JENNY ARNOLD'S

PERTH WETLANDS RESOURCE BOOK

CHAPTER 8

WETLANDS OF THE WESTERN SUBURBS

ENVIRONMENTAL PROTECTION AUTHORITY
AND THE WATER AUTHORITY OF WESTERN AUSTRALIA

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Jenny Arnold's Perth Wetlands
Resource Book

Chapter 8: Wetlands of the Western Suburbs

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the Water Authority of Western Australia

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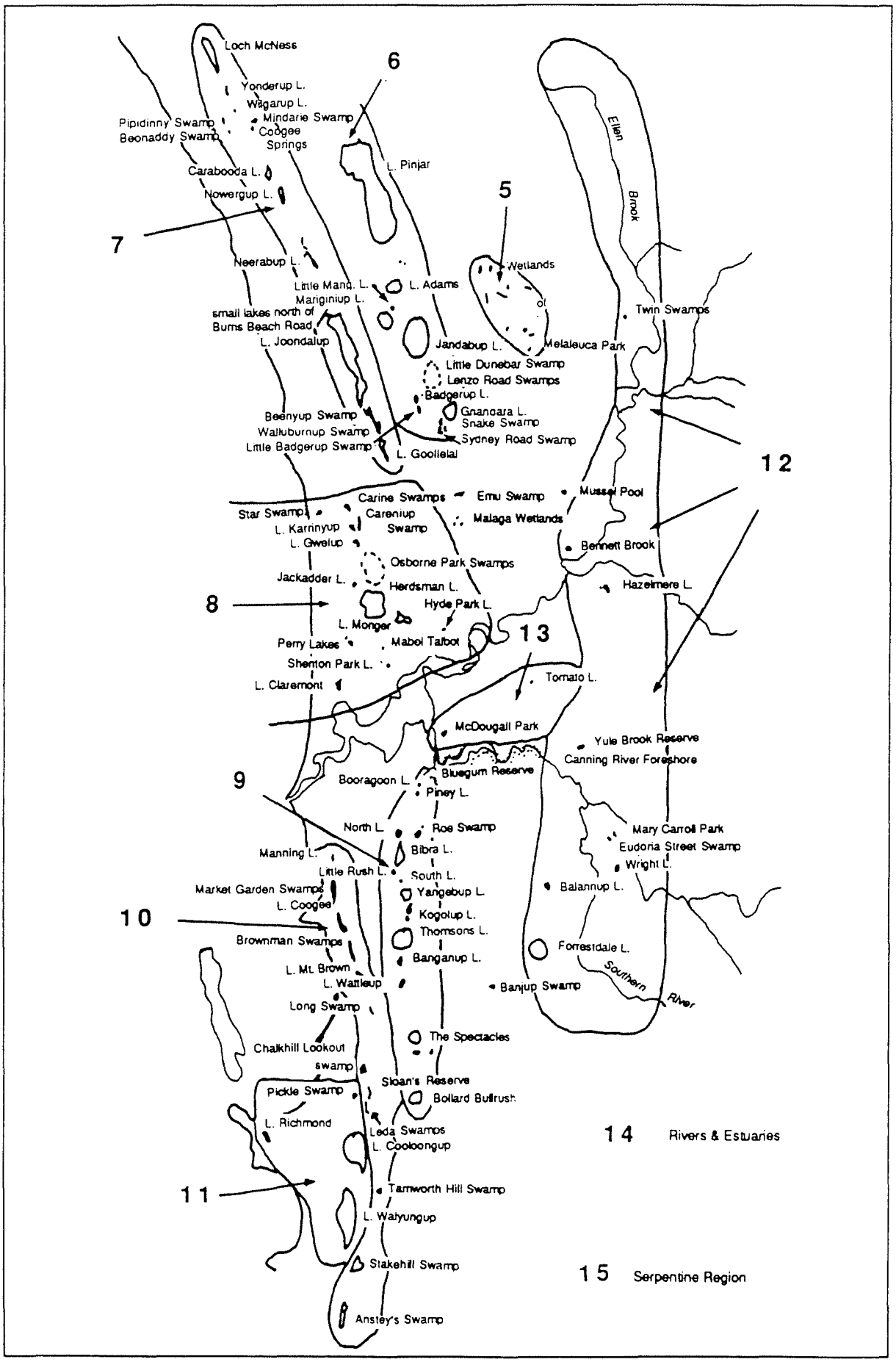
NOTES FOR USERS

Bulletin 266 consists of 15 chapters published in 6 separate volumes.

Chapters 1 - 4 (bound with the appendices) contain information general to wetlands. They form essential background to the subsequent chapters which describe most of the clearly definable seasonal and permanent lakes with open water. As such readers of Chapters 5 - 15 should be used in conjunction with Chapter 1 - 4.

The Bulletin is not an exhaustive inventory of all wetland types. Readers are referred to C. A. Semeniuk (1987), Wetlands of the Darling System - A geomorphic approach to habitat classification. Journal of the Royal Society of Western Australia. Volume 69, Part 3. pp 95-112 for a comprehensive classification of wetland types on the Swan Coastal Plain.

The index map on page (ii) shows how the wetland chains have been grouped into chapters. The position in the text where individual wetlands are discussed is shown in the index on page 418 (Chapters 1 - 4).



Map of Perth's wetlands showing the grouping of wetlands into Chapters in this Bulletin.

Chapter 8: Wetlands of the Western Suburbs

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FIGURES (Cont'd)

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8. WETLANDS OF THE WESTERN SUBURBS

8.1 GENERAL SETTING

The wetlands considered in this section lie within an area arbitrarily defined by the Spearwood landform from north of Carine Lakes to the Swan River. The wetlands, with the exception of Star Swamp, lie in the Spearwood landform, near the boundary between the Karrakatta and Cottesloe associations (as defined by Churchward & McArthur, 1978). Star Swamp is situated further west within the Quindalup Association.

Le Provost, Semeniuk and Chalmer (1987) recognise this group of wetlands as a suite related in type and origin: the Spearwood - Balcatta Suite.

The area has been strongly affected by European settlement so that all the wetlands show influences of a range of land uses. Changes to this part of the Perth metropolitan region have been documented by Seddon (1972), Pitt Morison (1979) and Bekle (1981). Many of the wetlands have been filled or drained.

While the following summary does not include the entire wetland area as shown on early maps (see Pitt Morison, 1979), it indicates the extent of the changes (see also Table 8.1).

- Area of Spearwood Dune system: from $31^{0}50'S$ to $32^{0}00'S$ = 187 km^2 (100%).
- Area mapped as swamp and lacustrine deposits in GSWA Perth and Environs Geological Map - Perth Sheet = 11 km^2 (5.9%). This map does not show long-reclaimed wetlands in North and East Perth and Leederville.
- Area of wetland in Parks and Recreation Reserves and other open space = 4.6 km^2 (42% of swamp and lacustrine deposits).

While much of the wetland has been filled or drained and developed for urban uses, a considerable area has become Typha fenland following use for market gardens and grazing.

The wetlands occur at sites of groundwater discharge on the western and southern flanks of the Gnangara Mound. They lie at elevations between 15 m AHD and 1-2 m AHD. The larger wetlands Big Carine Swamp, Careniup Swamp, Lake Gwelup, the Osborne Park Swamps, Herdsman Lake, Lake Monger and the now filled North Perth Swamps are described geologically as marshes in low-level interbarrier depressions while smaller wetlands such as Star Swamp, Jackadder, Claremont and Shenton Park Lake are described as swamps in interdunal swales (Gozzard, 1986).

