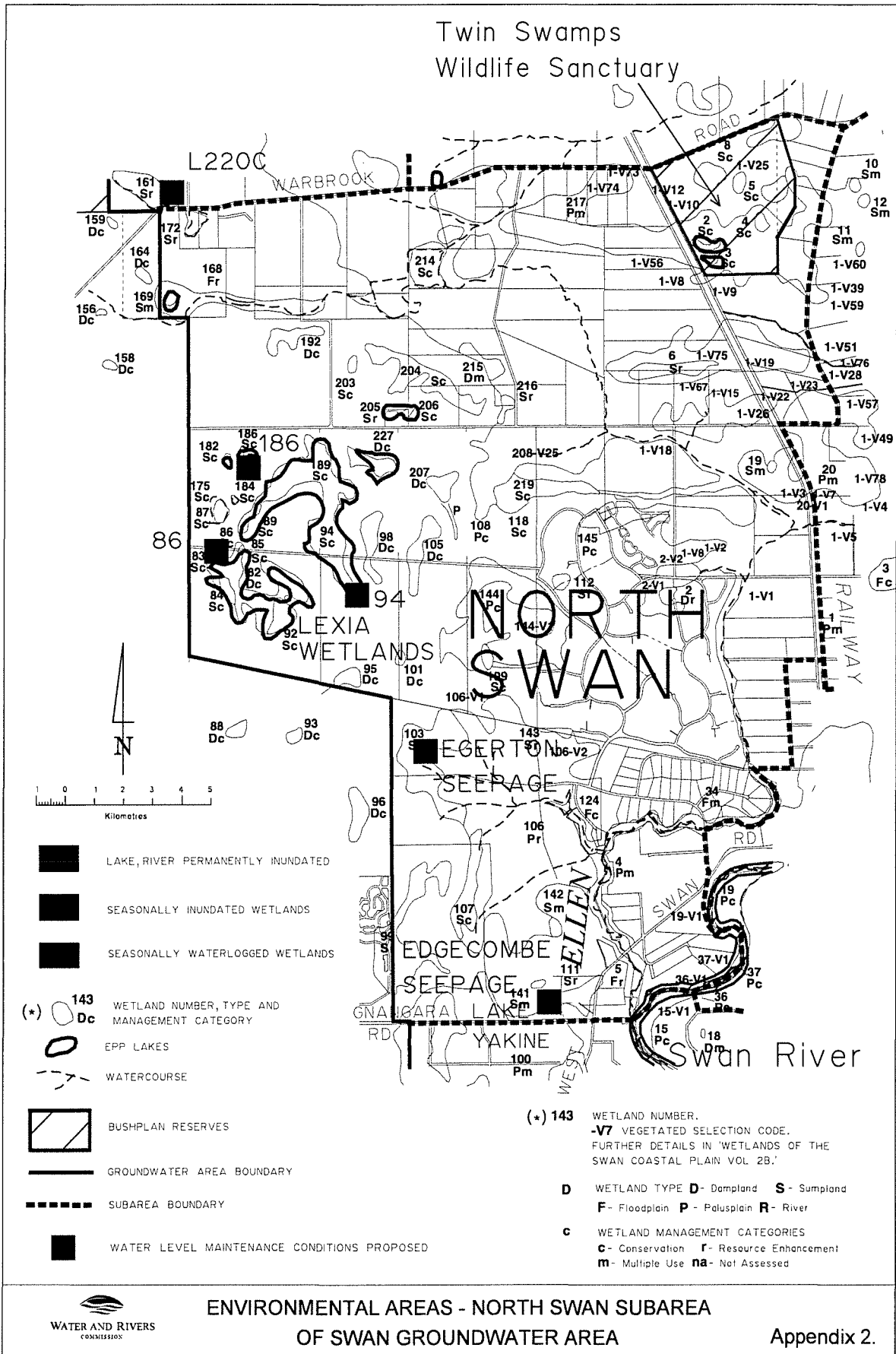


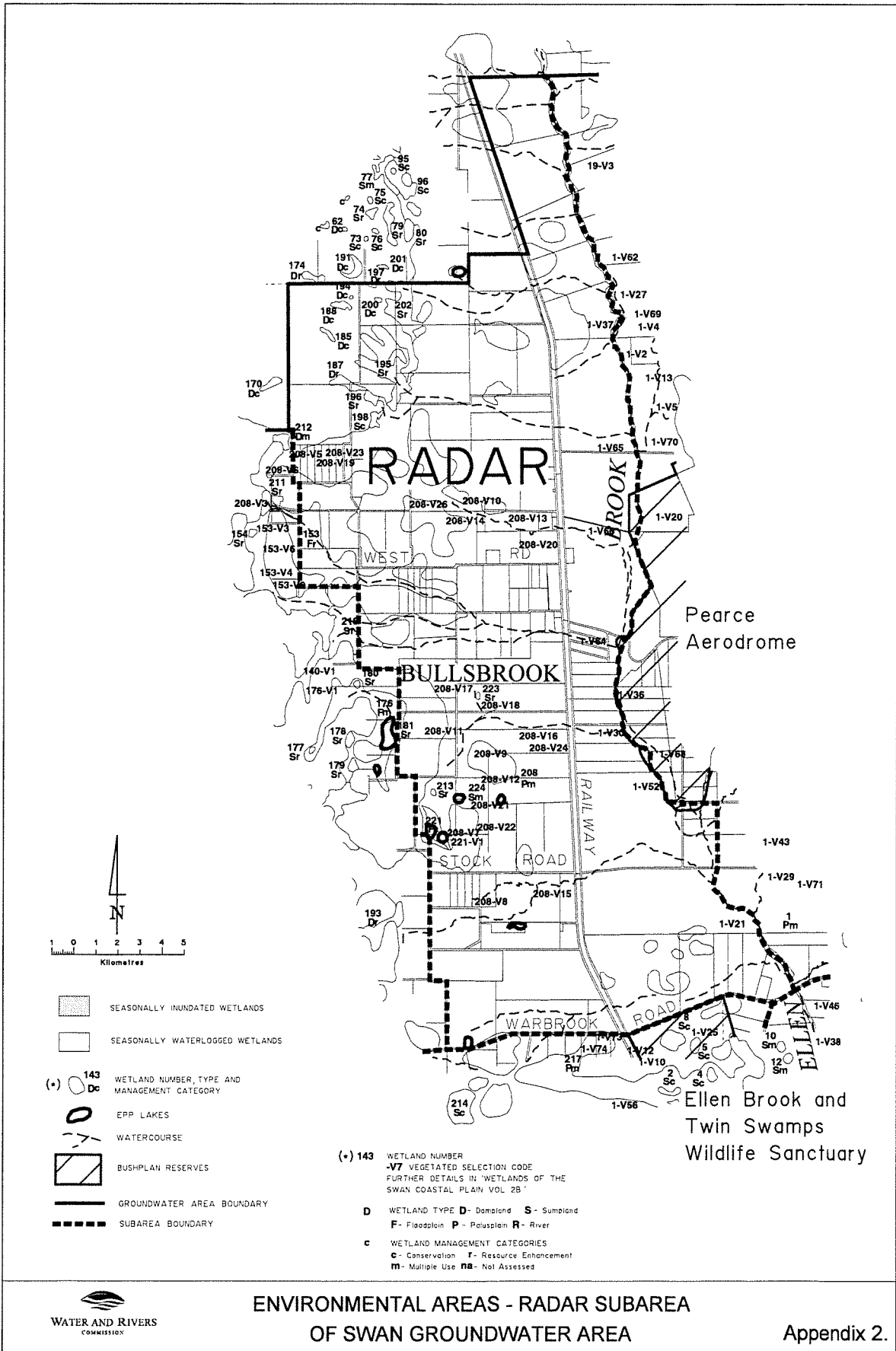






# Twin Swamps Wildlife Sanctuary









# Appendix 3

## Recommended Groundwater Monitoring Program in the Swan Groundwater Area

| CHEMISTRY**                | WELL        | COMMENT   |                             |                                           |                                                                               |
|----------------------------|-------------|-----------|-----------------------------|-------------------------------------------|-------------------------------------------------------------------------------|
| <b>SUPERFICIAL AQUIFER</b> |             |           |                             |                                           |                                                                               |
|                            | 3 New Wells | -         | (A) Monthly+ ,<br>Quarterly | (A) Salinity annually                     | 2 Wells in Cockman Bluff<br>and 1 well in Radar Subareas<br>Adjacent to AM31a |
|                            | GD12        | G61611074 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | GD13        | G61611084 | (NC) Quarterly              | (A) Comprehensive<br>chemistry annually++ |                                                                               |
|                            | GD14        | G61611077 | (NC) Quarterly              |                                           |                                                                               |
|                            | GD15        | G61611085 | (NC) Quarterly              | (A) Comprehensive<br>Chemistry annually++ | Needs replacing                                                               |
|                            | GD16        | G61611071 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | GD 17       | G61611072 | (NC) Quarterly              | (A) Comprehensive<br>Chemistry annually++ |                                                                               |
|                            | GD 19       | G61611083 | (NC) Quarterly              | (A) Comprehensive<br>Chemistry annually++ |                                                                               |
|                            | GN14        | G61611062 | (NC) Quarterly              |                                           |                                                                               |
|                            | GN21        | G61611019 | (NC) Quarterly              |                                           |                                                                               |
|                            | GN24        | G61611043 | (NC) Monthly                | (A) Salinity annually                     |                                                                               |
|                            | NR2C        | G61611021 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | NR4C        | G61611020 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | NR11C       | G61611042 | (NC) Monthly                | (A) Salinity annually                     |                                                                               |
|                            | PB1         | G61611035 | (C) Quarterly               |                                           |                                                                               |
|                            | PB2         | G61611034 | (NC) Monthly                |                                           |                                                                               |
|                            | PB3         | G61611031 | (C) Quarterly               | (A) Salinity annually                     |                                                                               |
|                            | PB10        | G61611052 | (C) Quarterly               |                                           |                                                                               |
|                            | M81         | G61610551 | (NC) Quarterly              |                                           |                                                                               |
|                            | M190        | G61610574 | (C) Monthly                 | (A) Salinity annually                     |                                                                               |
|                            | M290        | G61610577 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | MM45        | G61610545 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | MM47        | G61610546 | (NC) Quarterly              |                                           |                                                                               |
|                            | MM47A       | G61610547 | (NC) Quarterly              |                                           |                                                                               |
|                            | MM48        | G61610570 | (NC) Quarterly              |                                           |                                                                               |
|                            | MM48A       | G61610571 | (NC) Quarterly              |                                           |                                                                               |
|                            | MM51A       | G61610572 | (NC) Quarterly              | (A) Salinity annually                     |                                                                               |
|                            | MM57        | G61610576 | (C) Monthly                 | (A) Salinity annually                     |                                                                               |
|                            | MM61        | G61611048 | (C) Monthly                 | (A) Comprehensive<br>chemistry annually++ | Downflow from Ellenbrook<br>urban area                                        |
|                            | MM63        | G61611050 | (C) Monthly                 | (A) Comprehensive<br>Chemistry annually++ | Downflow from Ellenbrook<br>urban area                                        |
|                            | MM64        | -         | (C) Monthly                 | (A) Comprehensive<br>chemistry annually++ | Well to be redrilled. Well<br>near Ellenbrook urban area                      |

(cont.)



| AQUIFER/<br>WELL             | STATION NO. | LEVEL*                         | CHEMISTRY**                               | COMMENT           |
|------------------------------|-------------|--------------------------------|-------------------------------------------|-------------------|
| L50A                         | G61611032   | (NC) Quarterly                 |                                           |                   |
| L50C                         | G61611033   | (NC) Quarterly                 |                                           |                   |
| L60A                         | G61611054   | (NC) Quarterly                 |                                           |                   |
| L60C                         | G61611053   | (NC) Quarterly                 |                                           |                   |
| L80A                         | G61611063   | (C) Monthly                    |                                           | Near Vines Resort |
| L80C                         | G61611064   | (C) Monthly                    | (A) Salinity annually                     | Near Vines Resort |
| L90A                         | G61611075   | (NC) Monthly                   |                                           |                   |
| L90C                         | G61611076   | (NC) Monthly                   |                                           |                   |
| L130A                        | G61611036   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L130C                        | G61611077   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L140A                        | G61611057   | (NC) Quarterly                 |                                           |                   |
| L140C                        | G61611056   | (NC) Quarterly                 |                                           |                   |
| L150A                        | G61611059   | (NC) Quarterly                 |                                           |                   |
| L150C                        | G61611058   | (NC) Quarterly                 |                                           |                   |
| L160A                        | G61611066   | (NC) Quarterly                 |                                           |                   |
| L160C                        | G61611065   | (NC) Quarterly                 |                                           |                   |
| L170A                        | G61611080   | (C) Quarterly                  | (A) Salinity annually                     |                   |
| L170C                        | G61611079   | (C) Quarterly                  | (A) Comprehensive<br>chemistry annually++ |                   |
| L230A                        | G61611038   | (NC) Quarterly                 |                                           |                   |
| L230C                        | G61611039   | (NC) Quarterly                 |                                           |                   |
| L240A                        | G61611040   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L240C                        | G61611041   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L260A                        | G61611067   | (NC) Quarterly                 |                                           |                   |
| L260C                        | G61611068   | (NC) Quarterly                 |                                           |                   |
| L270A                        | G61611069   | (NC) Quarterly                 |                                           |                   |
| L270C                        | G61611070   | (NC) Quarterly                 |                                           |                   |
| L280A                        | G61611081   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L280C                        | G61611082   | (NC) Quarterly                 | (A) Comprehensive<br>chemistry annually++ |                   |
| L310A                        | G61611173   | (NC) Quarterly                 |                                           |                   |
| L320A                        | G61611174   | (NC) Quarterly                 |                                           |                   |
| L320C                        | G61611175   | (NC) Quarterly                 |                                           |                   |
| L330A                        | G61611178   | (NC) Quarterly                 |                                           |                   |
| L330C                        | G61611179   | (NC) Quarterly                 |                                           |                   |
| L340A                        | G61611182   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L340C                        | G61611183   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| L350A                        | G61611184   | (NC) Quarterly                 |                                           |                   |
| L350C                        | G61611185   | (NC) Quarterly                 |                                           |                   |
| 10/85                        | G61619610   | (NC) Quarterly                 | (A) Salinity 1997<br>then 3-yearly        |                   |
| 11/85                        | G61619611   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| 15/85                        | G61619615   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| 2/87                         | G61619294   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| 4/87                         | G61619296   | (NC) Quarterly                 | (A) Salinity annually                     |                   |
| 8/85                         | G61619608   | (NC) Quarterly                 | (A) 1997 then 3-yearly                    |                   |
| GNM 14 & EPP<br>173 wetland  | G61613213   | (NC) Monthly<br>well & wetland | (NC) EPP173annually<br>Comprehensive++    | Wetland Series    |
| GNM15 &<br>Lexia 186 wetland | G61613214   | (NC) Monthly<br>well & wetland | (NC)Lexia186Annually<br>Comprehensive++   |                   |

(cont.)



| AQUIFER/<br>WELL           | STATION NO. | LEVEL*                         | CHEMISTRY**                               | COMMENT                 |
|----------------------------|-------------|--------------------------------|-------------------------------------------|-------------------------|
| GNM16 &<br>Lexia 86        | G61613215   | (NC) Monthly<br>Well & Wetland | (NC) Lexia 86 annually<br>Comprehensive++ |                         |
| GNM17a                     | G61613216   | (NC) Monthly                   |                                           |                         |
| GNM17b                     | G61613217   | (NC) Monthly                   |                                           |                         |
| EGERTON<br>SEEPAGE         |             | (NC) Monthly                   | (NC) annually<br>Comprehensive++          | Access currently denied |
| EDGECOMBE<br>SEEPAGE       |             | (NC) Monthly                   | (NC) annually<br>Comprehensive++          | Access currently denied |
| BEBICH                     | G61619274   |                                | (C) Salinity annually                     | Previously quarterly    |
| BONDI                      | G61619275   |                                | (C) Salinity annually                     | "                       |
| CARNE                      | G61619273   |                                | (C) Salinity 1997<br>then 3-yearly        | "                       |
| D'ANGELO                   | G61619277   |                                | (C) Salinity annually                     | "                       |
| MANOLINI                   | G61619283   |                                | (C) Salinity annually                     | " (pump seized)         |
| NIELSON                    | G61619285   |                                | (C) Salinity annually                     | "                       |
| SCOTT                      | G61619286   |                                | (C) Salinity annually                     | "                       |
| SHAW EST BELL              | G61619288   |                                | (C) Salinity annually                     | "                       |
| SORGIOVANNI                | G61619281   |                                | (C) 1997 then 3-yearly                    | "                       |
| STONE                      | G61619287   |                                | (C) Salinity annually                     | "                       |
| THOMAS                     | G61619292   |                                | (C) Salinity annually                     | "                       |
| NO.2 MULTIPLEX             | G61619270   |                                | (C) Salinity annually                     | "                       |
| NO.3 MULTIPLEX             | G61619271   |                                | (C) 1997 then 3-yearly                    | "                       |
| NO.28 SEVEN<br>PILLAR      | G61619254   |                                | (C) 1997 then 3-yearly                    | "                       |
| NO.29 BELHUS<br>ESTATE     | G61619255   |                                | (C) 1997 then 3-yearly                    | "                       |
| NO.45<br>MIJACIKA          | G61619256   |                                | (C) 1997 then 3-yearly                    | "                       |
| NO.47 TAYLOR<br>BROS       | G61619257   |                                | (C) Salinity annually                     | "                       |
| NO.68 HAMPTON<br>HATCH     | G61619258   |                                | (C) Salinity annually                     | "                       |
| NO.71 NATAKE               | G61619259   |                                | (C) Salinity 1997 then 3-yearly           | "                       |
| NO.72 CEPO                 | G61619260   |                                | (C) Salinity 1997 then 3-yearly           | "                       |
| NO.76 DEL<br>BORRELLO      | G61619261   |                                | (C) Salinity annually                     | "                       |
| NO. 87 SWAN<br>RESEARCH    | G61619262   |                                | (C) Salinity 1997 then 3-yearly           | (property for sale)     |
| NO. 96 DELLA               | G61619264   |                                | (C) Salinity annually                     | "                       |
| YURISCH                    | G61619625   |                                | (A) Salinity 1997 then 3- yearly          | Previously GSWA         |
| UPPER SWAN<br>PRIM. SCHOOL | G61619631   |                                | (A) Salinity 1997 then 3-yearly           | "                       |
| WORTHINGTON                | G61619636   |                                | (A) Salinity 1997 then 3-yearly           | "                       |
| KATICH                     | G61619637   |                                | (A) Salinity 1997 then 3-yearly           | "                       |
| RULLO A                    | G61619645   |                                | (A) Salinity 1997 then 3-yearly           | "                       |
| McSHANE                    | G61619652   |                                | (A) Salinity 1997 then 3-yearly           | "                       |
| MEWS                       | G61619656   |                                | (A) Salinity 1997 then 3-yearly           | "                       |

(cont.)



| AQUIFER/<br>WELL           | STATION NO. | LEVEL*         | CHEMISTRY**            | COMMENT                       |
|----------------------------|-------------|----------------|------------------------|-------------------------------|
| <b>MIRRABOOKA AQUIFER</b>  |             |                |                        |                               |
| 7/85                       | G61619607   | (NC) Quarterly | (A) Salinity annually  |                               |
| 14/85                      | G61619614   | (NC) Quarterly | (A) Salinity annually  |                               |
| 16/85                      | G61619616   | (NC) Quarterly | (A) Salinity annually  |                               |
| L52                        | G61611176   | (NC) Quarterly | 'Once off'             | Needs redeveloping            |
| L132                       | G61611115   | (NC) Quarterly | 'Once off'             |                               |
| L142                       | G61611177   | (NC) Quarterly | 'Once off'             |                               |
| L242                       | G61611171   | (NC) Quarterly | (A) Salinity annually  | Needs redeveloping            |
| PB19                       | G61611055   | (C) Quarterly  | (A) Salinity annually  |                               |
| TAYLOR                     | G61619618   |                | (A) Salinity annually  | Previously GSWA               |
| ANTUNOVICH                 | G61619626   |                | (A) Salinity annually  | "                             |
| SARICH                     | G61619627   |                | (A) Salinity annually  | "                             |
| <b>LEEDERVILLE AQUIFER</b> |             |                |                        |                               |
| 1 New Well                 |             | (A) Quarterly  | (A) Salinity Annually  |                               |
| AM26A                      | G61615100   | (NC) Quarterly | 'Once off'             |                               |
| AM26B                      | G61615101   | (NC) Quarterly | 'Once off'             |                               |
| AM29A                      | G61615098   | (NC) Quarterly | 'Once off'             |                               |
| AM31A                      | G61615105   | (NC) Monthly   | 'Once off'             |                               |
| AM35                       | G61615055   | (NC) Monthly   | 'Once off'             |                               |
| PB12                       | G61615099   | (C) Quarterly  | (A) Salinity annually  | Needs redeveloping            |
| 4/85                       | G61619604   | (NC) Quarterly | (A) Salinity annually  |                               |
| 6/85                       | G61619606   | (NC) Quarterly | 'Once off'             |                               |
| 1/87                       | G61619293   | (NC) Quarterly | (A) Salinity annually  |                               |
| 3/87                       | G61619295   | (NC) Quarterly | (A) Salinity annually  |                               |
| 5/87                       | G61619297   | (NC) Quarterly | 'Once off'             |                               |
| 6/87                       | G61619298   | (NC) Quarterly | 'Once off'             |                               |
| PRNICH                     | G61619650   |                | (A) Salinity annually  | "                             |
| KENDALL                    | G61619263   |                | (C) Salinity annually  | Monitored by WAWA<br>and GSWA |
| SWAN ATH CLUB              | G61619289   |                | (C) annually           | "                             |
| SWAN RES. STA.             | G61619291   |                | (C) annually           | (property for sale)           |
| HENLEY PARK                | G61619619   |                | (A) 1997 then 3-yearly | Previously GSWA               |
| MULTIPLEX                  | G61619620   |                | (A) 1997 then 3-yearly | "                             |
| GREEN                      | G61619621   |                | (A) 1997 then 3-yearly | "                             |
| GUILDFORD<br>CARAVAN PK.   | G61619622   |                | (A) 1997 then 3-yearly | "                             |

(cont.)



| AQUIFER/<br>WELL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | STATION NO. | LEVEL*         | CHEMISTRY**            | COMMENT |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|------------------------|---------|
| SANDLEFORD<br>WINES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | G61619623   |                | (A) 1997 then 3-yearly | "       |
| LENDICH                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619624   |                | (A) 1997 then 3-yearly | "       |
| GERRARD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619629   |                | (A) 1997 then 3-yearly | "       |
| OKMAZICH                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | G61619632   |                | (A) 1997 then 3-yearly | "       |
| WILSON                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | G61619635   |                | (A) 1997 then 3-yearly | "       |
| BUSELICH                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | G61619638   |                | (A) 1997 then 3-yearly | "       |
| BIGNELL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619639   |                | (A) 1997 then 3-yearly | "       |
| RENDALL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619640   |                | (A) 1997 then 3-yearly | "       |
| BEROS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | G61619641   |                | (A) 1997 then 3-yearly | "       |
| RULLO B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619642   |                | (A) 1997 then 3-yearly | "       |
| MATELJAN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | G61619643   |                | (A) 1997 then 3-yearly | "       |
| BARETT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | G61619646   |                | (A) 1997 then 3-yearly | "       |
| DAWSON                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | G61619647   |                | (A) 1997 then 3-yearly | "       |
| STOWE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | G61619648   |                | (A) 1997 then 3-yearly | "       |
| STONE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | G61619649   |                | (A) 1997 then 3-yearly | "       |
| SIMPSON                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619651   |                | (A) 1997 then 3-yearly | "       |
| BOWMAN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | G61619653   |                | (A) 1997 then 3-yearly | "       |
| LOVRETA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | G61619654   |                | (A) 1997 then 3-yearly | "       |
| RUDEZ                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | G61619655   |                | (A) 1997 then 3-yearly | "       |
| <b>YARRAGADEE AQUIFER</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |             |                |                        |         |
| AM26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | G61615107   | (NC) Quarterly | 'Once off'             |         |
| AM29                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | G61615097   | (NC) Quarterly | 'Once off'             |         |
| AM31                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | G61615104   | (NC) Monthly   | 'Once off'             |         |
| AM35A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | G61615056   | (NC) Monthly   | 'Once off'             |         |
| <p>* <i>A = addition = represents a new measurement.</i><br/> <i>C = change = represents a change to a current measurement, e.g. quarterly to annually.</i><br/> <i>NC = no change to current measurement.</i></p> <p>** <i>All groundwater salinity sampling is to be done in the months of March/April and measured for conductivity in the field. Conversion factor from conductivity to TDS is 5.6 for the superficial aquifer in the Swan Groundwater Area. Conversion factors for the Mirrabooka and Leederville aquifer need to be determined. For components for comprehensive chemical analysis, refer to McCrea (1997).</i></p> <p>+ <i>Some new superficial monitoring wells in the north should be sampled monthly for water level. Other new wells should be sampled quarterly.</i></p> <p>++ <i>Components of comprehensive chemical analysis given in McCrea (1997).</i></p> |             |                |                        |         |

(cont.)



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# Appendix 4

## Horticulture Development Application Form

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*To assist with processing your proposal please provide the following information:*

|                  |
|------------------|
| <b>SECTION A</b> |
|------------------|

1. Applicant's name: .....
2. Postal address:  
.....  
.....  
.....
3. Phone number: ..... Fax: .....
4. Property address (include street address and/or lot number):  
.....  
.....  
.....
5. Local shire: .....
6. Current zoning of site under the Town Planning Scheme (this information is available from the shire):  
.....
7. Size of property (in hectares): .....

|                  |
|------------------|
| <b>SECTION B</b> |
|------------------|

8. On a locality plan, show where the property is located in relation to:
  - wetlands;
  - watercourses;
  - remnant native vegetation;
  - crown land, including existing or proposed national parks, nature reserves etc. (confirmation should be sought from the shire if unknown); and
  - adjoining landuses.



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## Horticulture Development Application Form

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### SECTION C

9. On a site plan drawn to scale please indicate the location of:

- production bores;
- irrigation areas (e.g. centre pivot sites);
- native vegetation or bush to be cleared;
- main soil types;
- areas to be replanted (plantation trees or native bushland);
- height contours;
- any winter flowing drainage lines (show direction flow);
- areas of waterlogging;
- rivers, swamps, streams or lakes; and
- the direction of groundwater flow.

### SECTION D

10. What is the current landuse on the property?

.....  
.....

11. What is the proposed horticultural activity (i.e. market garden, turf farm, floriculture)?

***Please complete Table 1 to provide additional details regarding the proposal.***

.....

12. What is the depth to groundwater in summer: ..... metres.

13. How much irrigation water will you need in a year? ..... kilolitres.

14. What is the proposed source of the irrigation water? (groundwater, main water supply)

.....

15. Are you constructing perimeter bunds to control surface runoff? If so, please show on the site plan.

YES (circle your answer)

NO



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## Horticulture Development Application Form

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|                          |
|--------------------------|
| <b>SECTION D (cont.)</b> |
|--------------------------|

16. Will 'nutrient stripping' (i.e. vegetation buffers, retention basins) areas be provided? If so, please show on site plan.

.....

17. How will fertiliser requirements be monitored?

.....

.....

18. How will water requirements be monitored?

.....

.....

19. Are there any rare plants and/or animals on the subject lot (if clearing)?

YES     (circle your answer)

NO

If there are rare plants or animals describe which species

.....

20. Describe the soil types (deep grey sand, brown loamy sands, gravel, clay) on the subject lot. Please show the location of the main soil types on the site plan.

.....

21. Are you planning to modify the drainage or amend the soils?

.....

.....

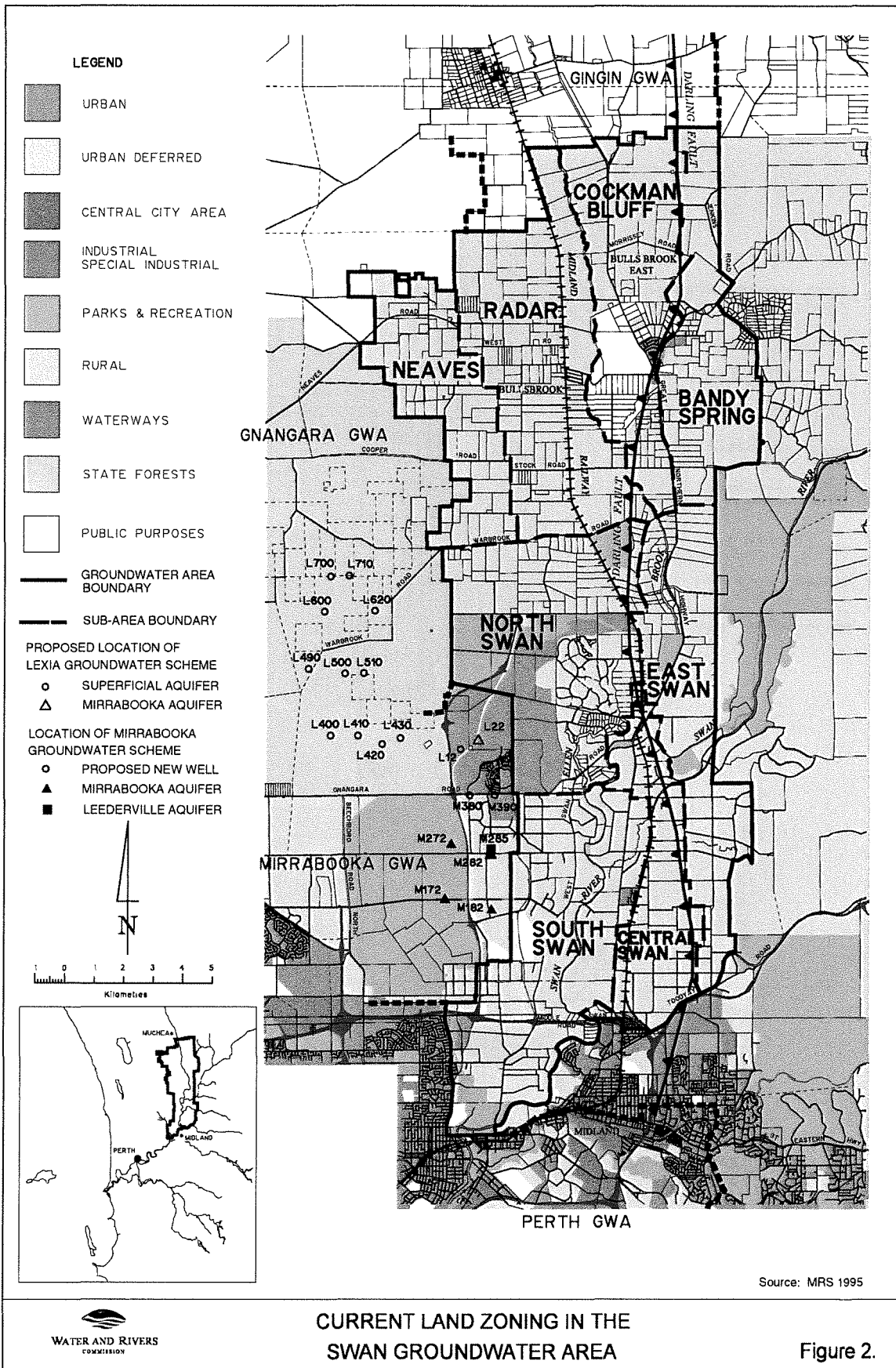
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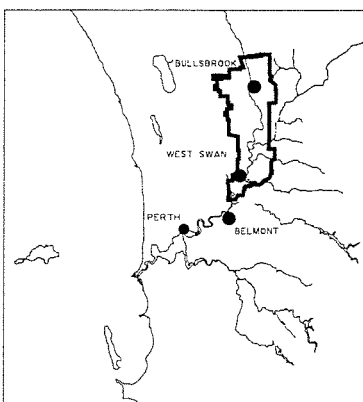
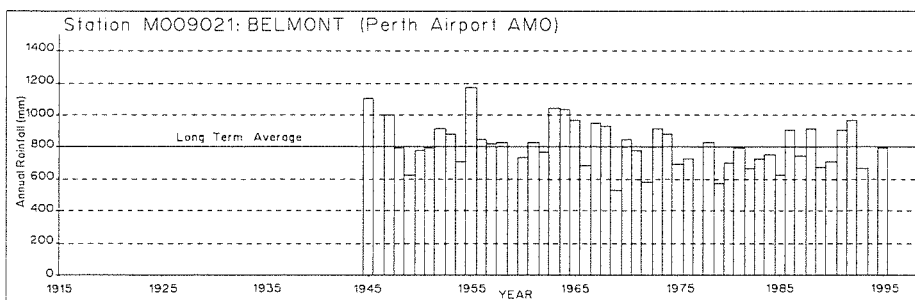
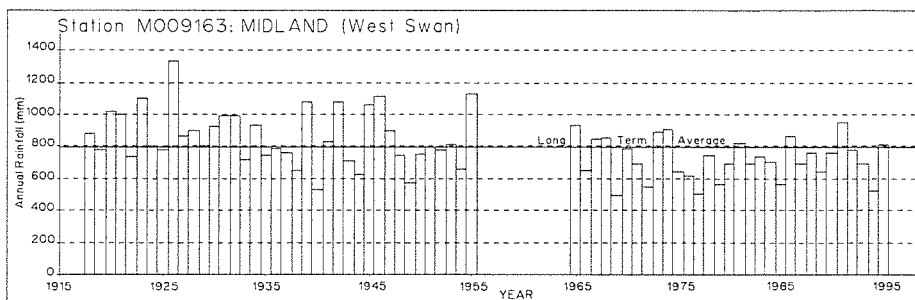
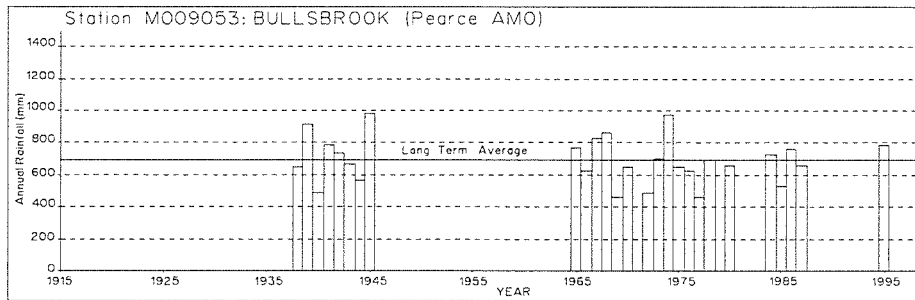