Bestow (1981) discussed the hydrogeology of the Gwelup area, making reference to lake deposits and providing a description of these deposits in a wetland at Hertha Road, Stirling, now reclaimed by sanitary landfill. His description is quoted below:

> "An important addition to the regional succession is peat and some associated clay at shallow depth immediately on top of the Quaternary sands. These lithologies have developed in former inter-dunal depressions where swamps or lakes have persisted for an appreciable length of geological time. Peat has been explored in some detail over the adjoining Jones Street depression, where it reached a thickness of as much as 5.2 metres. The maximum thickness encountered in the Hertha Road bores is

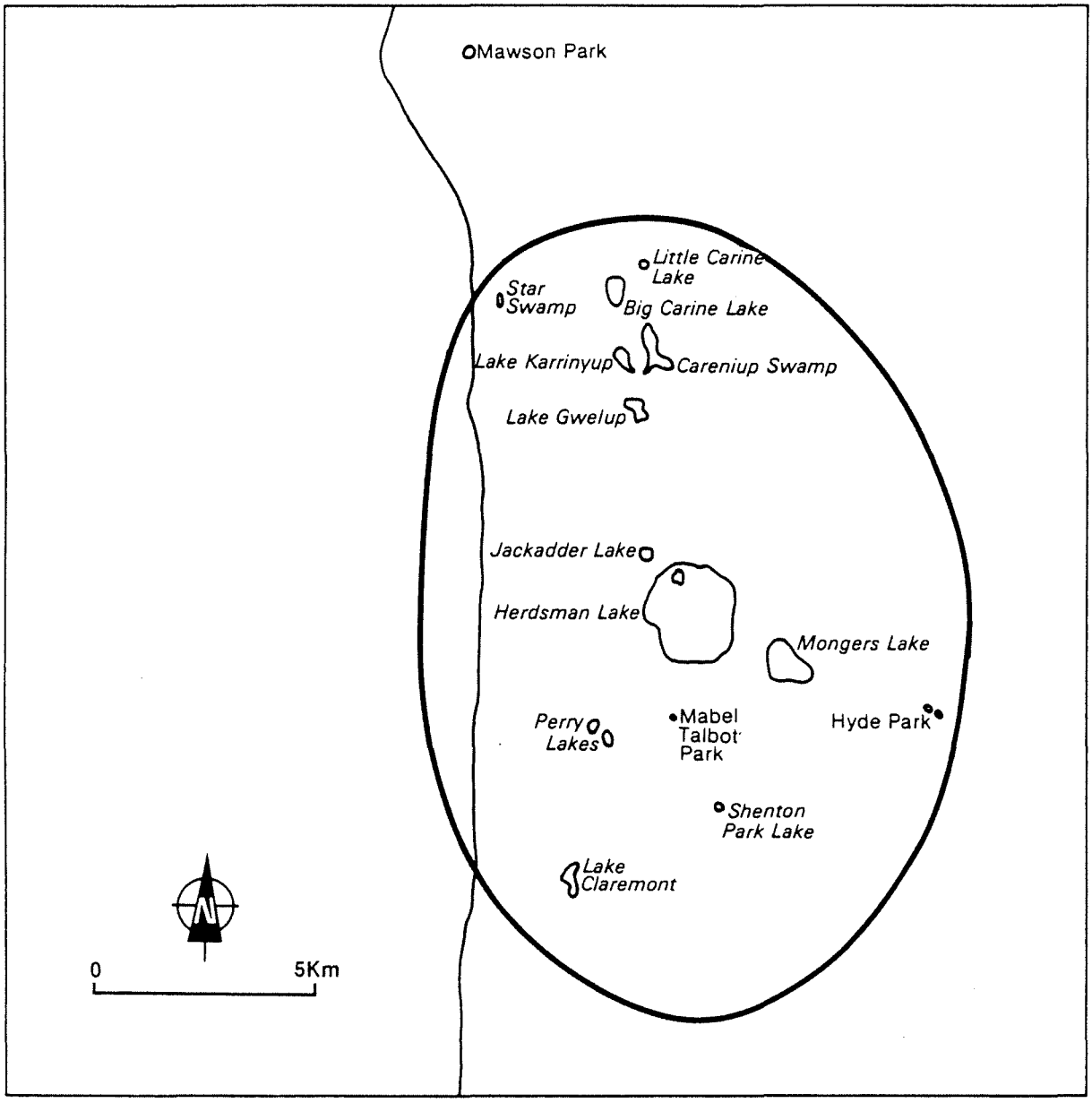

Figure 8.1 Map showing the wetlands of the western suburbs.

Table 8.1. Western suburban wetlands: areas of wetland vegetation.

LAKE NAME	AREAS OF WETLAND VEGETATION (HECTARES)				
	PAPERBARK	SEDGE	OPEN WATER MUD FLATS	ISLANDS MODIFIED	TOTAL
Big Carine	8.6	15.1	1.1	-	24.8
Careniup	4.5	26.8	1.9	0.4 (drain)	33.6*
Gwelup	-	8.8	18.5	-	27.3
Karrinyup	8.8	-	8.6	-	17.4**
Jackadder	-	-	7.18	0.12	7.3
Herdsman	6	229	42	-	277
Monger	-	-	70	1.3	71.3
Hyde Park			2.3	0.5	2.8
Perry NW		0.5	5.3	0.2	6.0
Perry SE		1.9	4.5	0.2	6.6
Shenton Park			2.7	0.2	2.9
Star Swamp	3.1	0.1	0.4	0.6	4.2
Claremont	0.3	3.6	14.4	-	18.3
Other small infiltration basins, compensating basins and landscape features eg Little Carine, Dog Swamp, Mabel Talbot Park, Shearwater Place Osborne Park Swamps & wetlands beside Mitchell Freeway	-	-	-	4.0	4.0
TOTALS	31.3	285.8	178.9	3.5	503.5

* Privately owned apart from small drain reserve.
** Private Open Space.

3.5 m. The peat is lenticular in form and saucer-shaped in section, tapering in thickness towards the margin. The peat and clay bed which underlies it may be expected to have a much lower permeability than the sediments on which they rest." (p 297.)

Thick deposits of peat occur at other wetlands in the area. At Herdsman Lake the deposits are several metres thick in parts of the lake bed. At Careniup Swamp peat is greater than 3 m deep in the centre of the swamp and verbal accounts of Lake Monger suggest deep deposits of peat there.

Teakle and Southern (1937a) described in detail the peat deposits at Herdsman Lake. Teakle and Southern (1937b) have described peat at Joondanna marsh (north of Lake Monger), Yambago Marsh (Osborne Park) and Careniup marsh.

The hydrology of the wetlands in this area is now greatly altered from its pre-settlement state. Lowering of the water table to allow urban development, assimilation of remaining wetlands into the urban drainage system as compensating basins and infiltration basins, alterations to the

regional water balance resulting from clearing of deep-rooted vegetation, increased numbers of private bores, and increased surface run-off are some of the factors which contribute to the changes. Whereas in the past the lakes would have received a large part of their recharge from groundwater, now, for the most part, recharge is from surface runoff in constructed drains. During dry summers lakes may be recharged with bore water to protect the amenity of parks (Perry Lakes, Lake Monger).

The vegetation of the wetlands is greatly changed. From a contemporary account, Miller (1980) reconstructed the appearance of Lake Monger in 1830: a swampy lagoon with sprawling paperbarks and dense reeds and rushes 1.8 m and more in height. Miller, in describing the lake during the first world war refers to the 'sienna water', indicating that as late as 70 years ago Lake Monger's waters were highly coloured by swamp deposits as are those in the Gingin Brook catchment and in the Jandakot area today.

The Gwelup Public Water Supply Area lies within this area. Groundwater from the unconfined and confined aquifers is pumped from a borefield for public water supply.

8.1.1 REFERENCES

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8.2 WETLANDS IN CARINE OPEN SPACE

8.2.1 GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Parks and Recreation
RESERVE NUMBERS: Owned by State Planning Commission
PURPOSE: Parks and Recreation
MANAGEMENT: City of Stirling
SYSTEM 6 RECOMMENDATION: M37
WAC CLASSIFICATION: LE.f.s.p.sc
WATER RESERVE: west of Gwelup Public Water Supply Area
DRAINAGE: Main and local
ROADWORKS: North Perimeter Highway impinges on southern side of lake.