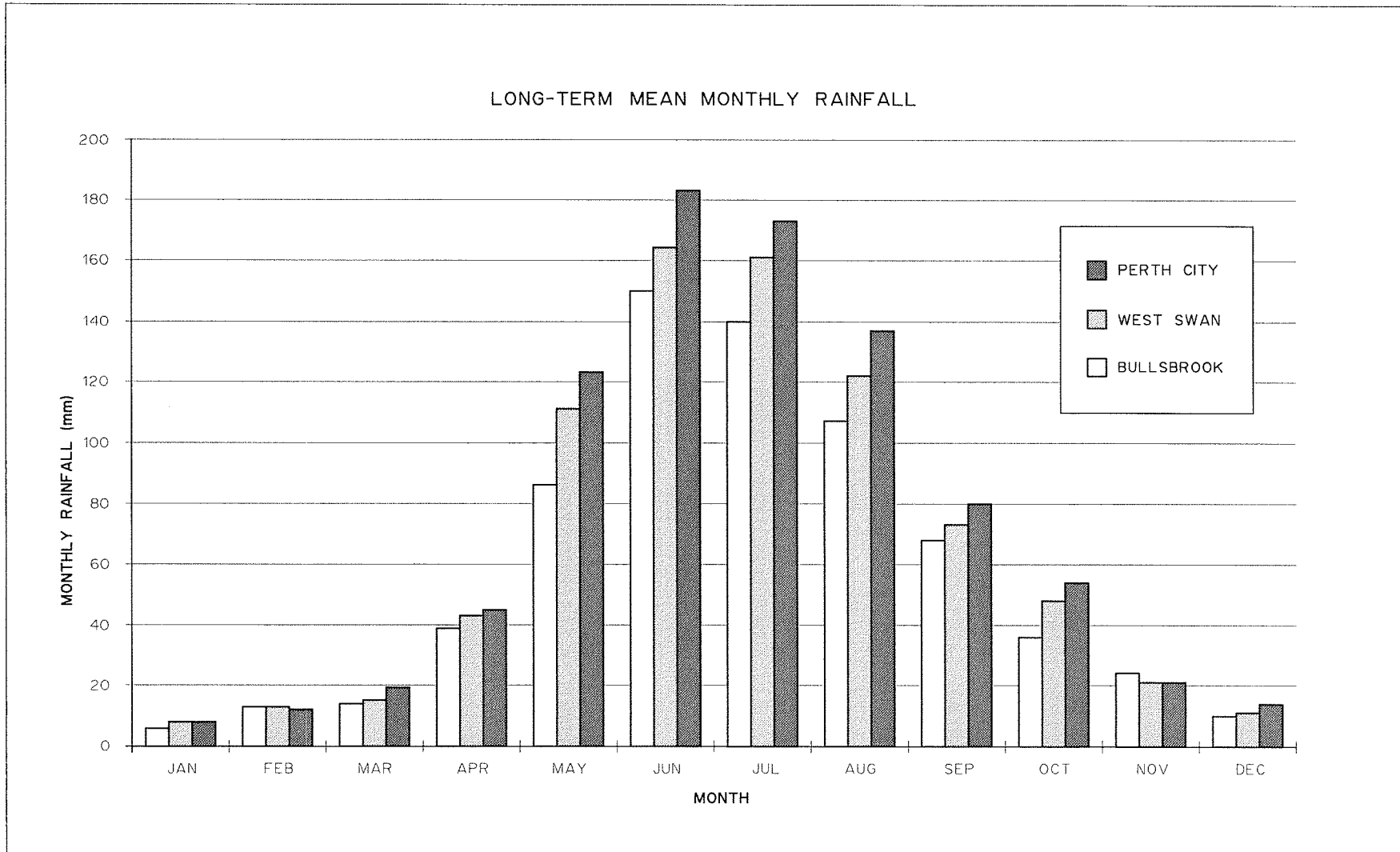






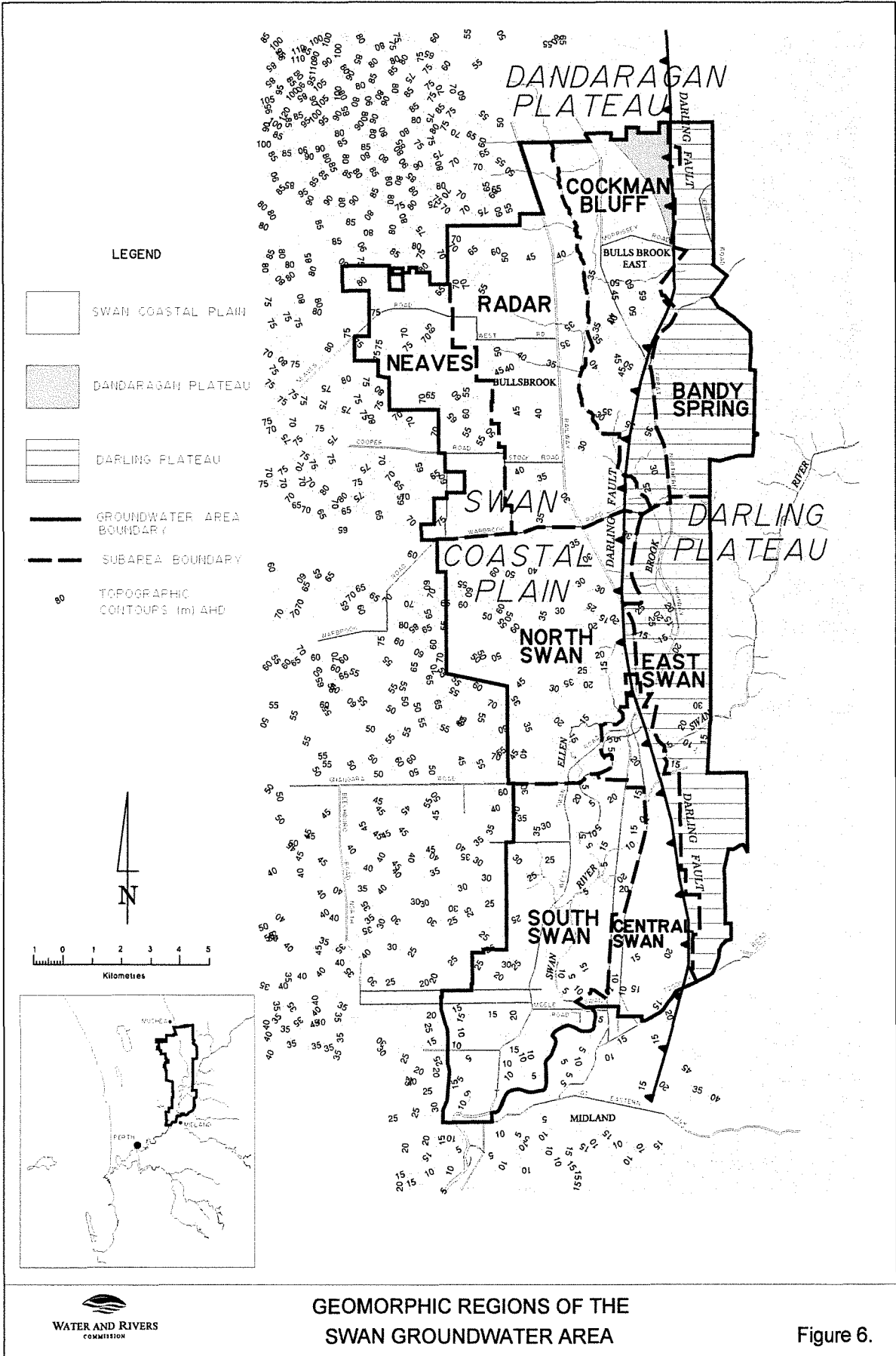






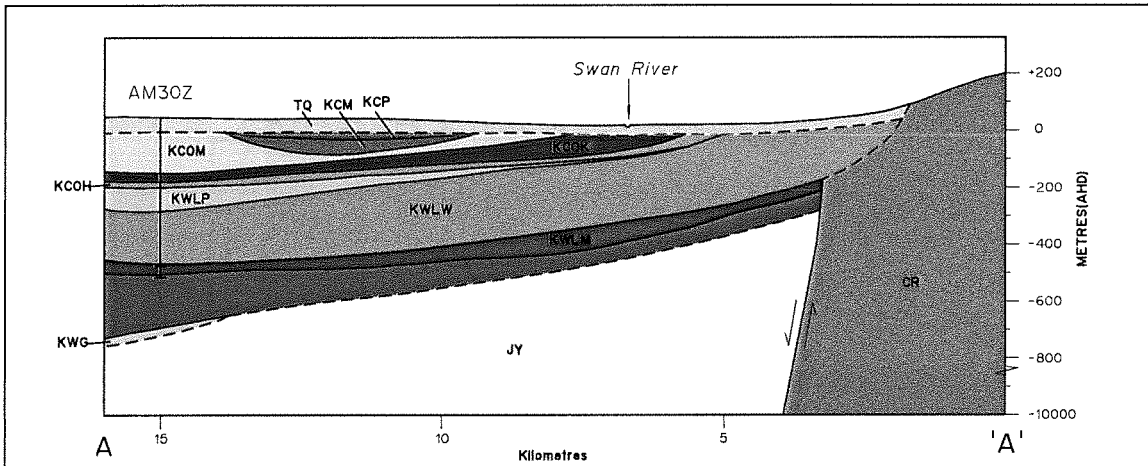
**LONG-TERM MEAN MONTHLY RAINFALL  
FOR BULLSBROOK, WEST SWAN AND PERTH**

Figure 5.



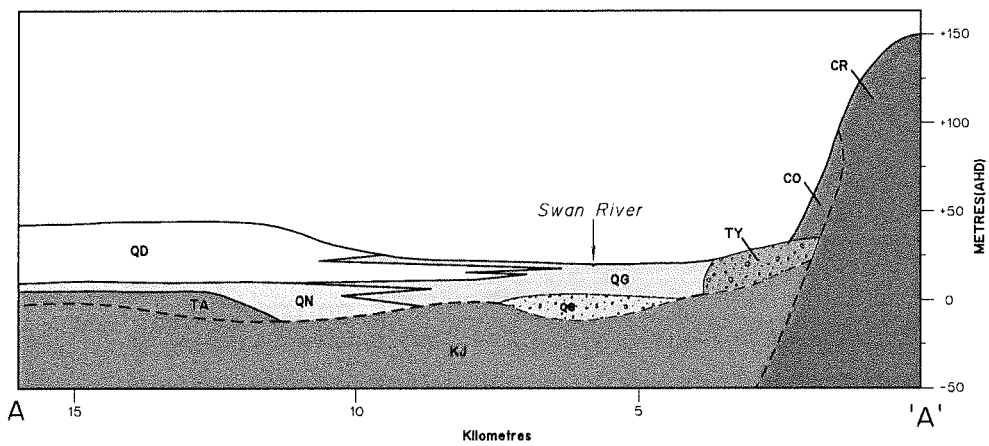
**GEOMORPHIC REGIONS OF THE SWAN GROUNDWATER AREA**

**Figure 6.**

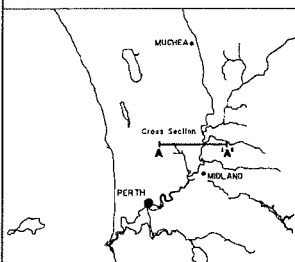


(a) GENERAL STRATIGRAPHY  
(Adopted from W. A. Davidson 1995)

|                  |                       |                              |                         |     |                      |
|------------------|-----------------------|------------------------------|-------------------------|-----|----------------------|
| <b>CAINOZOIC</b> |                       | <b>Osborne Formation</b>     |                         |     |                      |
| TQ               | Superficial Formation | KCOM                         | Mirrabooka Member       | KWS | South Perth Shale    |
|                  |                       | KCOK                         | Kardinya Shale Member   | KWG | Gage Formation       |
| <b>MESOOZOIC</b> |                       | KCOH                         | Henley Sandstone Member | JY  | Yarragadee Formation |
| KCP              | Poison Hill Greensand | <b>Leederville Formation</b> |                         | CR  | Crystalline Rocks    |
| KCM              | Molecap Greensand     | KWLP                         | Pinjar Member           |     |                      |
|                  |                       | KWLW                         | Wanneroo Member         | ↕↕  | Fault                |
|                  |                       | KWLM                         | Marigninup Member       | --- | Major Unconformity   |

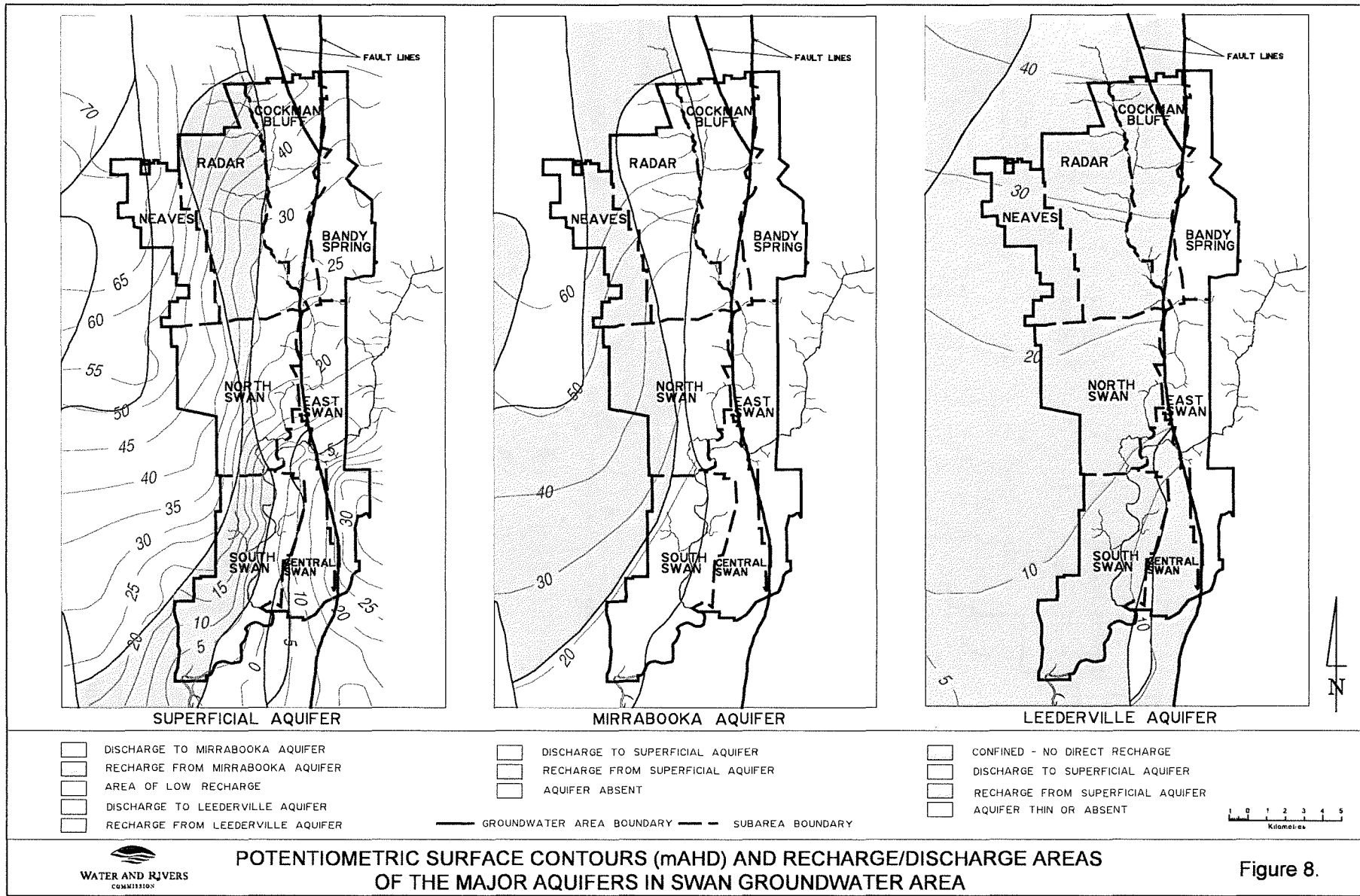


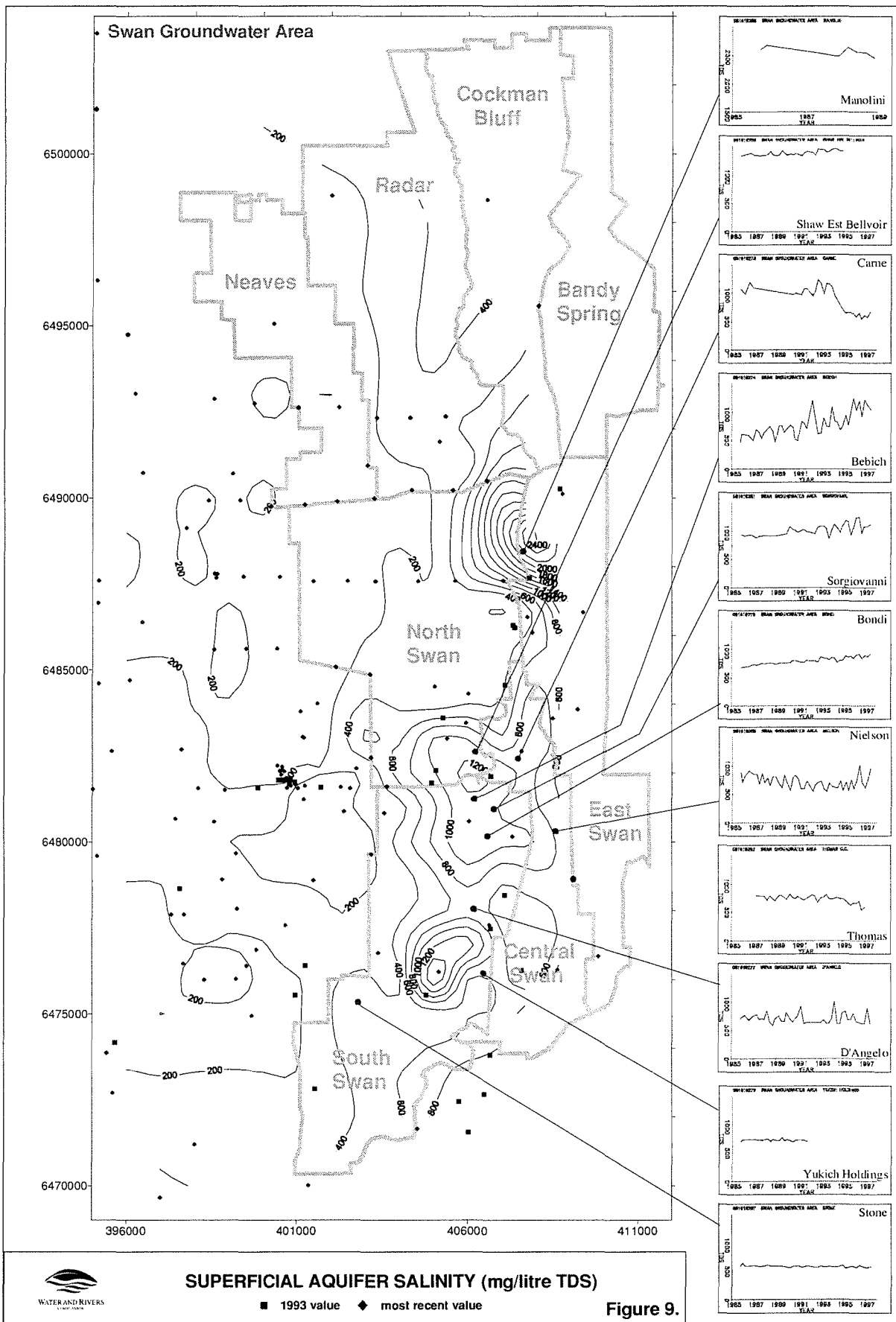
(b) STRATIGRAPHY OF THE SUPERFICIAL FORMATIONS  
(Adopted from W. A. Davidson 1995)