8.2.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Big Carine Swamp is situated on peats and peaty sands on coastal limestone, in the Karrakatta association near its interface with the Cottesloe association.

8.2.3 AREAS

Total area of open space:	92.3 ha
Tuart woodland	5 ha
Big Carine Swamp	24.8 ha
Including mixed sedge/rush	8.2 ha
Central paperbarks (including paperbarks over water)	4.6 ha
Fringing paperbark	4.0 ha
Baumea/weed	1.8 ha
Typha	5.1 ha
open water	1.1 ha

8.2.4 HYDROLOGY (Figure 8.3)

Townley (1984) provided a broad overview of the hydrology of the general region with specific reference to Star Swamp but applicable to Carine.

Big Carine Lake is connected to the main drainage system of the Hamersley, Balcatta, Gwelup, Stirling and Carine districts. This drainage system links Lake Gwelup, Lake Karrinyup and Careniup Swamp to Big Carine Lake. A pump station on the western side of Big Carine pumps water to the ocean if necessary.

Local drains also flow into Big Carine, either directly or through Little Carine Lake. Little Carine Lake has recently been recontoured and landscaped.

The water level record for Big Carine Lake reflects its role in the regional drainage system. The upper level can be controlled by pumping to the ocean. In below-average to average rainfall years the upper level does not reach the control level. Variations in minimum levels reflect private pumping and groundwater use to maintain surrounding parkland.

Table 8.2. Big Carine Lake: water levels 1967-84.

i Maximum level: 4.68 m AHD
ii Number of years maximum lake level has fallen within the specified limits.

m AHD	1967-75	1976-84
>4.5	3	1
4.0-4.5	3	8
3.5-4.0	3	0

iii Minimum levels: 1.93 m AHD (1962); 2.02 m (1960); 2.5 m (1981).
iv Number of years minimum lake level has fallen within the specified limits.

m AHD	1968-75	1976-85
>4.0	1	0
3.5-4.0	2	1
3.0-3.5	2	5
2.5-3.0	3	4

Minimum levels since 1976 have tended to be lower than in the previous few years. However, the very low levels of the early 1960's have not occurred recently.

8.2.5 WATER QUALITY (Big Carine Swamp)

Table 8.3. Big Lake Carine: summary of spring and autumn water samples 1970-84 (Water Authority of WA).

PARAMETER	1970-75			1976-84		
	MEAN	RANGE	N	MEAN	RANGE	N
i pH	8.27	7.6-9.8	10	7.92	7.5-9.1	17
ii Total Nitrogen						
mg/L						
Autumn	1.6	1.31-1.80	3	1.37	0.75-2.35	7
Spring	1.5	0.16-5.5	6	0.70	0.6 -0.95	7
iii Phosphorus as P						
mg/L						
Autumn	0.30	0.14-0.57	3	<0.09	<0.05-0.20	8
Spring	<0.11	<0.01-0.25	5	<0.17	<0.05-0.70	7

Table 8.3. Big Lake Carine: summary of spring and autumn water samples 1970-84 (Western Authority of WA) (Cont'd).

PARAMETER	1970-75			1976-84		
	MEAN	RANGE	N	MEAN	RANGE	N
iv Total Dissolved Solids mg/L						
Autumn	900	640-1 198	4	806	550-1380	8
Spring	610	400-774	6	491	400-590	9
v Heavy metals since 1975.						

Chromium (n=17) all values <0.05 mg/L)
Zinc: range <0.01-0.12 (high value 24.9.84)
Cadmium: all but one value <0.01mg/L;0.01mg/L 29/9/80
Lead: all values <0.04 except 24/9/84 <0.1mg/L
Copper: all values 0.01 mg/L or less
Mercury: all values <0.0002 mg/L

The limited data show, if anything, an improving trend in nutrient levels.

8.2.6 LAND USE

The area surrounding the Carine swamps has been used for rural activities in the past. Air photographs taken in 1948 show small holdings on the west and east of the swamps with fences running east-west across Big Carine Swamp. Traces of these fences still remain.

The area is being developed as a multi-purpose recreational area with emphasis on mowed lawns and paths with active recreation on the northern and eastern sides and equestrian uses on the north-east.

Under the terms of the concept plan for development of the parkland, emphasis at Big Carine Lake is on maintenance of natural habitats, while emphasis in the north-east, around Little Carine Lake, is towards a highly modified water feature (Metropolitan Regional Planning Authority, 1975). Earthworks and landscaping around Little Carine Lake have recently been carried out.

The road reserve for the North Perimeter Highway extends into the southern margin of Big Carine Lake. The lake is likely to be affected by road construction.

8.2.7 VEGETATION (Figure 8.2)

Little Carine Lake: the wetland vegetation has been removed, except for some paperbark woodland, and is being replaced by landscaped plantings.

Big Carine Lake: consists of a mosaic of sedgeland and closed paperbark woodland, with a small area of open water.

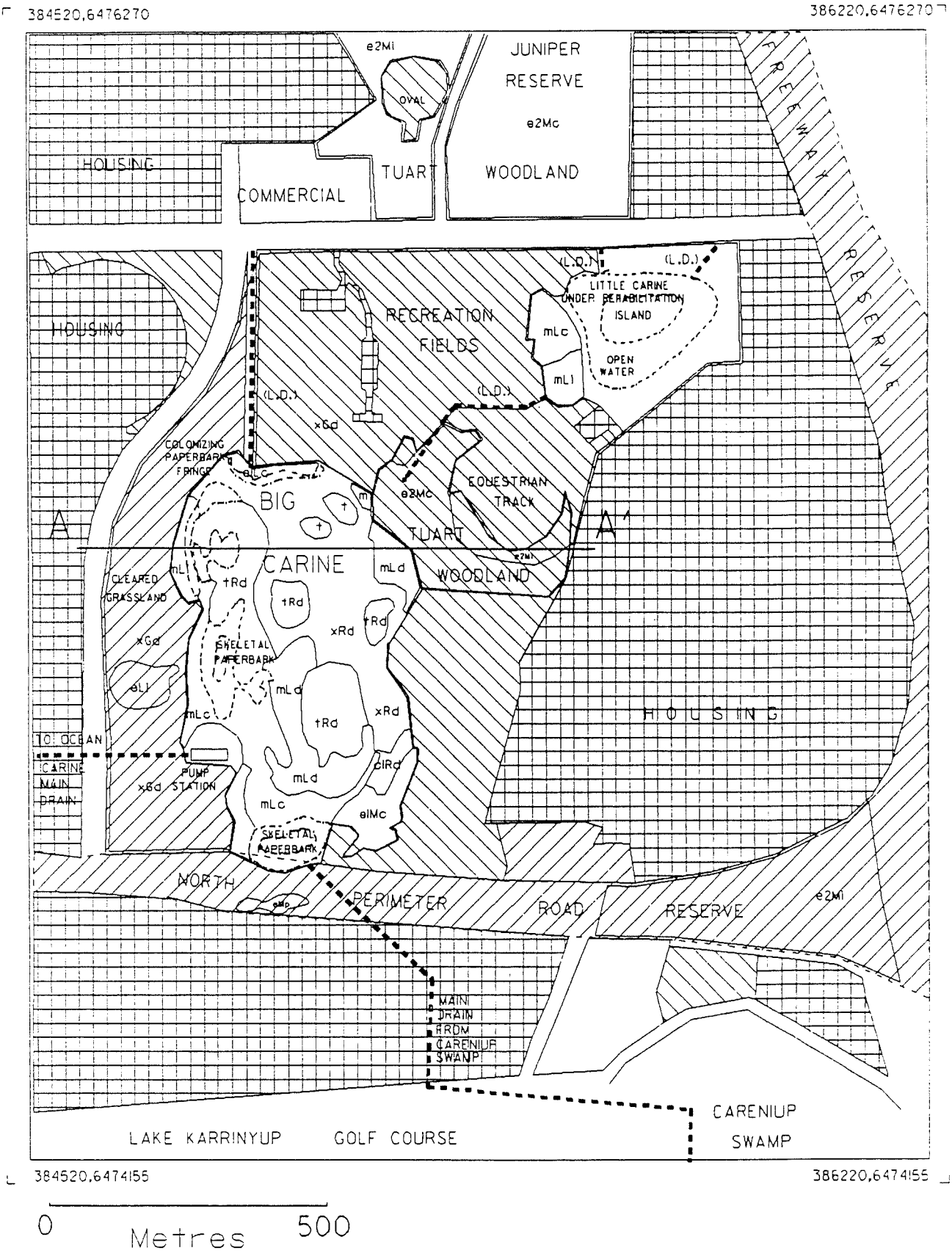

Figure 8.2 Big Carine Lake: wetland plant communities and surrounding land use.