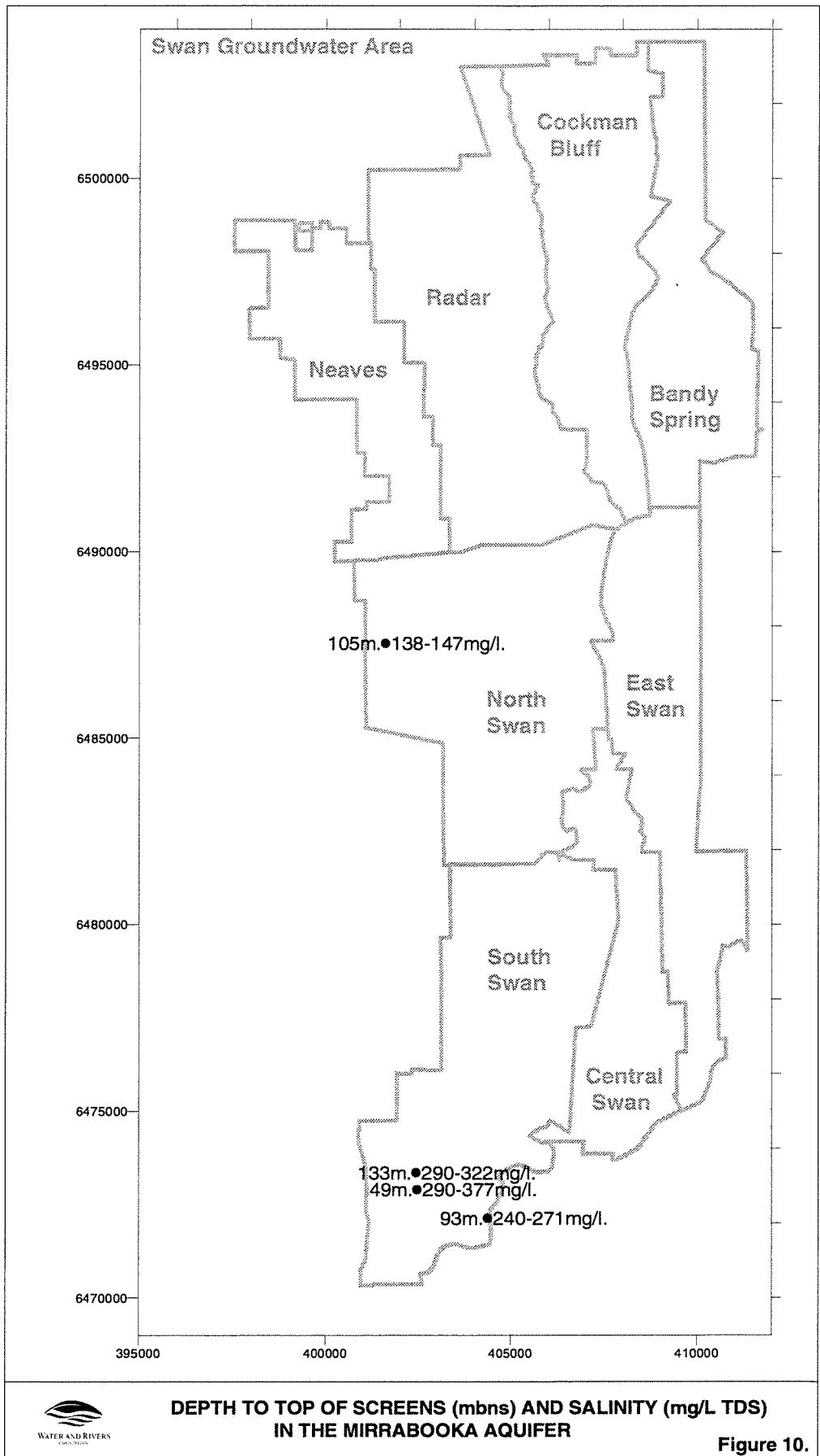


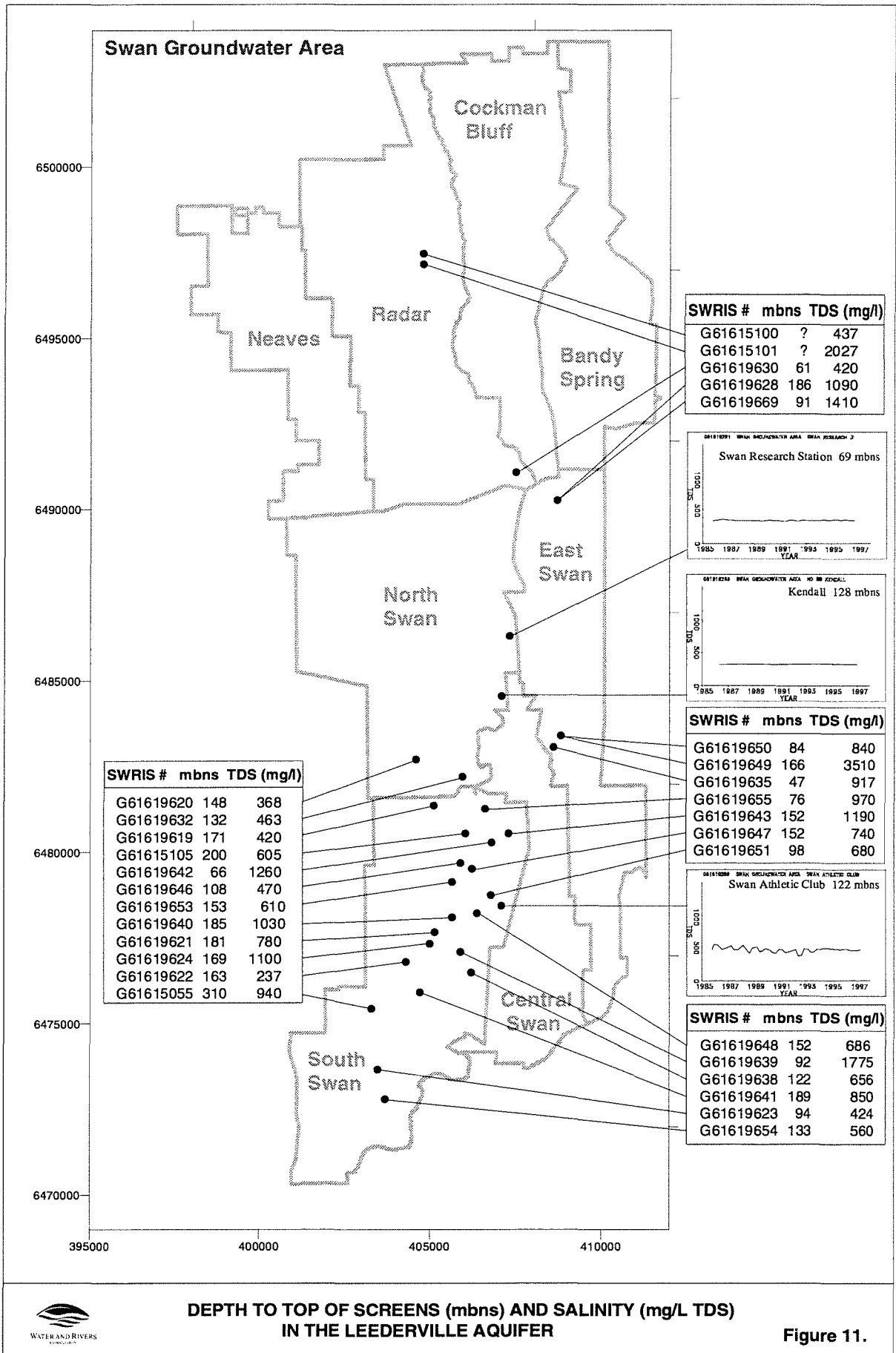
|    |                   |    |                                                              |     |                     |
|----|-------------------|----|--------------------------------------------------------------|-----|---------------------|
| CO | Colluvium         | QD | Bassendean Sand                                              | TA  | Ascot Formation     |
| TY | Yoganup Formation | QN | Gnangara Sand                                                | KJ  | Mesozoic Formations |
|    |                   | QG | Guildford Clay                                               | CR  | Crystalline Rocks   |
|    |                   | QG | Sand and Gravel Remnant Ascot Formation or Yoganup Formation | --- | Major Unconformity  |

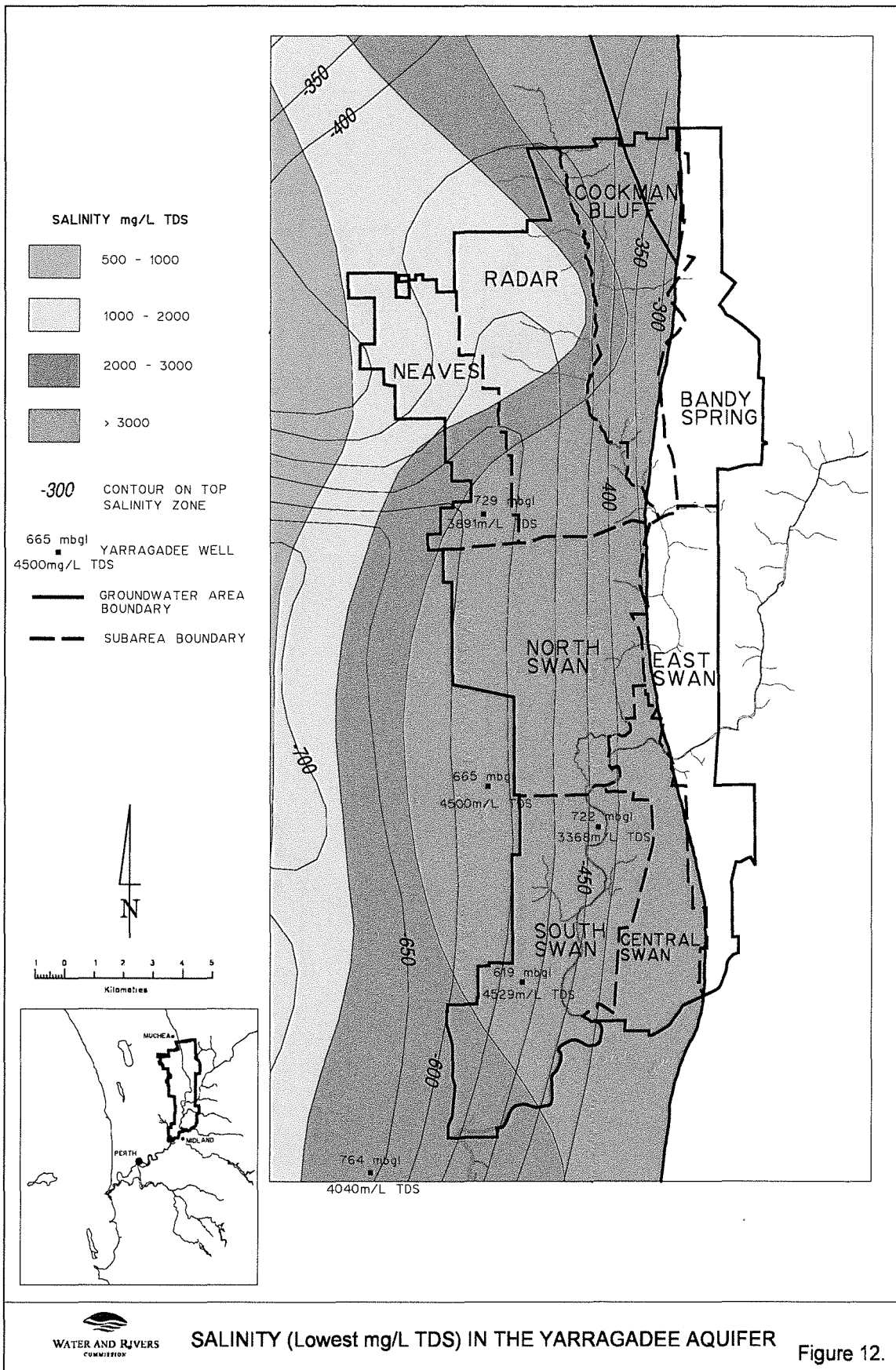


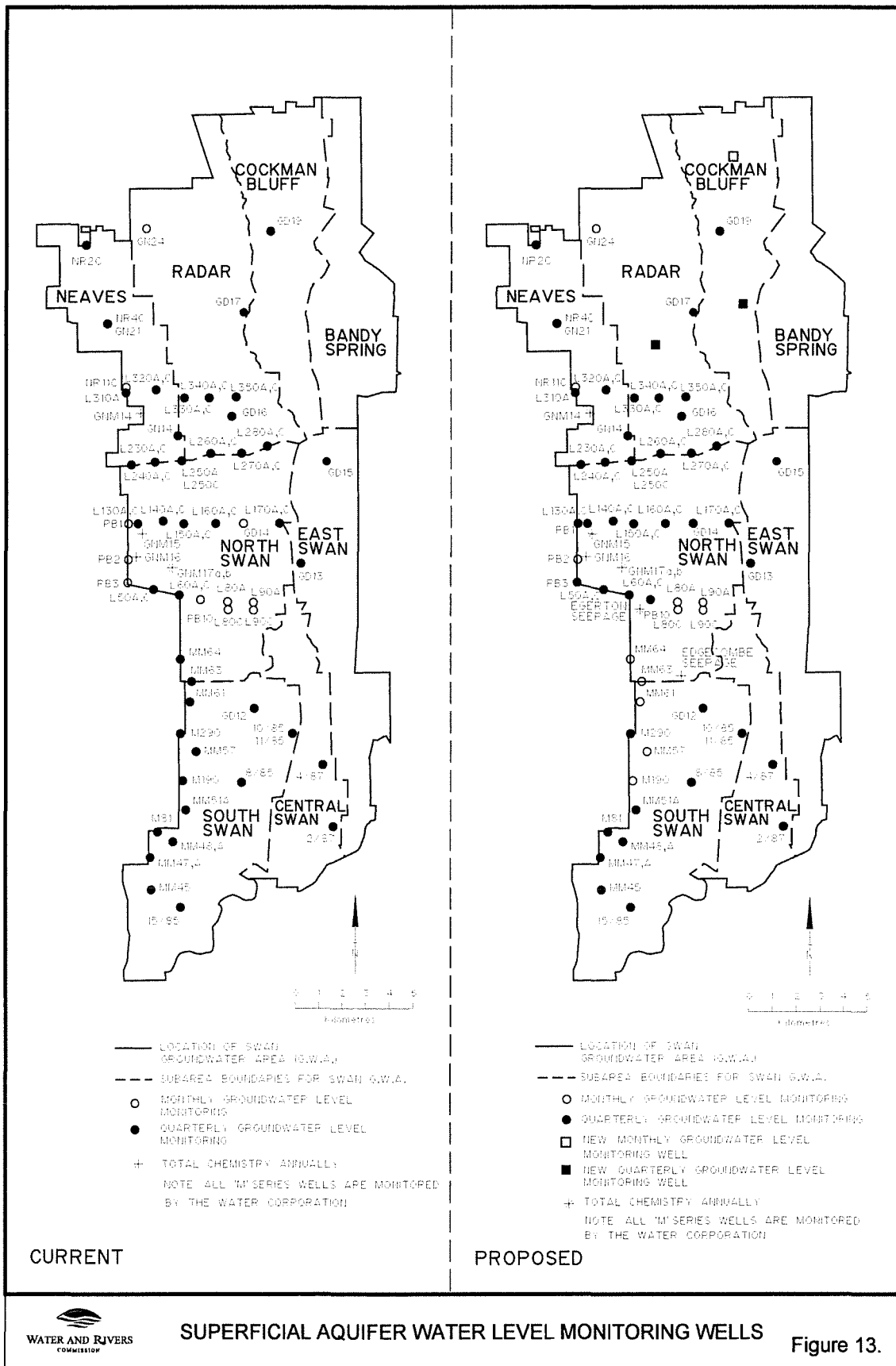


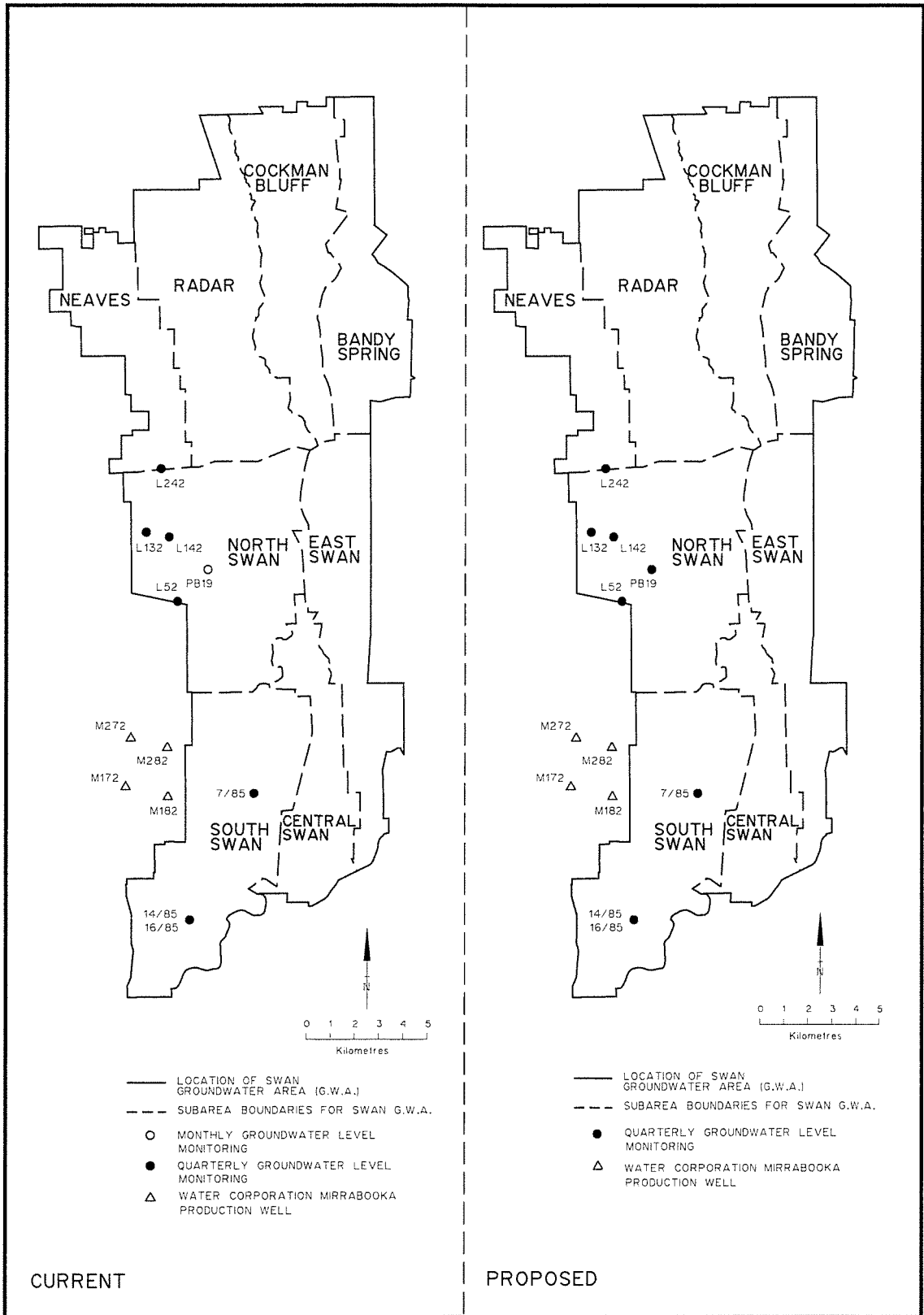


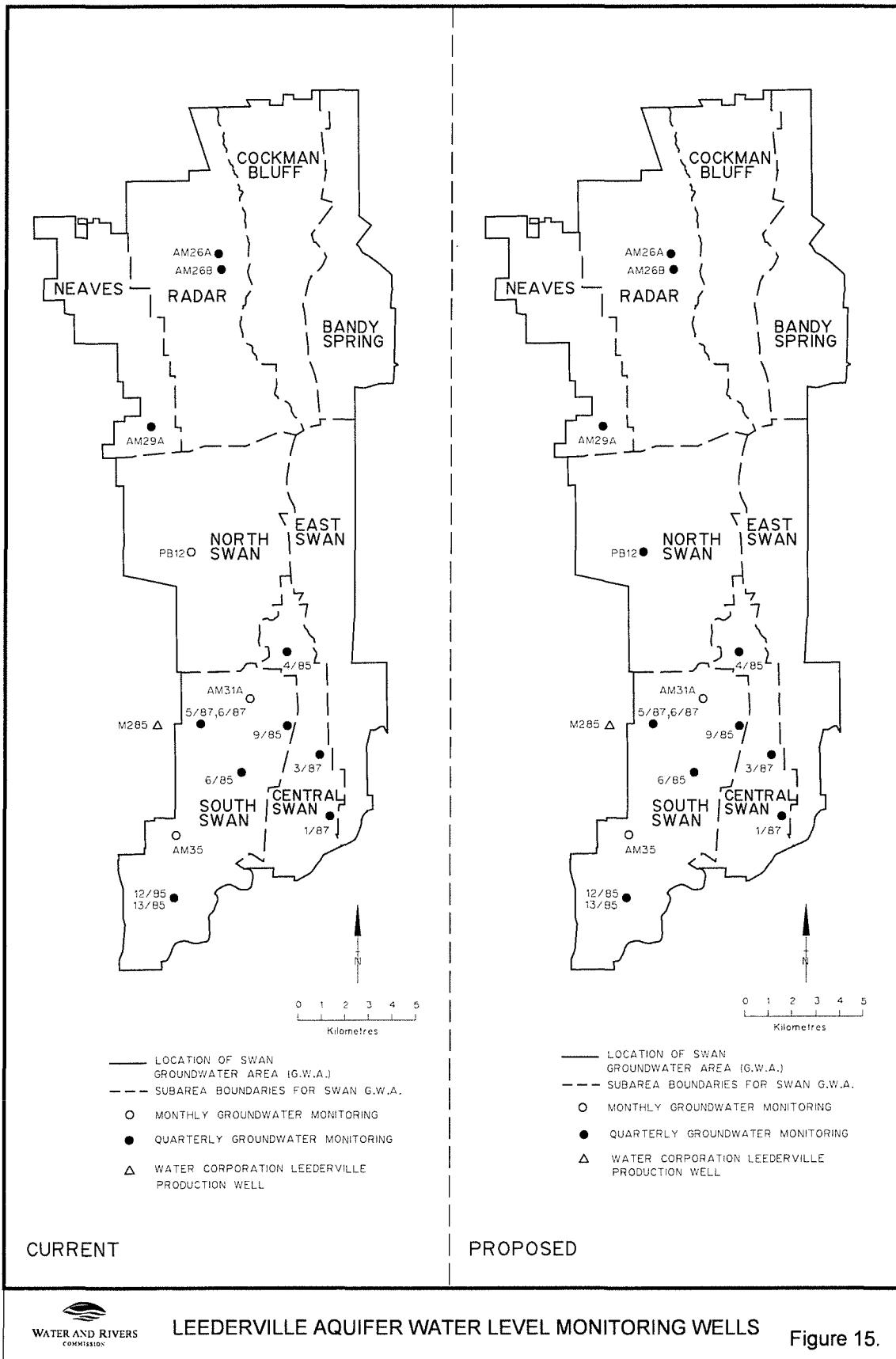




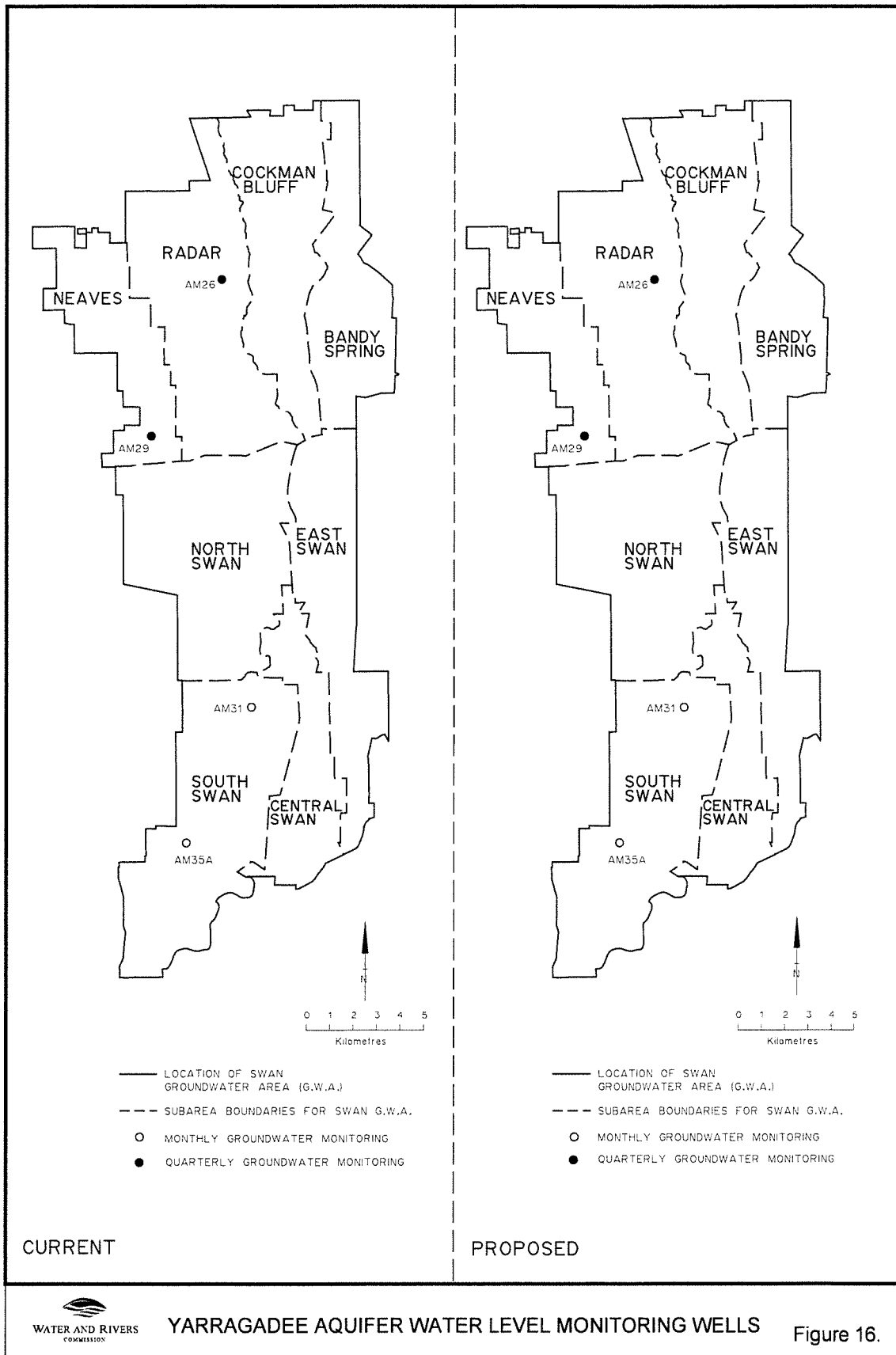


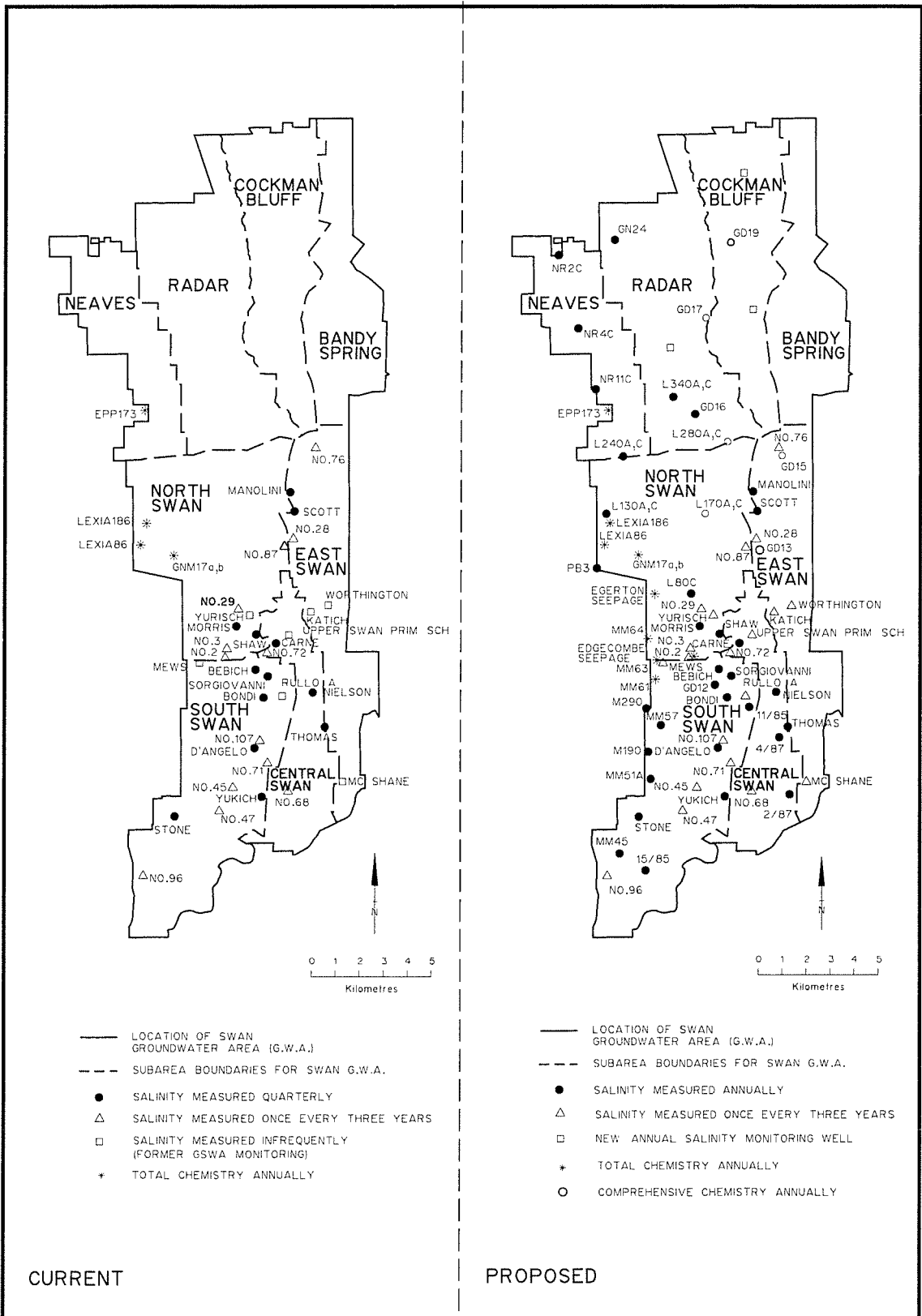


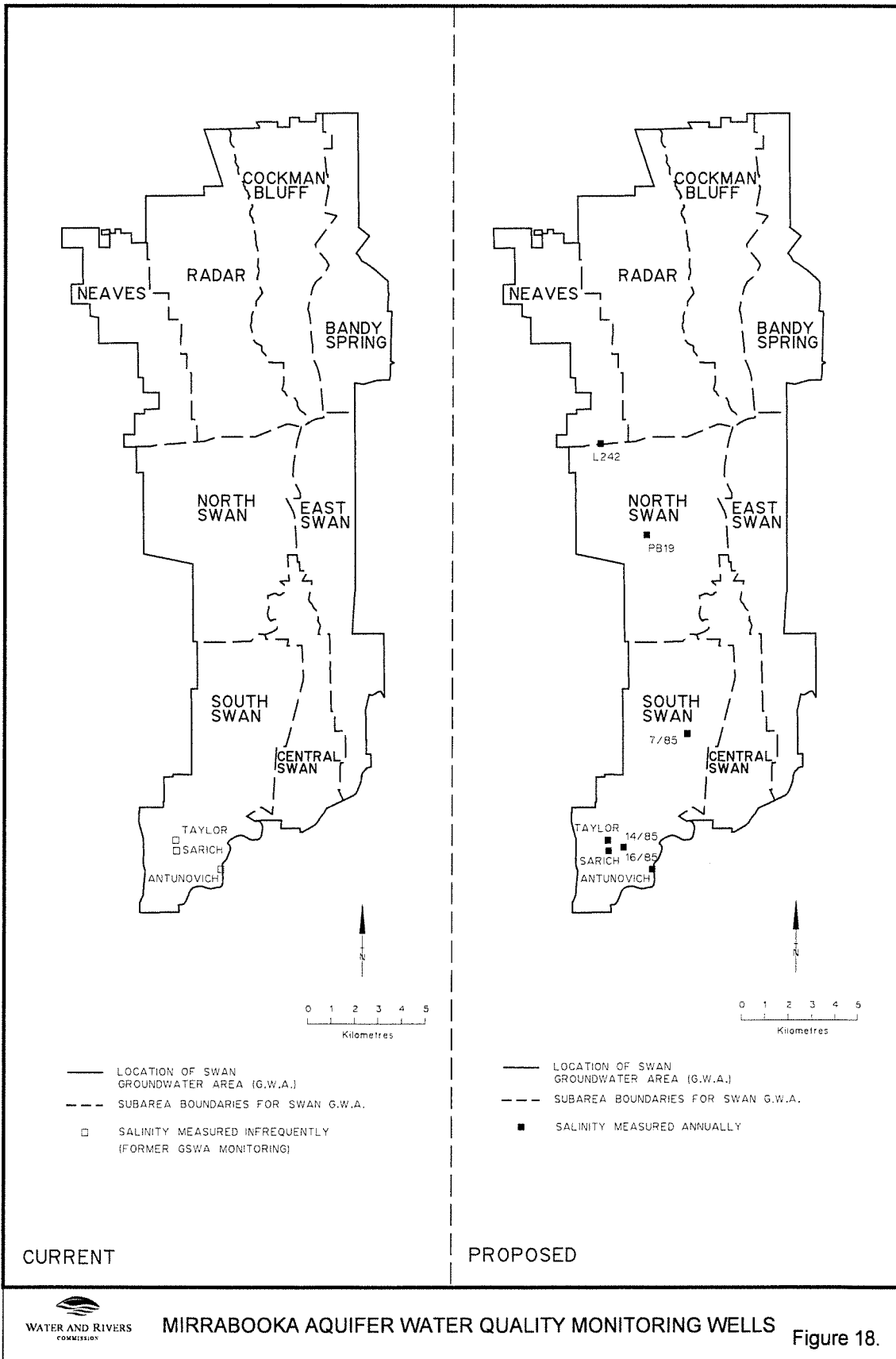