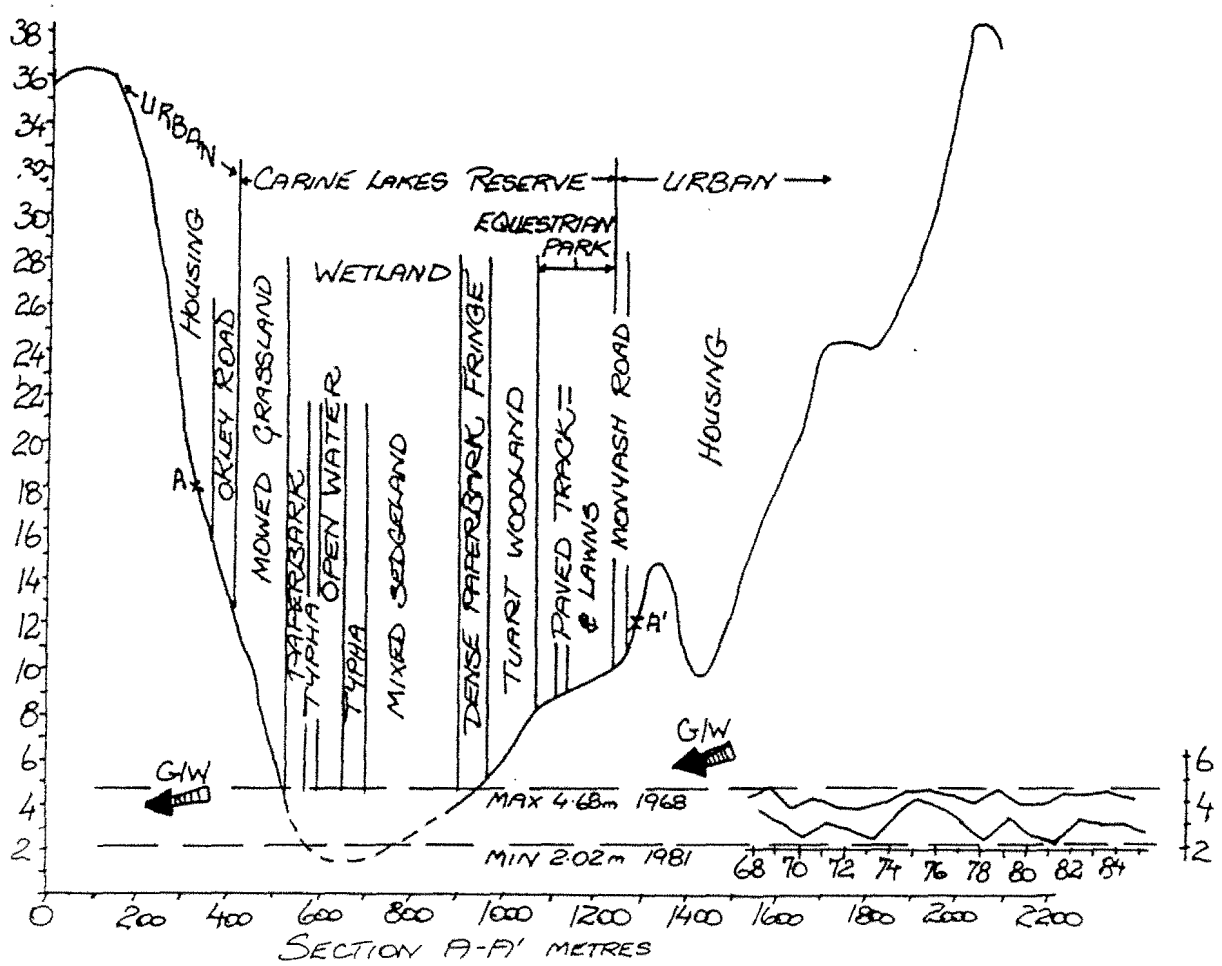

Figure 8.3 Big Carine Lake: diagrammatic cross-section and water level record.

The vegetation shows a high degree of interspersion, differing from most of the urban lakes which have concentric rings of vegetation around water. The edges between the various communities contribute to the habitat richness of the wetland. The lake lacks a buffer of upland woodland to minimise direct effects of fertiliser and pesticide application to the surrounding lawns.

It is possible that the relatively good water quality in the lake is a result of the presence of emergent vegetation.

8.2.8 FAUNA

There appears to be little recorded information about the fauna of the area. Consultants carried out a study of Little Carine Lake in 1984 for the City of Stirling.

8.2.9 MANAGEMENT ISSUES

Drainage waters should be managed to reduce the possibility of nutrient pollution. The apparent fall in nutrient levels since 1975 may be a consequence of increased inflows of surface runoff which has come either from a relatively clean catchment or which is being favourably modified as it passes through the drainage network of Lake Gwelup and Careniup Swamp.

The Carine Open Space clearly has an important social function in the region.

High water and nutrient levels in spring may result in flushes of spring-breeding mosquitoes and lead to demands for pesticide use to control them.

The wetlands are well separated from surrounding residences and this will tend to reduce effects of insect pests originating from them.

Big Carine Lake has a high potential as a nature study area for nearby schools. It offers points of comparison with Star Swamp and Lake Gwelup.

The wetlands contribute to the variety of the Carine Open Space. There will need to be a balance between open water and protection of emergent vegetation which plays a role in improving water quality.

Water supply to the wetlands is a most important aspect of management if environmental quality is to be maintained. There will need to be a balance between groundwater extraction for lawns and gardens and maintaining adequate groundwater levels to sustain the wetland vegetation. Heavy use of groundwater, for instance to maintain lawns in the open space, could lower the water table during the summer. Static water levels should be avoided if the health of the paperbark woodland is to be protected.

The expansion of Typha should be monitored.

8.2.10 REFERENCES

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8.3 STAR SWAMP

8.3.1 GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Urban - subject to rezoning
RESERVE NUMBERS: subject to change
MANAGEMENT: City of Stirling
SYSTEM 6 RECOMMENDATION: M35
DRAINAGE: Some local drains
WATER RESERVE: West of Gwelup Public Water Supply Area

8.3.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Star Swamp is situated at the interface of the Spearwood and Quindalup landforms (Churchward and McArthur, 1978). Its position is analagous to Pipidinny and Beonaddy Swamps near Yanchep.

8.3.3 AREAS

Total area of open space: about	100 ha
Total area of wetland	4.2 ha
Open water	0.4 ha
Sedgeland	0.1 ha
Paperbark	3.1 ha
Modified wetland	0.6 ha

8.3.4 HYDROLOGY (Figure 8.5)

Townley (1984) showed:

1. Star Swamp is in direct connection with the regional water table aquifer system and hence water flows into the swamp from the east and discharges towards the coast throughout the year. In winter the swamp acts as a recharge zone for the groundwater system; and in summer it acts as a discharge zone; and

2. water levels in the swamp are unlikely to be significantly affected by land use changes in the immediate watershed but will be influenced by land use along the flow line originating at the Gnangara Mound and by influences through the northern metropolitan region.

Townley went on to recommend care with the use of pesticides and herbicides. He also suggested that Typha may effectively control nutrient levels in the swamp. He recommended the regular monitoring of water quality in the swamp.

Table 8.4. Star Swamp: water levels 1964-84.

i Maximum level: 1.79 m (1975).

ii Number of years maximum lake levels have fallen within the specified ranges.

m AHD	1964-75	1976-84
1.6-1.8	2	7
1.4-1.6	8	2
1.2-1.4	2	0

iii Minimum level: 0.35 m AHD (1981).

iv Number of years minimum lake levels have fallen within the specified ranges.

m AHD	1964-75	1976-85
1.2-1.4	4	1
1.0-1.2	2	1
0.8-1.0	3	3
0.6-0.8	3	3
0.4-0.6	0	1
<0.4	0	1

It may be inferred from the water level record that winter levels have been higher and summer levels have been lower since 1976 than previously. This may reflect greater inputs of stormwater in winter and a falling water table as a result of private use of shallow groundwater from bores in the vicinity of the swamp. A fall in the regional water table resulting from consistently below average rainfall may also contribute to low water levels in Star Swamp. In this case it would be expected that the high levels in winter would be short term, following storms.

8.3.5 WATER QUALITY

A limited amount of data on water quality is reported by Townley (1984). He made the following points:

1. There has been an increase in phosphorus levels and a decrease in nitrogen levels in the interval since water quality analyses were reported by Bell et al. (1979).

2. There are relatively high nutrient levels near the drain outlet.

3. The groundwater may be a significant source of phosphorus for the swamp.

4. Typha may play a role in limiting nutrient levels.

5. Bacterial counts are low, indicating a healthy wetland environment.

8.3.6 LAND USE

There has been a long public debate about use of roughly 100 ha of bushland to the north, east and south of the swamp. A decision has now been taken to reserve the entire area of bushland and to manage it with the swamp proper.

Urban development is separated from the swamp on the west by Hope Road.

The bushland has been affected by incursions of exotic plants, by fire and dumping of litter. Strong community concern for the area has led to concerted efforts to clear litter and control weeds and to plant trees indigenous to the area.

8.3.7 VEGETATION (Figure 8.4)

Loneragan (1984) extended the species list of Watson and Bell (1981) and reported that a total of 49 plant species occur within the paperbark swampland. This list includes 25 introduced species, including six grasses and a number of weed species.

Closed paperbark forest which occurs at Star Swamp is very limited in the metropolitan region and its survival may be at risk if static water levels are maintained to protect landscape values (eg Lake Claremont, Town of Claremont, where prolonged high water levels led to the death of paperbarks in the wetland).

8.3.8 FAUNA

MacMillan (1984) reported a survey of the fauna of Star Swamp but placed a good deal of emphasis on the terrestrial fauna.

The aquatic invertebrate fauna included four species of Crustacea; representatives of 10 families of aquatic insects including low numbers of chironomid midges (which occur in plague numbers in more polluted urban lakes), and many predatory forms.

The vertebrate fauna included one species of native fish and the introduced mosquito fish, four species of frog and the long-necked tortoise.

The bird list (MacMillan, 1984) for the area included 10 species characteristic of wetlands. This list contained species with a range of habitat requirements, including secretive forms, those frequenting open water and a number of raptors. Van Delft (1988) provides notes on Star Swamp as a birding site, but does not record any waterbirds as birds regularly seen.

The wetland offers small areas of the following habitat types: deep fresh water >50 cm (winter and spring), shallow open water, grasslands (parkland lawn), reedbeds, flooded Melaleuca, roosting posts and tree stumps and hollows. It may be inferred that the wetland is utilised by small numbers of a relatively large range of species.

The data on the fauna suggests that the wetland system is healthy and complex.

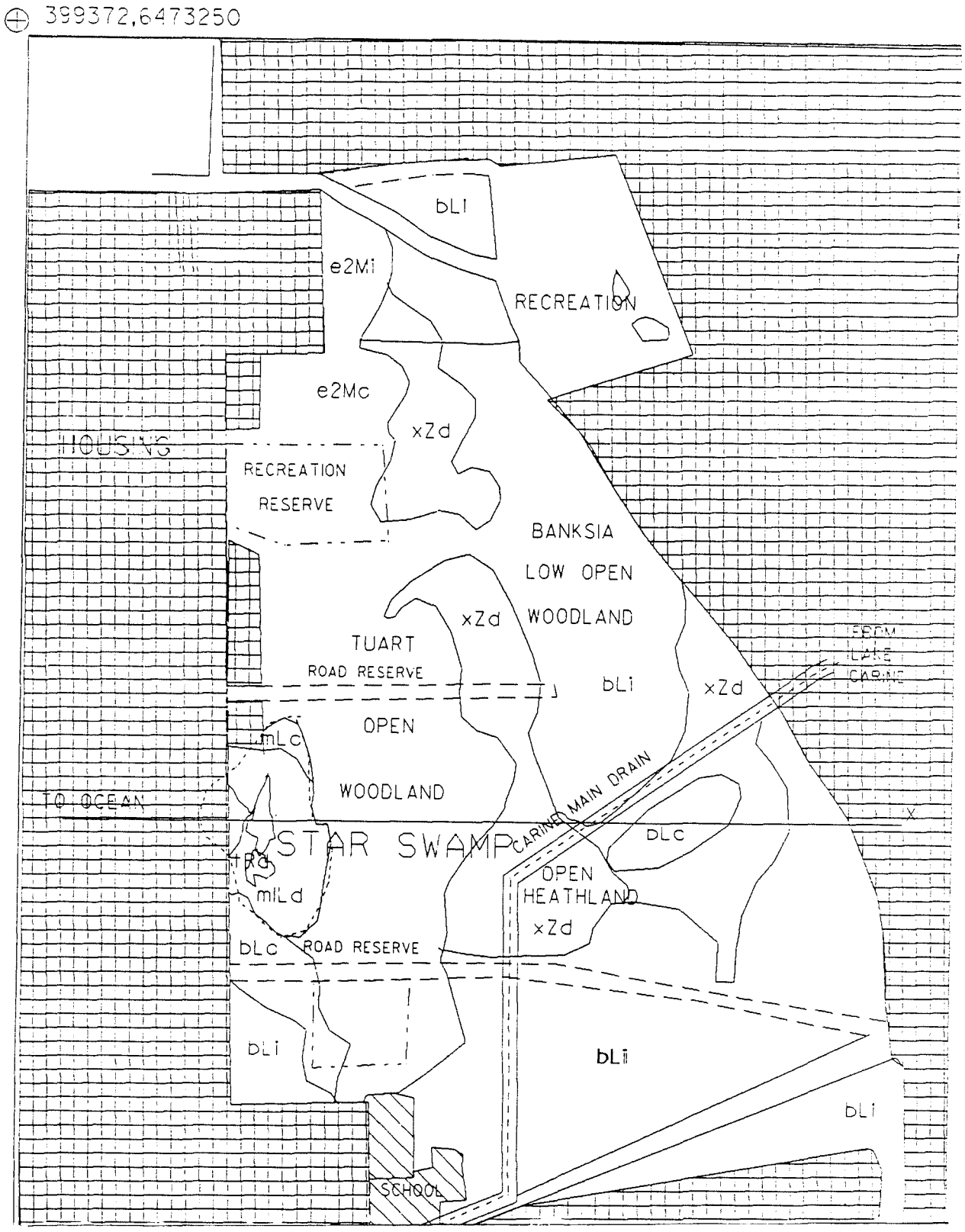

Figure 8.4 Star Swamp: Wetland plant communities and surrounding land use.