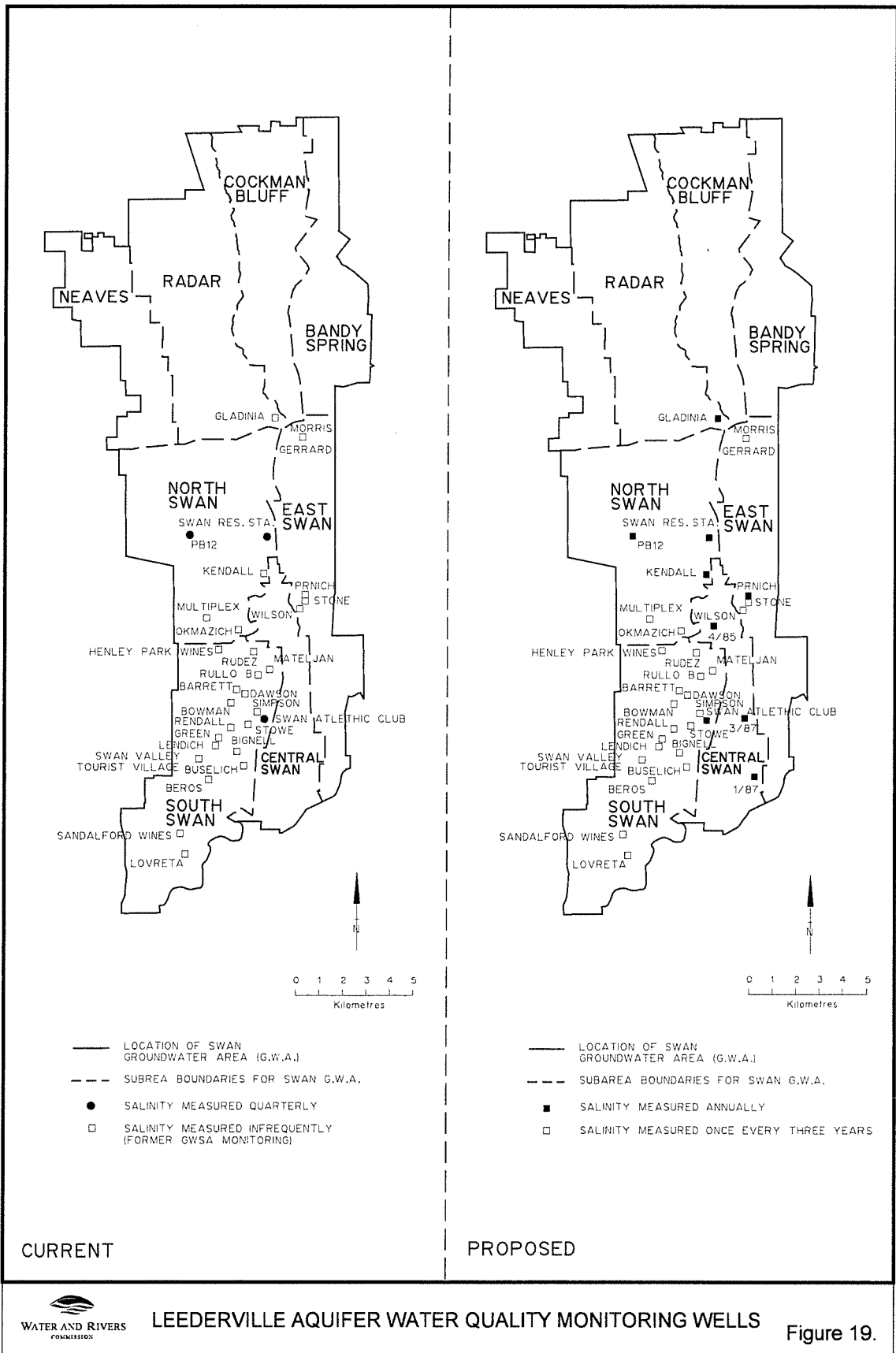


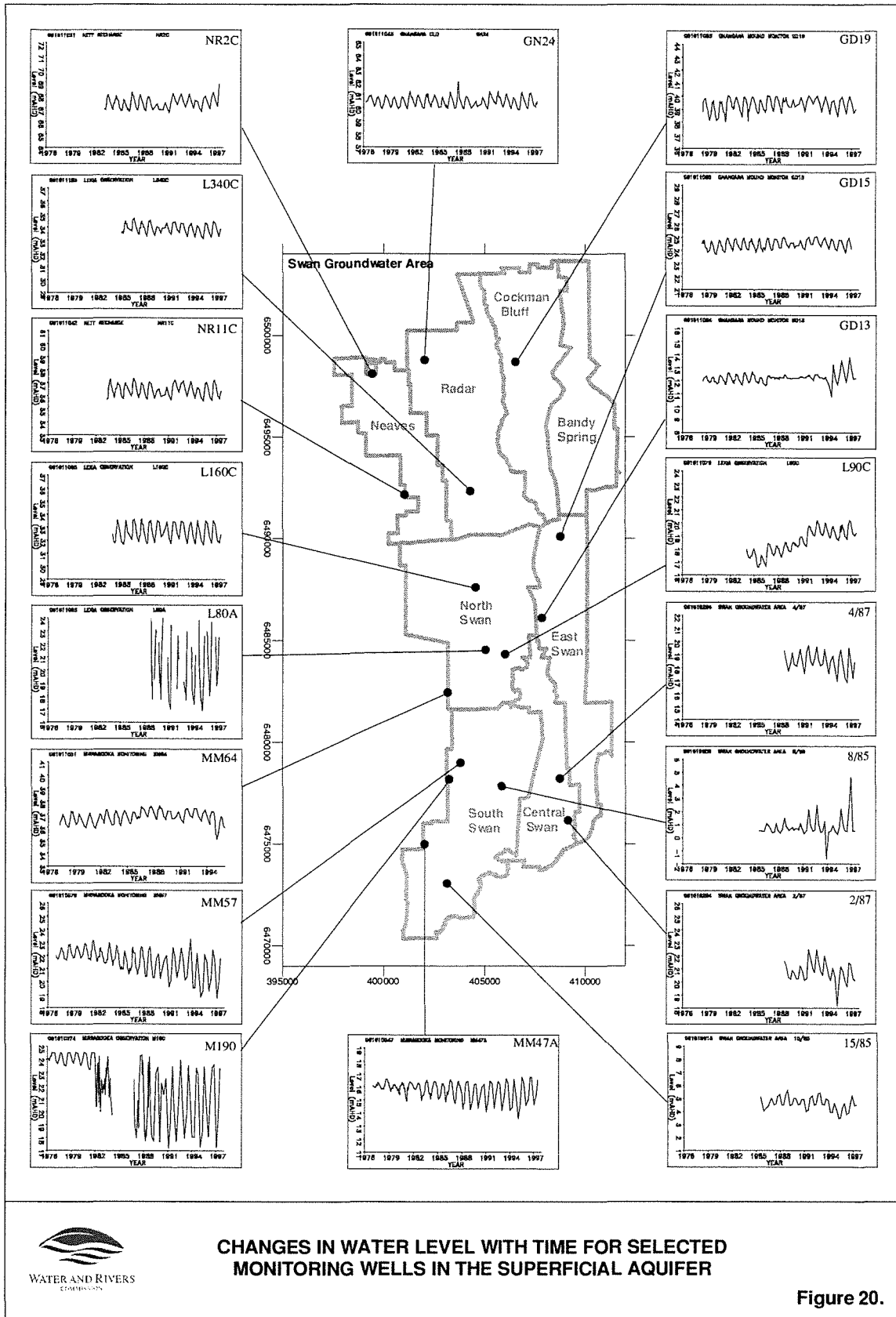












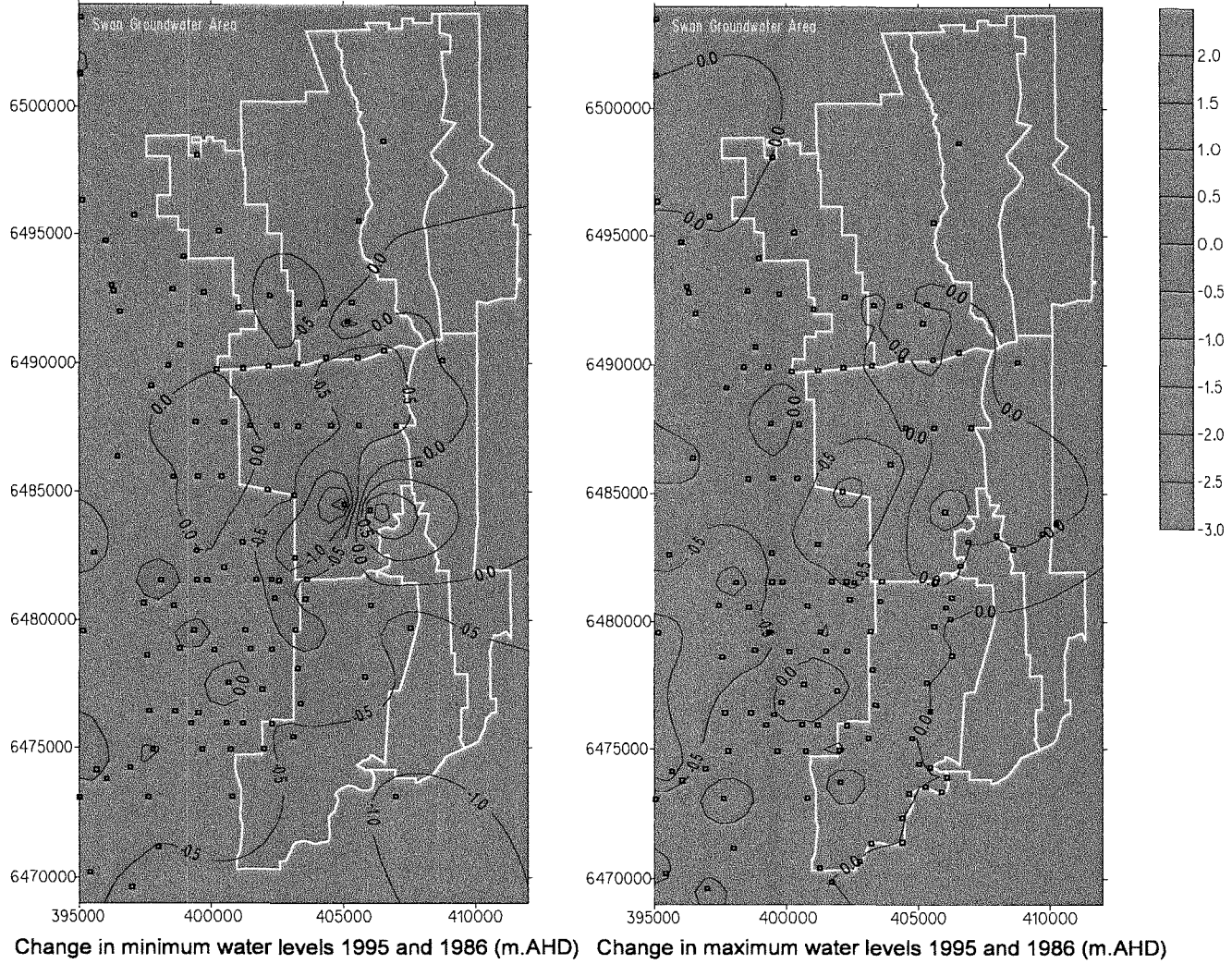
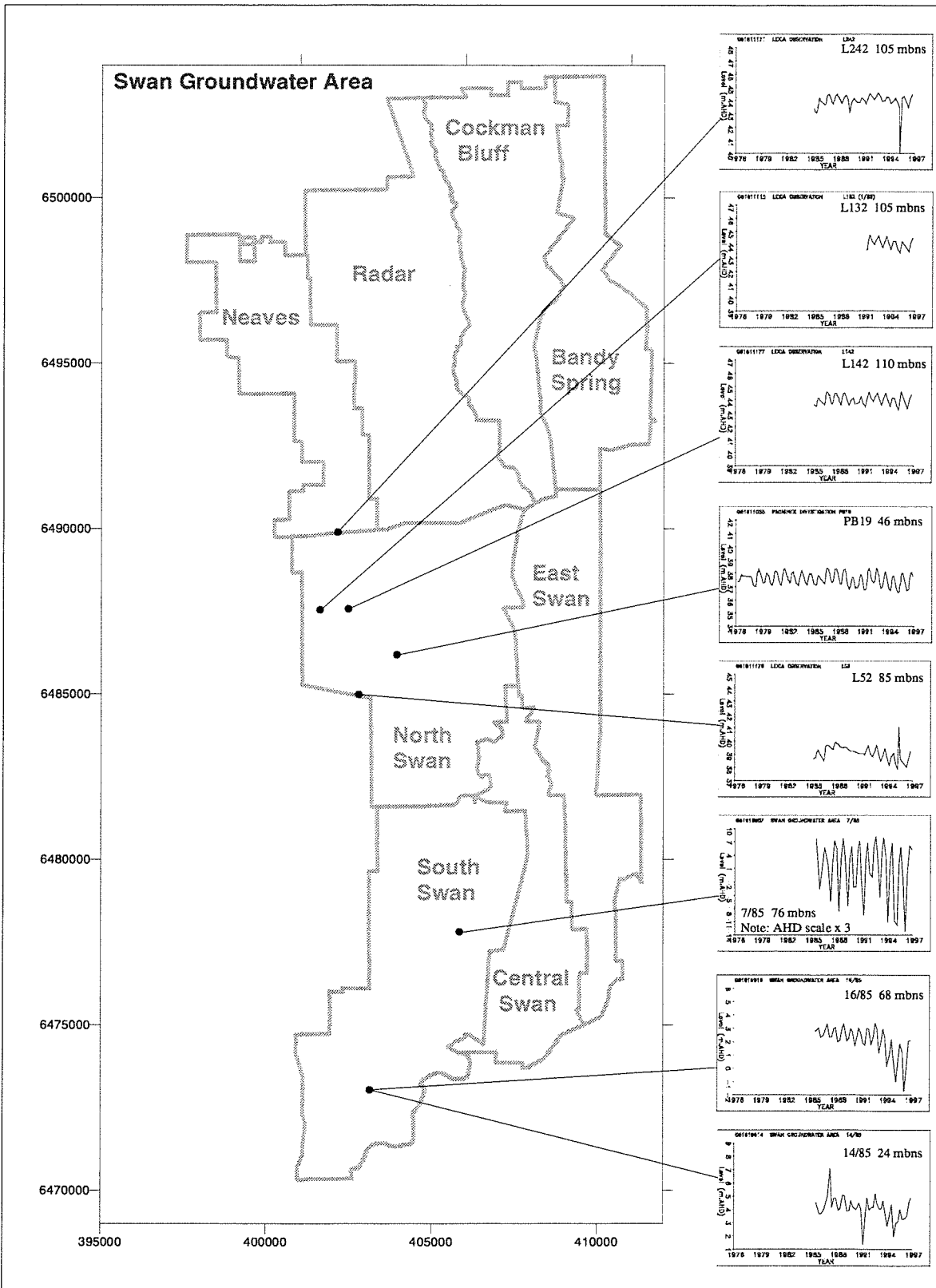


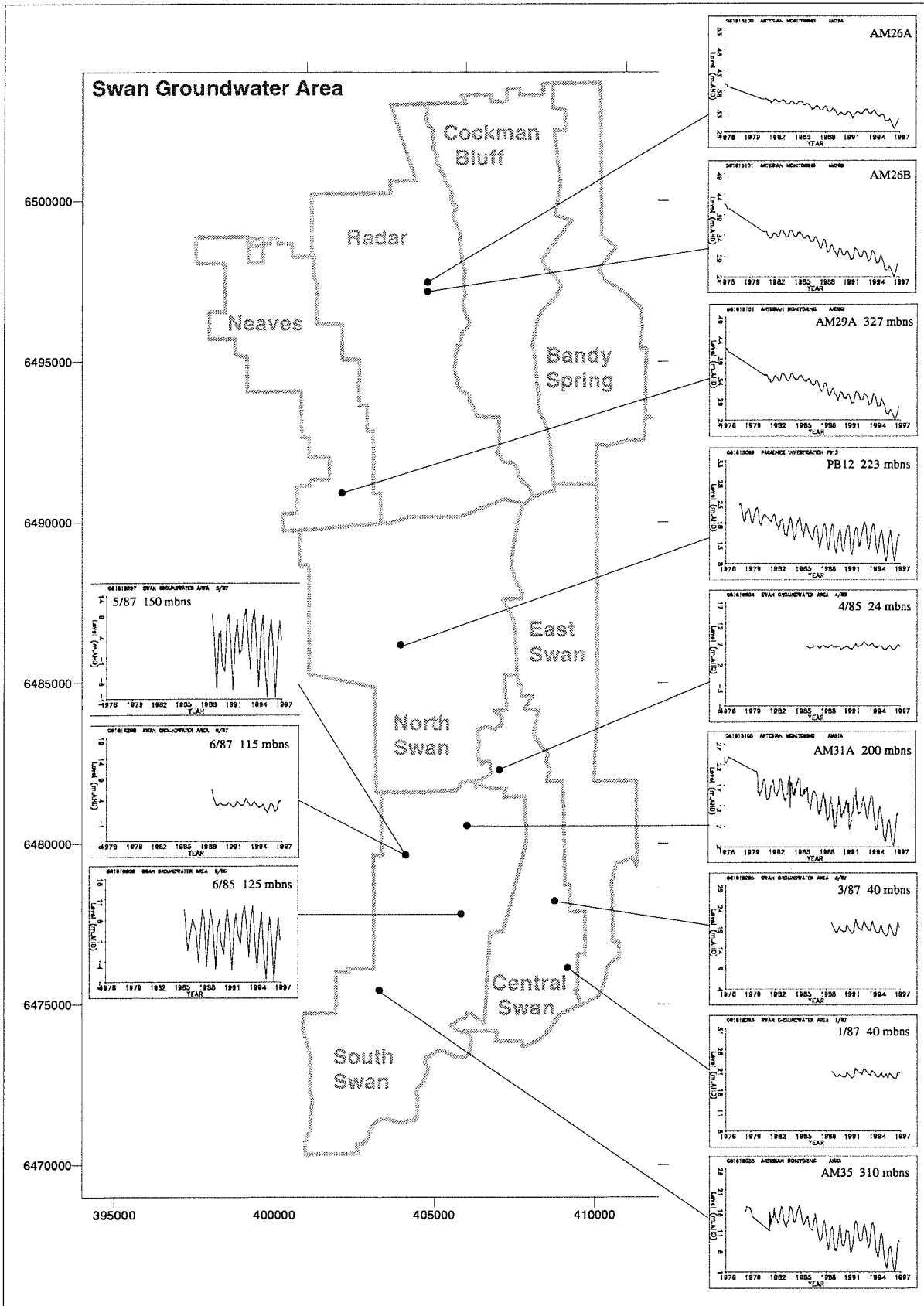
FIGURE 21. SUPERFICIAL AQUIFER WATERTABLE DIFFERENCE PLOTS (1986 and 1995)