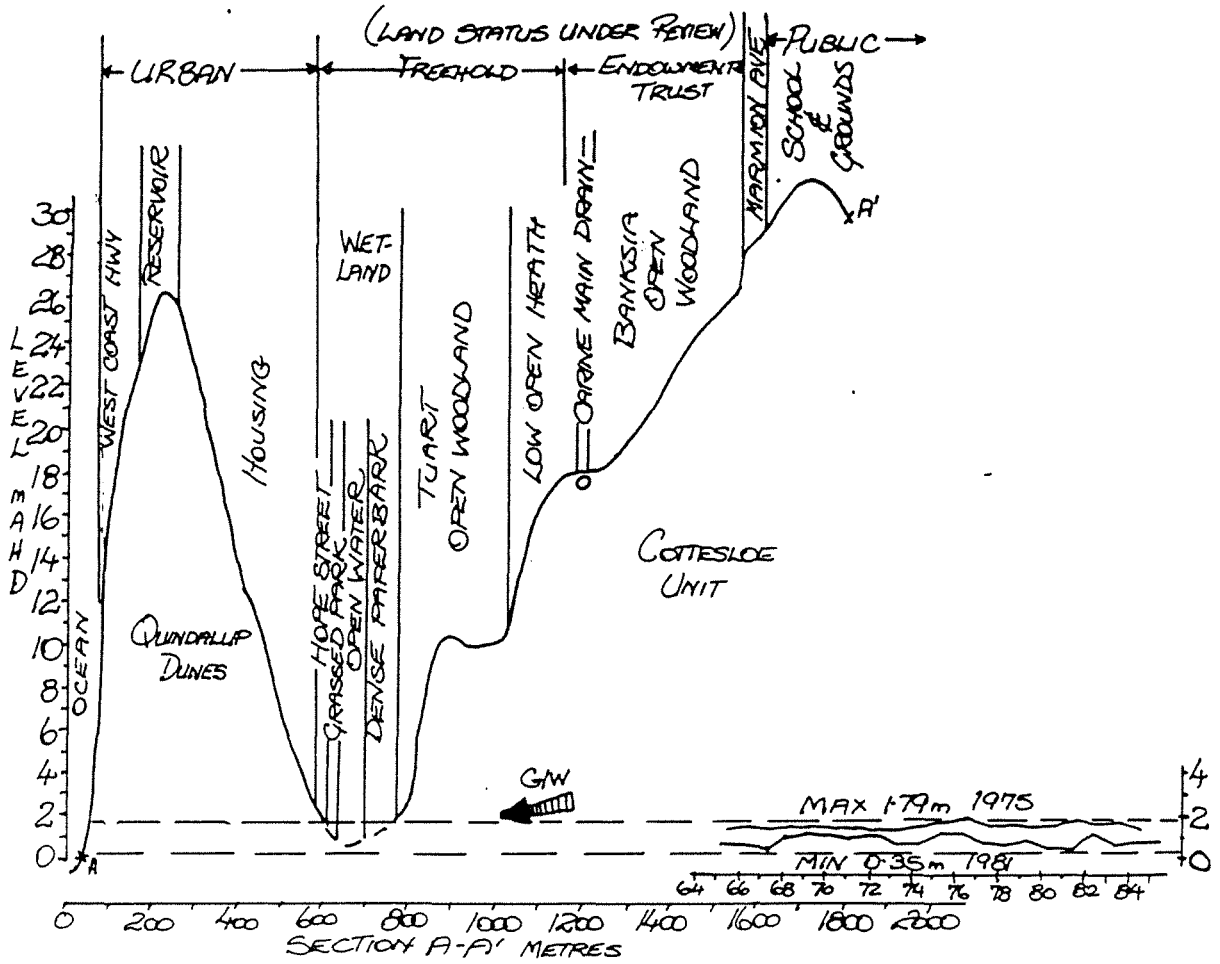

Figure 8.5 Star Swamp: diagrammatic cross-section and water level record.

8.3.9 MANAGEMENT ISSUES

Management of water levels and water quality are of central importance if the Star Swamp open space is to be adequately conserved.

A management plan for Star Swamp is now being put into effect.

Loneragan (1984) stated: "assuming that the swamp will remain a focal point within the reserve, development must protect its integrity and present informality."

To this end the following points are relevant:

1. bores used for park management should be sited away from the wetland to prevent drawdown;

2. peak water levels should inundate the paperbark woodland. The paperbark woodland should not be inundated during the hot summer months;

3. fringing and emergent vegetation should be maintained; and

4. any urban runoff should be allowed to settle and, if possible, be flowed through emergent plants before entering the swamp.

8.3.10 REFERENCES

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8.4 CARENIUP SWAMP

8.4.1 GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Urban Deferred
RESERVE NUMBER: privately owned/drain reserve
MANAGEMENT: Private landholders
SYSTEM 6 RECOMMENDATION: M38?
WETLAND ADVISORY COMMITTEE CLASSIFICATION: LE.f.m Se.C
PURPOSE: n/a
DRAINAGE: main and local drainage; stormwater infiltration from Mitchell Freeway

8.4.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Careniup Swamp is an area of lake deposits within the Spearwood Dune system near the interface of the Karrakatta and Cottesloe associations (Churchward and McArthur, 1978) with a prominent limestone outcrop to the north-east of the swamp. It is separated from Carine Lake to the north by a ridge above 18 m AHD. The swamp bed has deep peat deposits greater than 3 m deep. Teakle and Southern (1937) described the chemical and physical properties of the peat of the swamp (Careniup Marsh).

8.4.3 AREAS

Total area bounded by roads	97 ha
Swampland area (including drain)	33.6 ha
Paperbark area	4.5 ha
Sedgeland area	26.8 ha
Open water zone	1.9 ha
Landfill area	ca 2.2 ha

8.4.4 HYDROLOGY (Figure 8.7)

Careniup Swamp is on the western edge of the Gwelup Public Water Supply Area. Water levels in the swamp reflect the water balance of the region. Water level records provided by the Water Authority of Western Australia show that both maximum and minimum water levels are displaying a falling trend since the early 1970's. Teakle and Southern (1937) noted that the swamp was developed successfully for market gardening in the early part of the century but was suffering from a rising water table in 1937, with some portions once cultivated being submerged by that time.

Table 8.5. Careniup Swamp: water levels 1970-84.

i Maximum level recorded: 6.98 m AHD (1967).
ii Number of years maximum level has fallen within the specified limits.

m AHD	1970-75	1976-84
>6.5	4	0
6.0-6.5	2	9

Table 8.5. Careniup Swamp: water levels 1970-84 (Cont'd).

iii Minimum level recorded: 4.48 m AHD 1973.
iv Number of years minimum level has fallen within the specified limits.

m AHD	1971-75	1976-85
>6.0	1	1
5.5-6.0	2	2
5.0-5.5	0	3
4.5-5.0	1	4

8.4.5 WATER QUALITY

The values reported in Table 8.6 have been calculated from spot samples collected by the Water Authority of Western Australia.

Table 8.6. Careniup Swamp: summary of spring and autumn water samples 1975-84 (Water Authority of WA).

PARAMETER	n	MEAN	RANGE
Total Nitrogen: (mg/L)			
autumn	5	3.68	2.05-6.0
spring	8	1.14	0.80-2.0
(Background for groundwater from Tamala limestone at 14.6 m: ?3.34 mg/L - Cargeeg, McFarlane & Smith, 1981).			
Phosphorus as P (mg/L) 1975-84			
autumn	5	0.33	0.20-0.4
spring	10	<0.09	<0.05-0.2
(Background for groundwater from Tamala limestone at 14.6 m: 0.08 mg/L - Cargeeg, McFarlane & Smith, 1981)			
pH	15	7.97	7.60-9.2
(Background for groundwater from Tamala limestone at 14.6 m : 6.7).			
Total Dissolved Solids			
autumn	5	1840	720-3460
spring	10	1066	498-1795

Table 8.6. Careniup Swamp: summary of spring and autumn water sampled 1975-84 (Water Authority of WA) (Cont'd).