**CHANGES IN WATER LEVEL WITH TIME FOR SELECTED MONITORING WELLS IN THE MIRRABOOKA AQUIFER**

**Figure 22.**



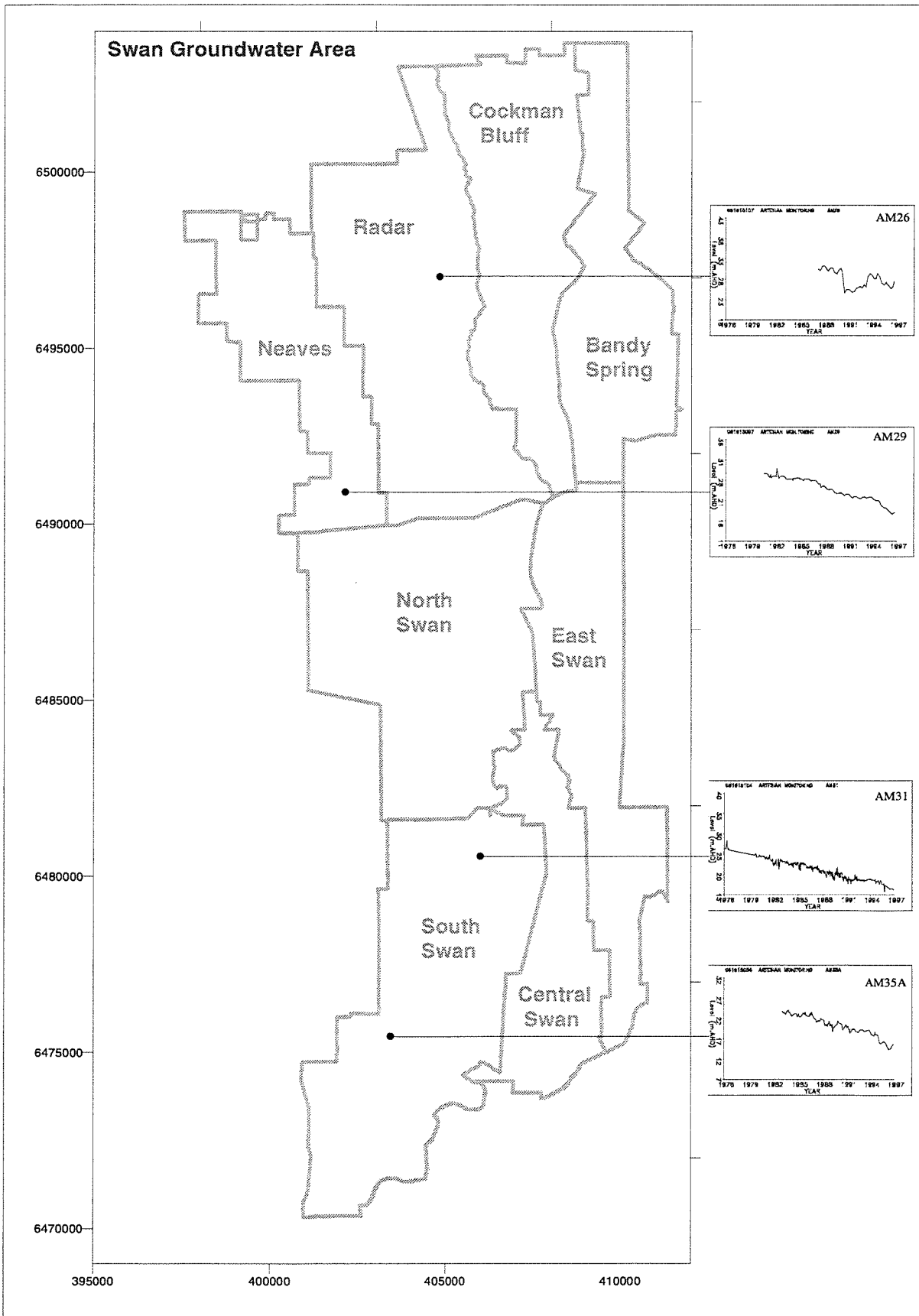


**CHANGES IN THE POTENTIOMETRIC LEVEL WITH TIME FOR SELECTED MONITORING WELLS IN THE LEEDERVILLE AQUIFER**

**Figure 23.**



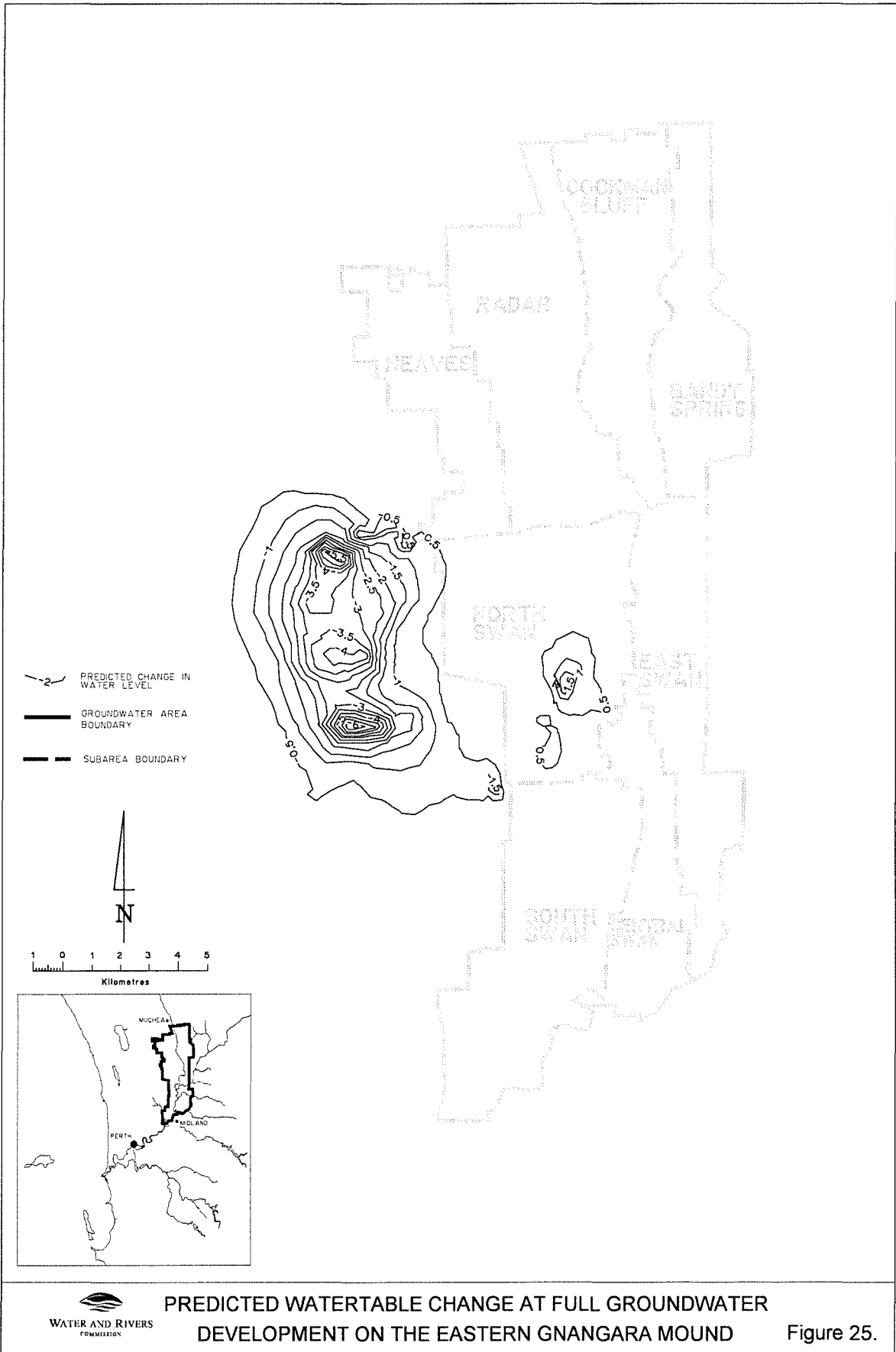




**CHANGES IN THE POTENTIOMETRIC LEVEL WITH TIME FOR SELECTED MONITORING WELLS IN THE YARRAGADEE AQUIFER**

**Figure 24.**

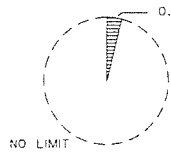




# GROUNDWATER USE

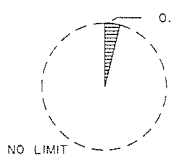
(MILLION kL/an)

SUPERFICIAL AQUIFER  
TOTAL - NO LIMIT

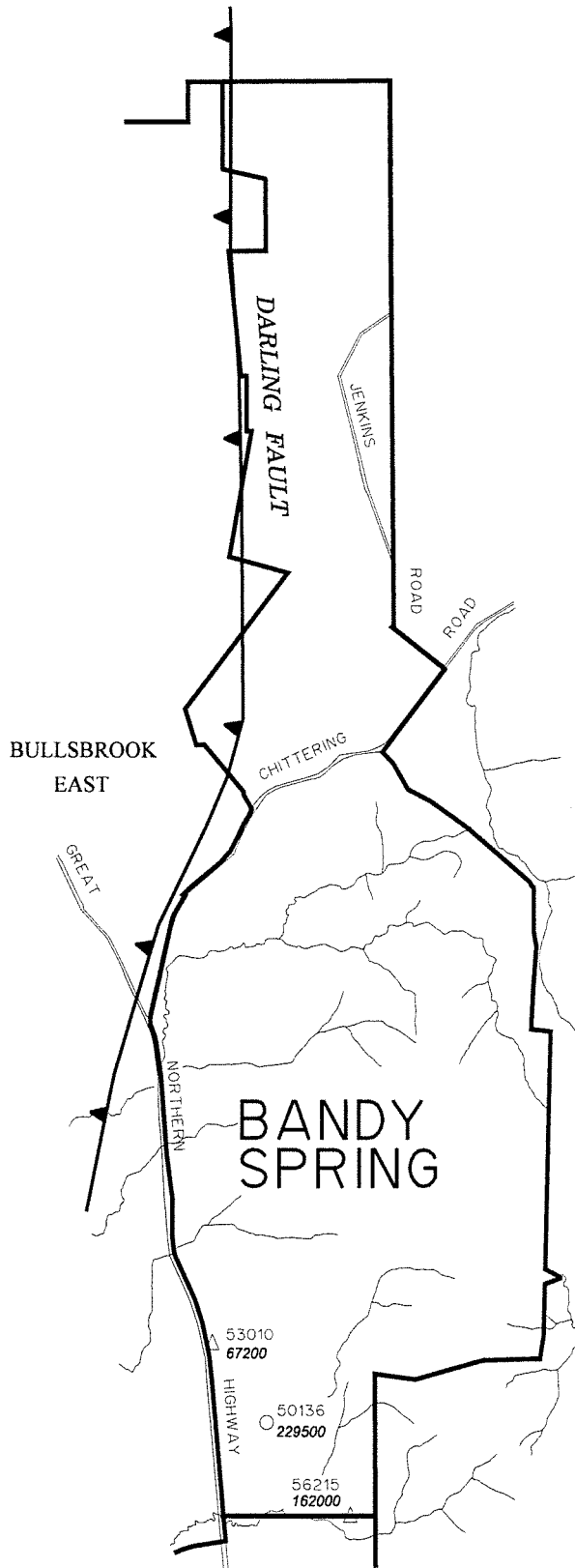
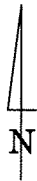