Heavy Metals (mg/L)	
Chromium:	<0.02 - <0.05
Zinc:	<0.01 - 0.12
Cadmium	<0.01
Lead:	<0.04 - <0.1
Copper:	0.01 - 0.02
Mercury:	<0.0002

8.4.6 LAND USE

The land surrounding the swamp is now used for a range of purposes including residential, caravan park, equestrian centre, market garden and storing or dumping of various materials. A number of landholders have dumped imported fill in the swamp and some peat has been excavated. An uncompleted road embankment on the northern end of the swamp has encroached upon the wetland.

There has been long deliberation on appropriate zoning for the swamp. Efforts to develop the area for residential use have been complicated by:

(i) the fragmented landownership;

(ii) the levels of the swamp and the presence of deep peat which would make the provision of deep sewerage difficult; and

(iii) the debate about the conservation value of the central swamp area. The conservation value of the swamp has been reduced by dumping and filling.

8.4.7 VEGETATION (Figure 8.6)

Teakle and Southern (1937) noted that "Careniup marsh" was originally covered by a tussock reed botanically different from the usual reeds in neighbouring marshes.

The vegetation at present is largely influenced by past and present land use and consists of extensive areas of Typha orientalis (which is highly invasive and requires considerable effort to clear), a small area of swamp paperbark, now assimilated into the caravan park, some flooded gum and a large area of weed community, with castor oil bushes prominent.

8.4.8 FAUNA

There is no published information on the fauna. The open water, paperbark and sedgeland provide a range of habitats for wildlife. Riggert (1966) drew attention to the potential of Careniup Swamp as a landscape feature and wildlife refuge.

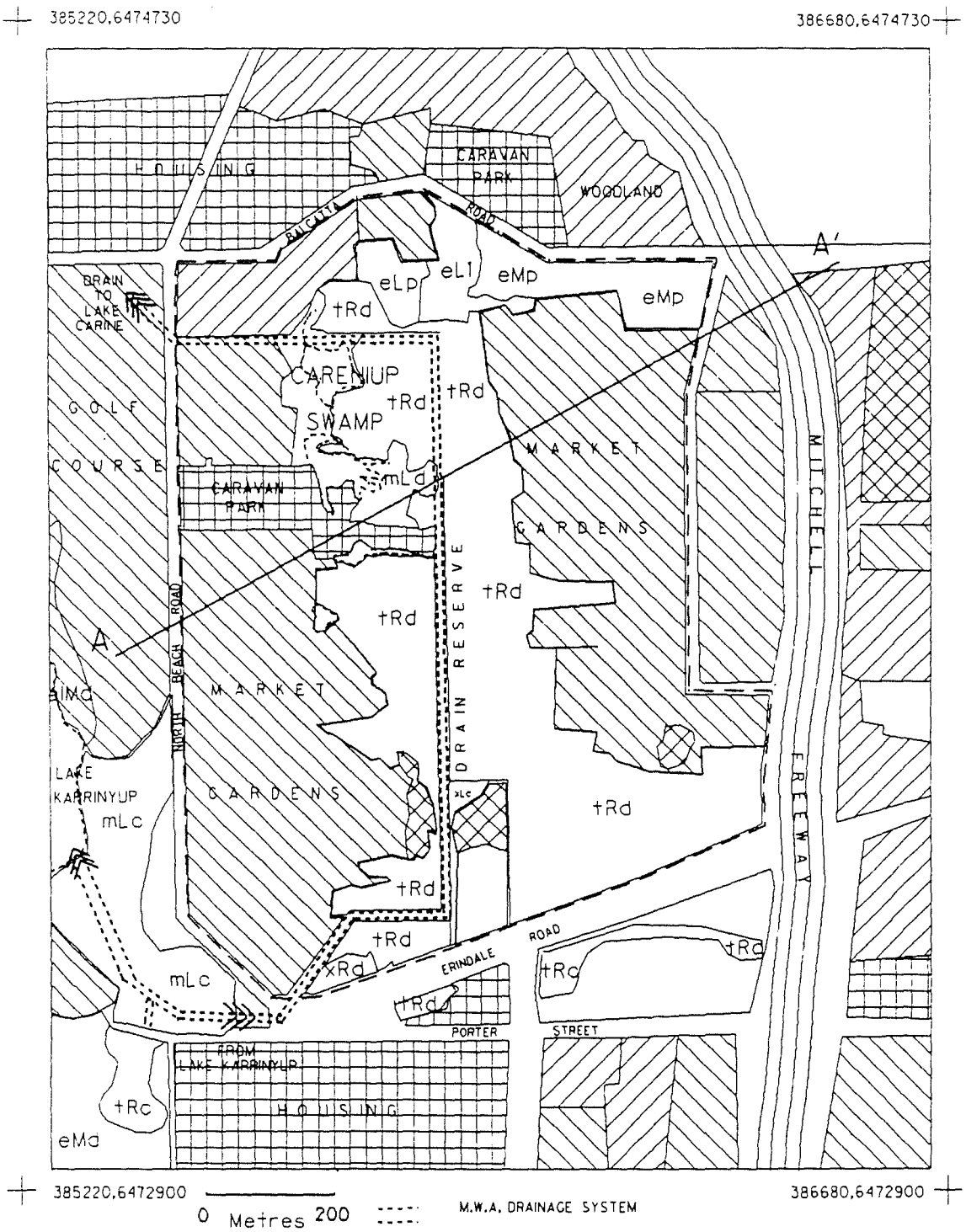

Figure 8.6 Careniup Swamp: wetland plant communities and surrounding land use.