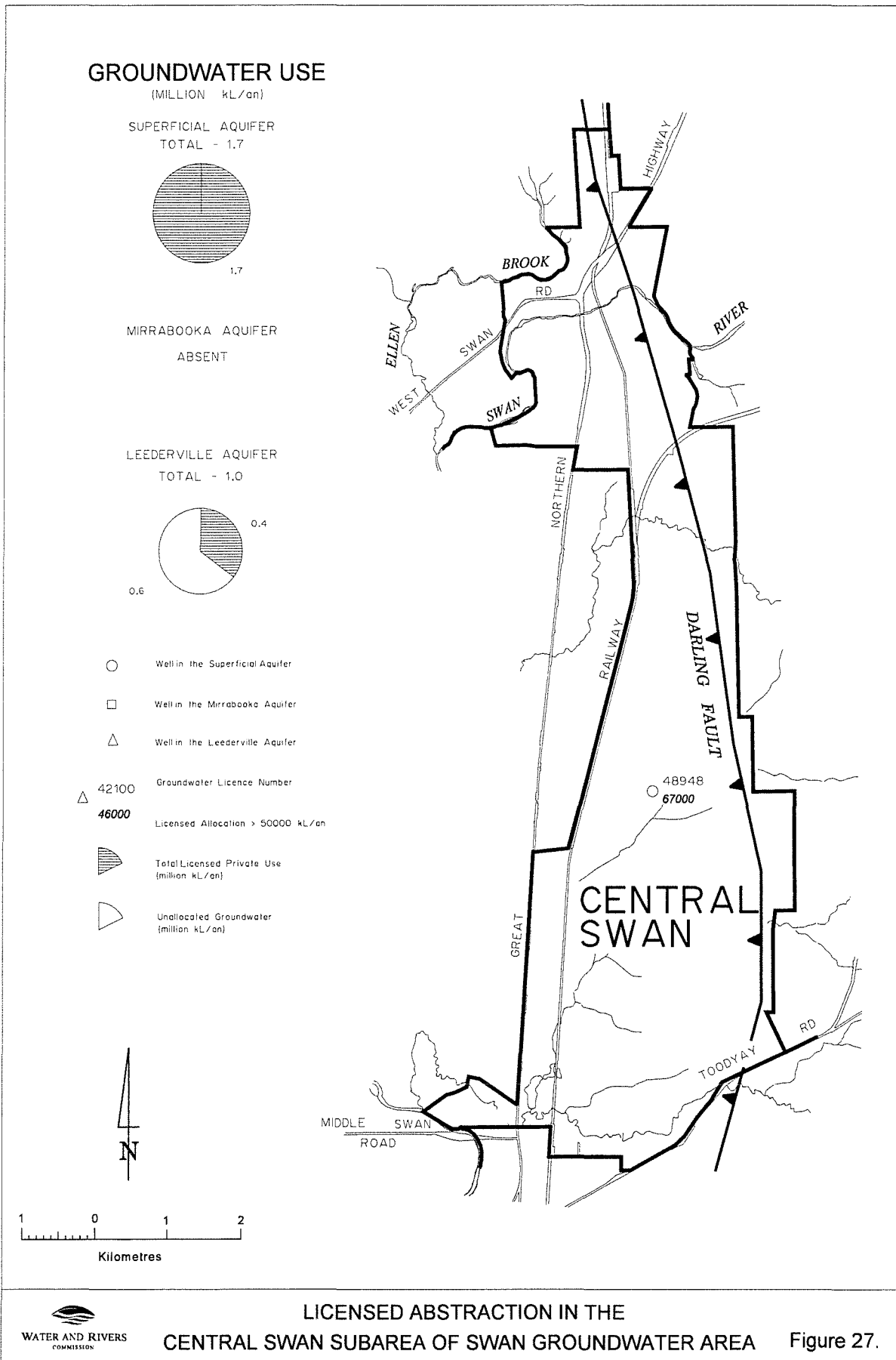
MIRRABOOKA AQUIFER  
ABSENT

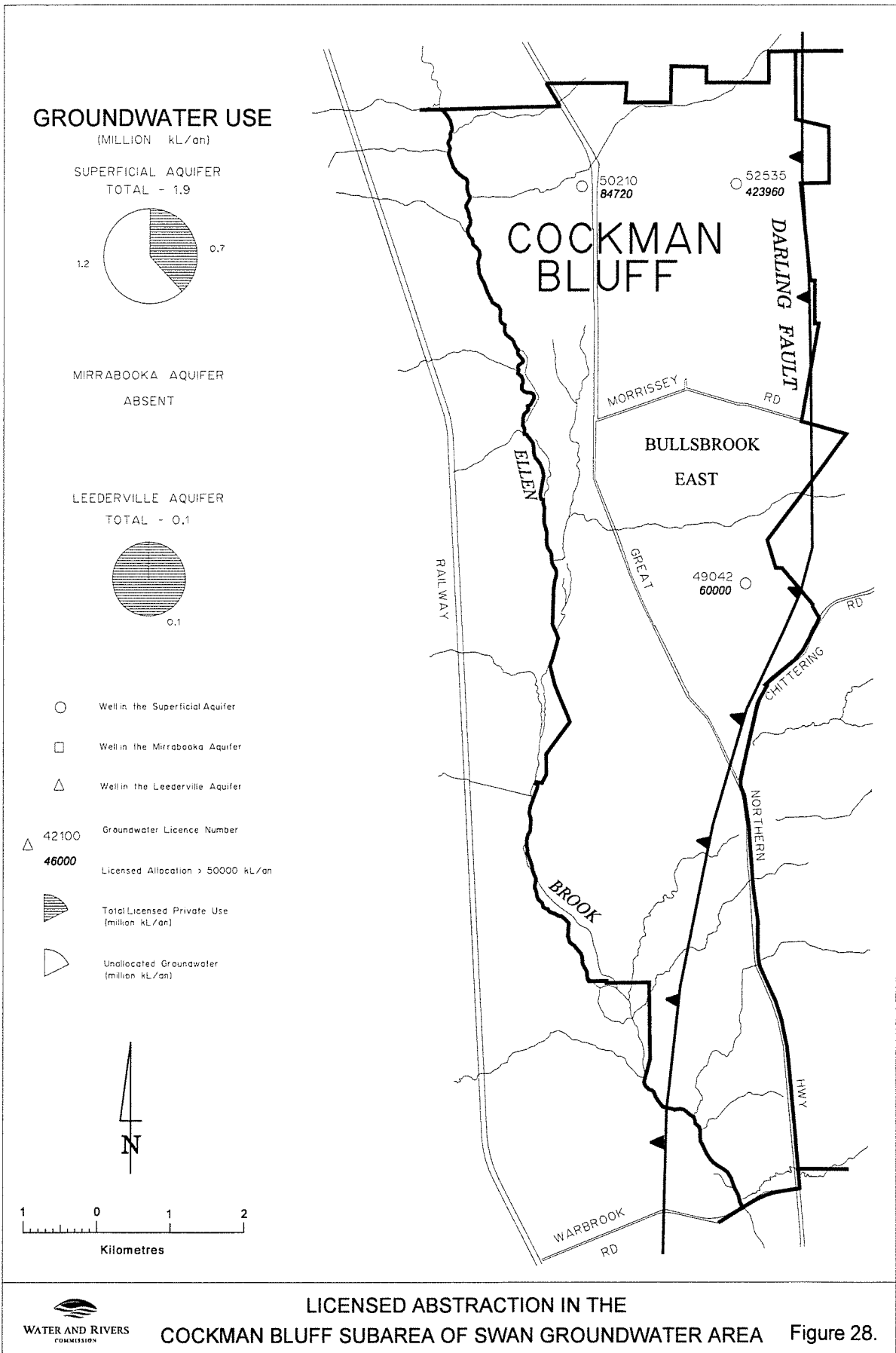
LEEDERVILLE AQUIFER  
TOTAL - NO LIMIT

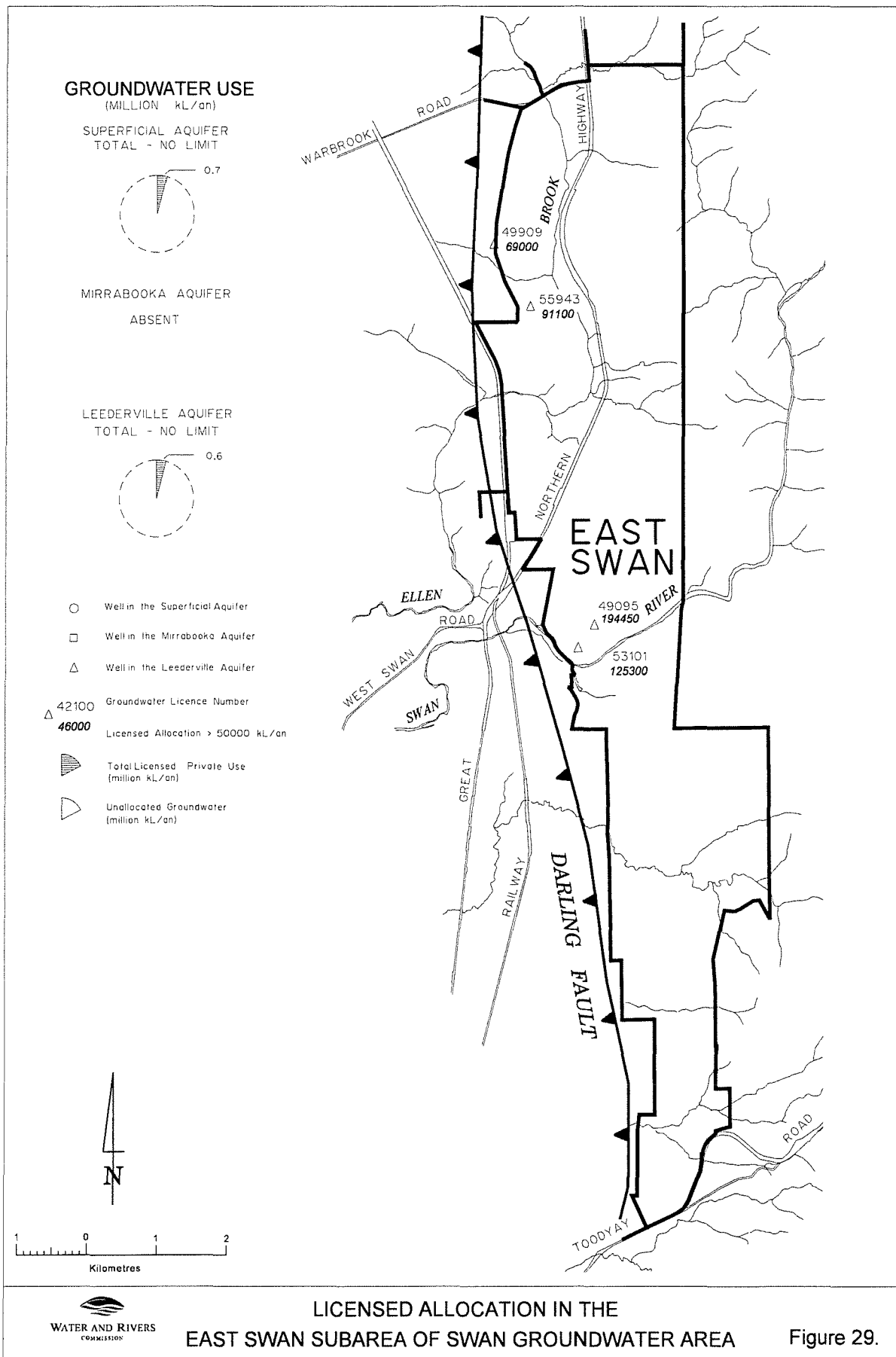


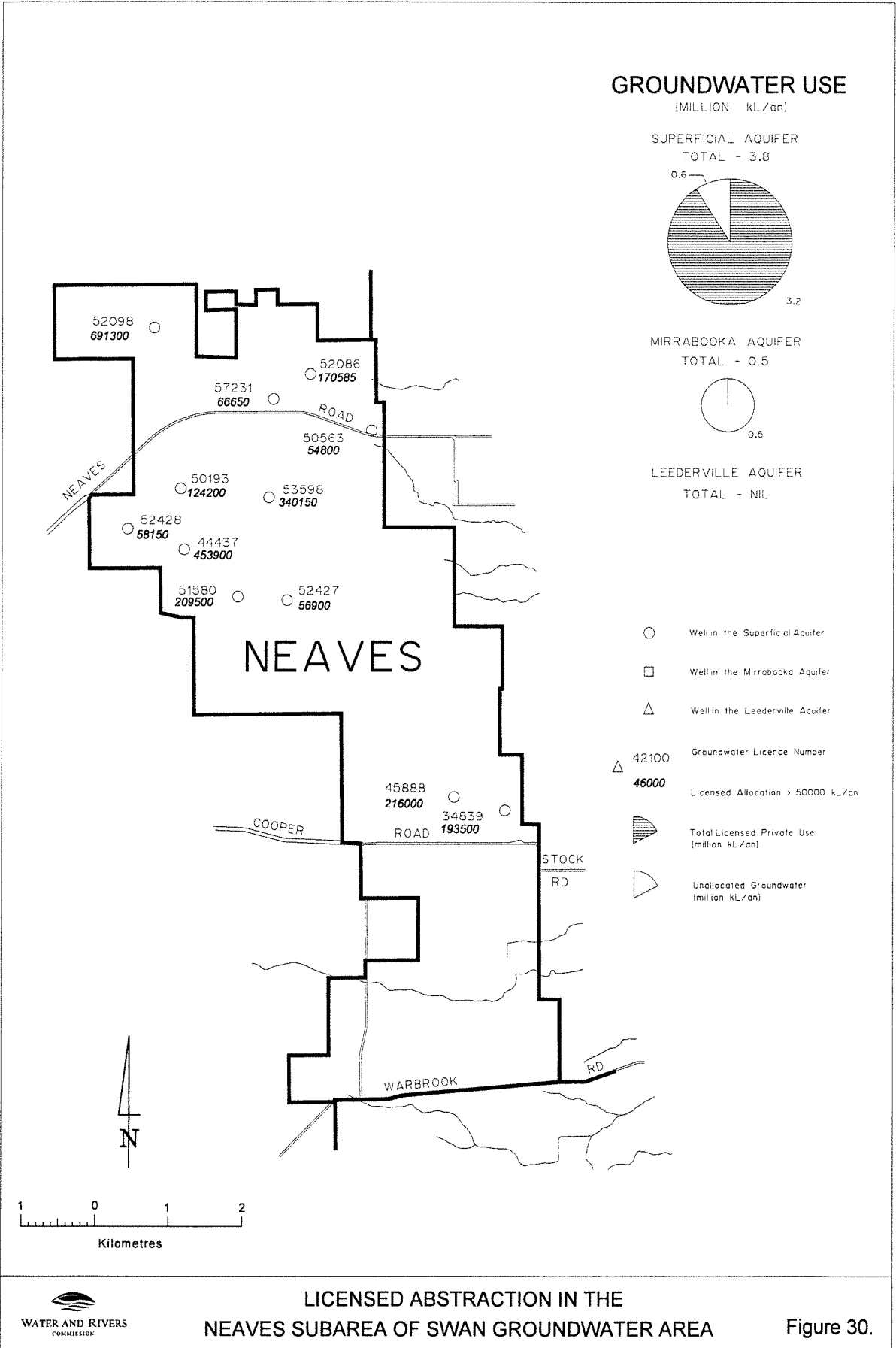
- Well in the Superficial Aquifer
- Well in the Mirrabooka Aquifer
- △ Well in the Leederville Aquifer
- △ 42100 Groundwater Licence Number
- △ 46000 Licensed Allocation > 50000 kL/an
- ▨ Total Licensed Private Use (million kL/an)
- ▨ Unallocated Groundwater (million kL/an)





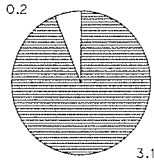






**GROUNDWATER USE**  
(MILLION kL/an)

SUPERFICIAL AQUIFER  
TOTAL - 3.3



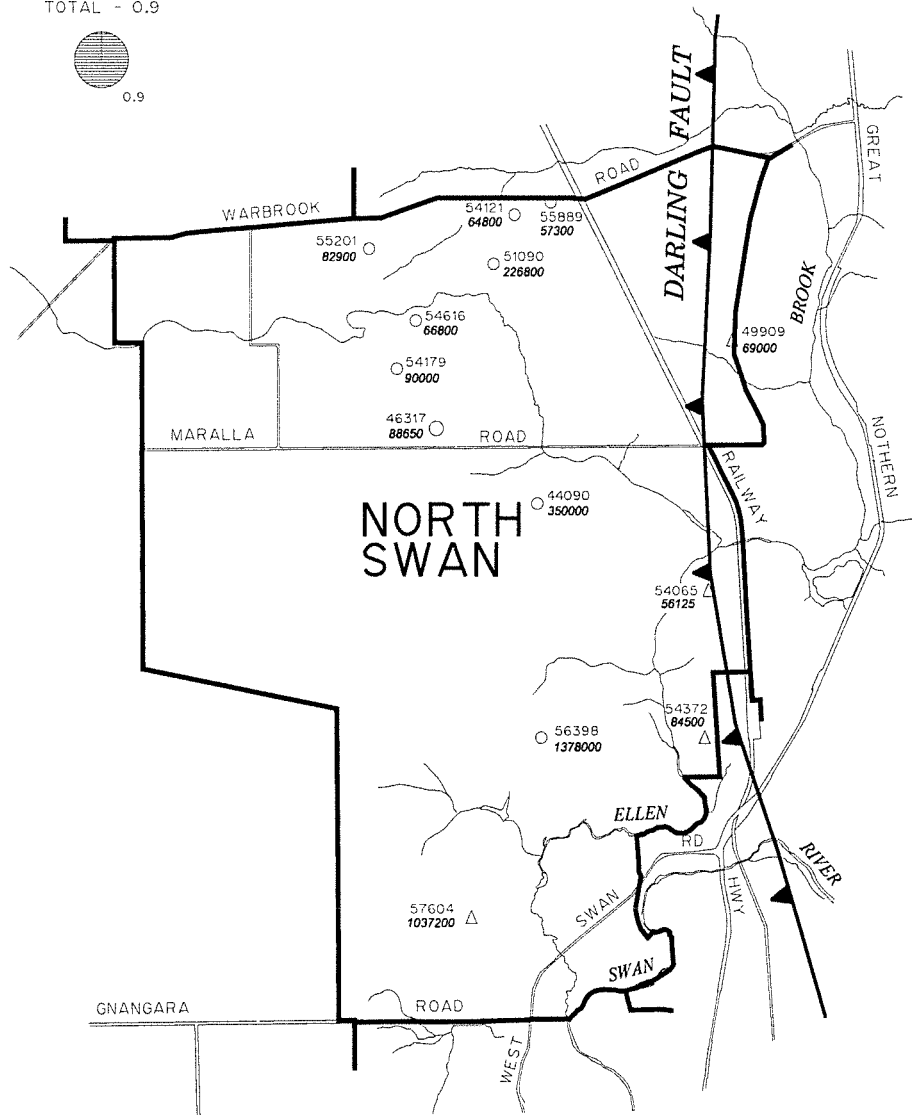
MIRRABOOKA AQUIFER  
TOTAL - 0.3



LEEDERVILLE AQUIFER  
TOTAL - 0.9



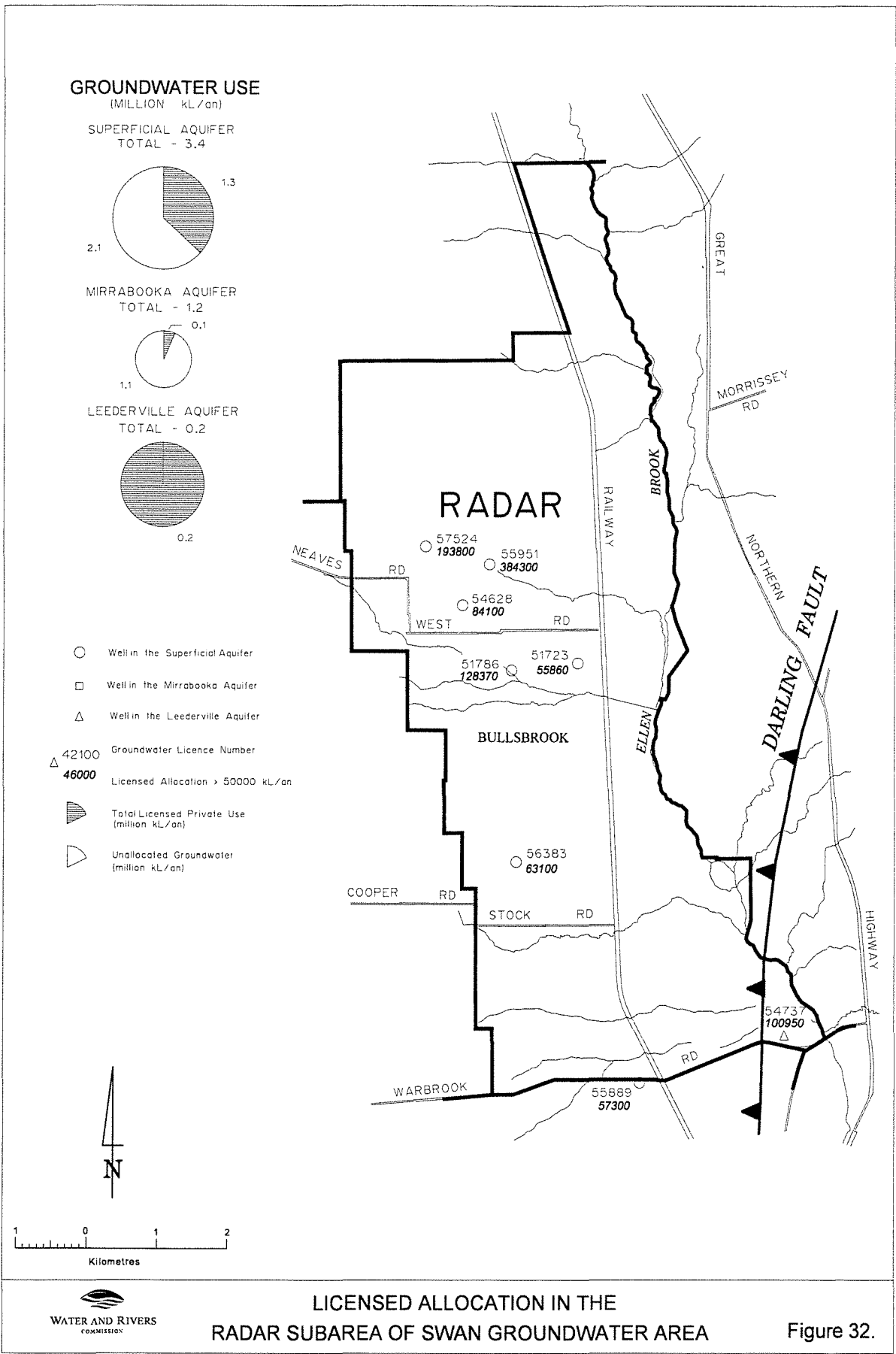
- Well in the Superficial Aquifer
- Well in the Mirrabooka Aquifer
- △ Well in the Leederville Aquifer
- 42100 Groundwater Licence Number
- 46000 Licensed Allocation > 50000 kL/an
- ▨ Total Licensed Private Use (million kL/an)
- ▩ Unallocated Groundwater (million kL/an)



LICENSED ALLOCATION IN THE  
NORTH SWAN SUBAREA OF SWAN GROUNDWATER AREA

Figure 31.





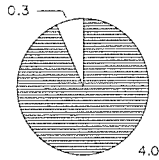
**LICENSED ALLOCATION IN THE  
RADAR SUBAREA OF SWAN GROUNDWATER AREA**

Figure 32.



**GROUNDWATER USE**  
 (MILLION kL/an)

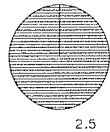
SUPERFICIAL AQUIFER  
 TOTAL - 4.3



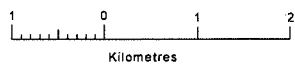
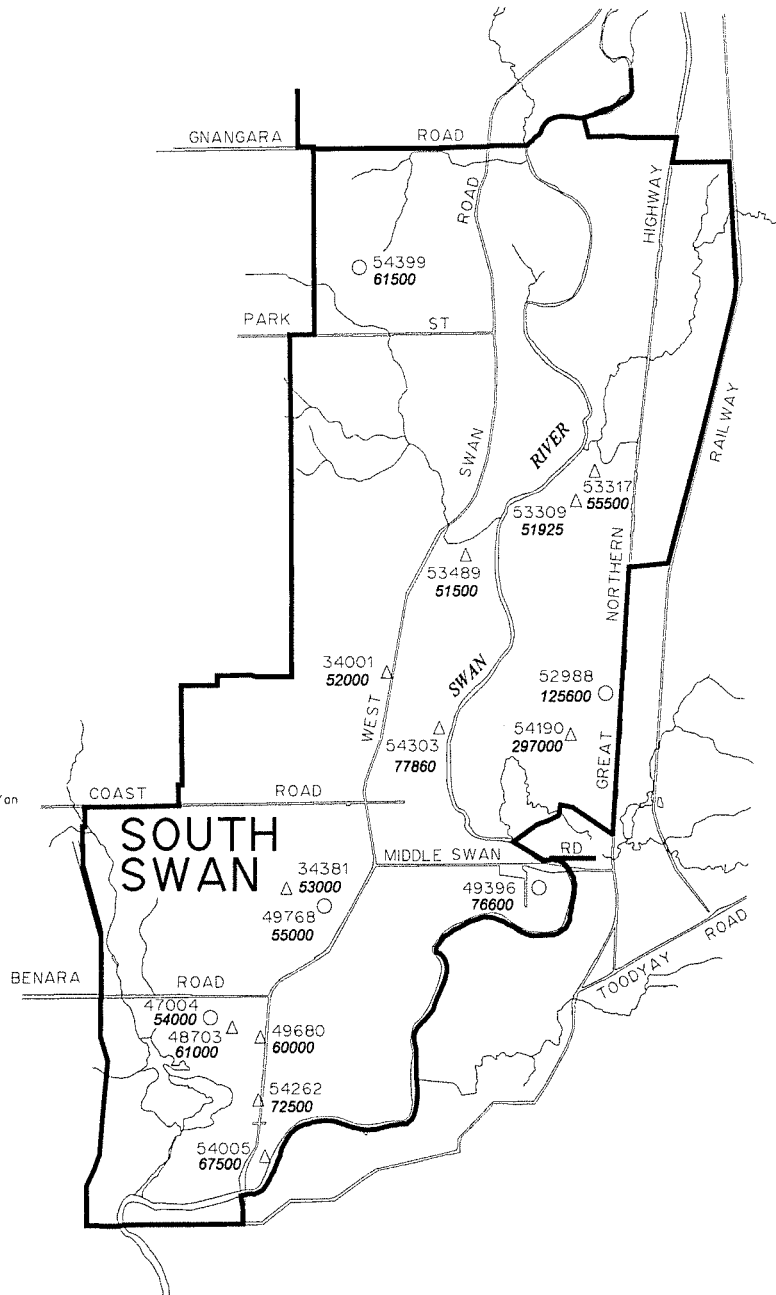
MIRRABOOKA AQUIFER  
 TOTAL - 1.6



LEEDERVILLE AQUIFER  
 TOTAL - 2.5



- Well in the Superficial Aquifer
- Well in the Mirrabooka Aquifer
- △ Well in the Leederville Aquifer
- △ 42100 Groundwater Licence Number
- △ 46000 Licensed Allocation > 50000 kL/an
- ▨ Total Licensed Private Use (million kL/an)
- ▤ Unallocated Groundwater (million kL/an)



LICENSED ALLOCATION IN THE  
 SOUTH SWAN SUBAREA OF SWAN GROUNDWATER AREA

Figure 33.