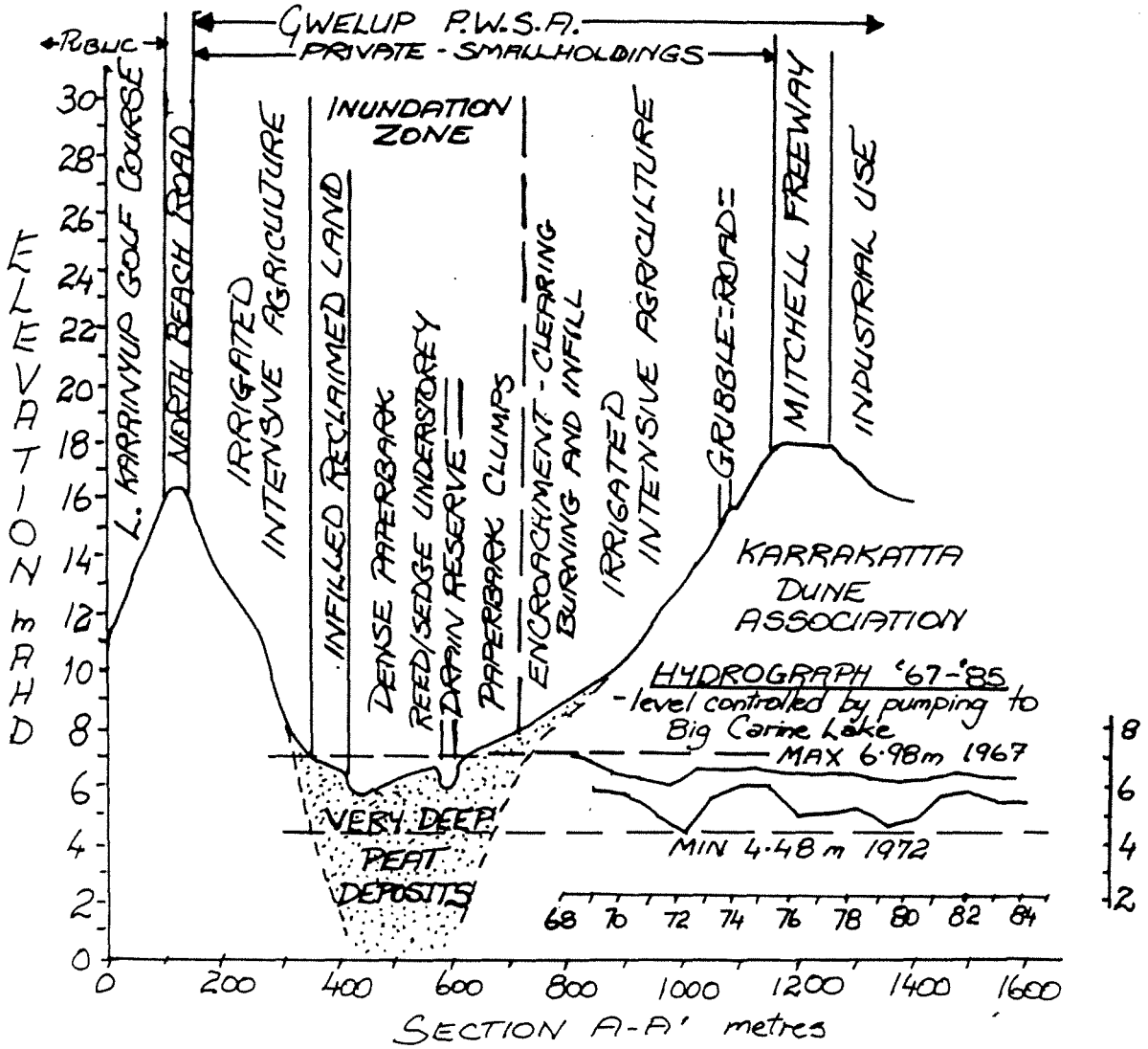

Figure 8.7 Careniup Swamp: diagrammatic cross-section and water level record.

8.4.9 MANAGEMENT ISSUES

Careniup Swamp has been severely altered by over 80 years of agricultural and other uses. The present fragmented ownership of the land makes coordinated management of the area difficult. Proposals have been made to develop the area and the area has been the subject of development proposals using a wetland feature.

Given the MRS zoning of "urban deferred", residential development will eventually occur. However, the wetland core is, to all intents and purposes, undevelopable. Rehabilitation of this wetland core, to improve the amenity of the development, appears a rational approach.

Management of the quantity and quality of the groundwater resource to provide for public water supply should be a very high priority.

8.4.10 REFERENCES

Cargeeg, G C, McFarlane, D J and Smith, R A (1983), Regional survey of groundwater quality in Perth, Western Australia. pp 44-49 in Water quality: its significance in Western Australia. Seminar, Perth, 13-14 October 1983. Water Research Foundation.

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Teakle, L J H and Southern, B L (1937), The peat soils and related soils of Western Australia. Notes on the occurrence and properties of peats and other poorly drained soils in the south west coastal areas of Western Australia. Journ Agric Western Australia, Vol 14,(September, 1937) pp 332-358.

8.5 KARRINYUP LAKE

8.5.(a) GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Private Open Space
RESERVES: Private Recreation and †32757
MANAGEMENT: Karrinyup Country Club
SYSTEM 6 RECOMMENDATION: n/a
WAC CLASSIFICATION: LE.f.sm.p.o
WATER RESERVE: West of Gwelup Public Water Supply Area
DRAINAGE: Connected to main drain - water level control

8.5.(b) SETTING

Lake Karrinyup is a wetland which has been modified to provide the landscape feature of the Karrinyup Country Club (see Figures 8.8 and 8.9). Water from the main drain running north from Lake Gwelup can be diverted to flow to Karrinyup Lake if required to maintain the lake levels or to flow to Careniup Swamp and then to Big Carine Swamp.

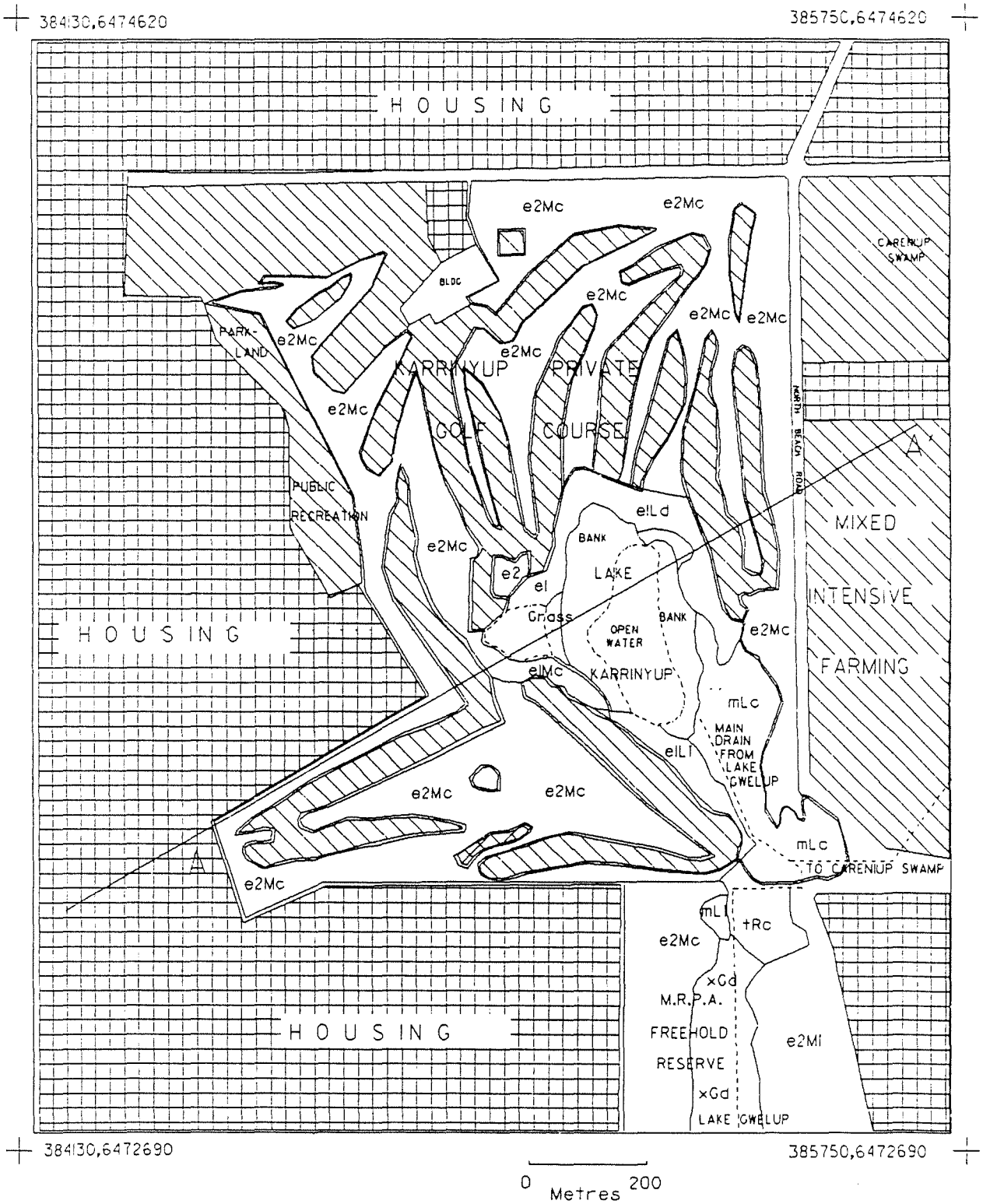

Figure 8.8 Lake Karrinyup: wetland plant communities and surrounding land use.

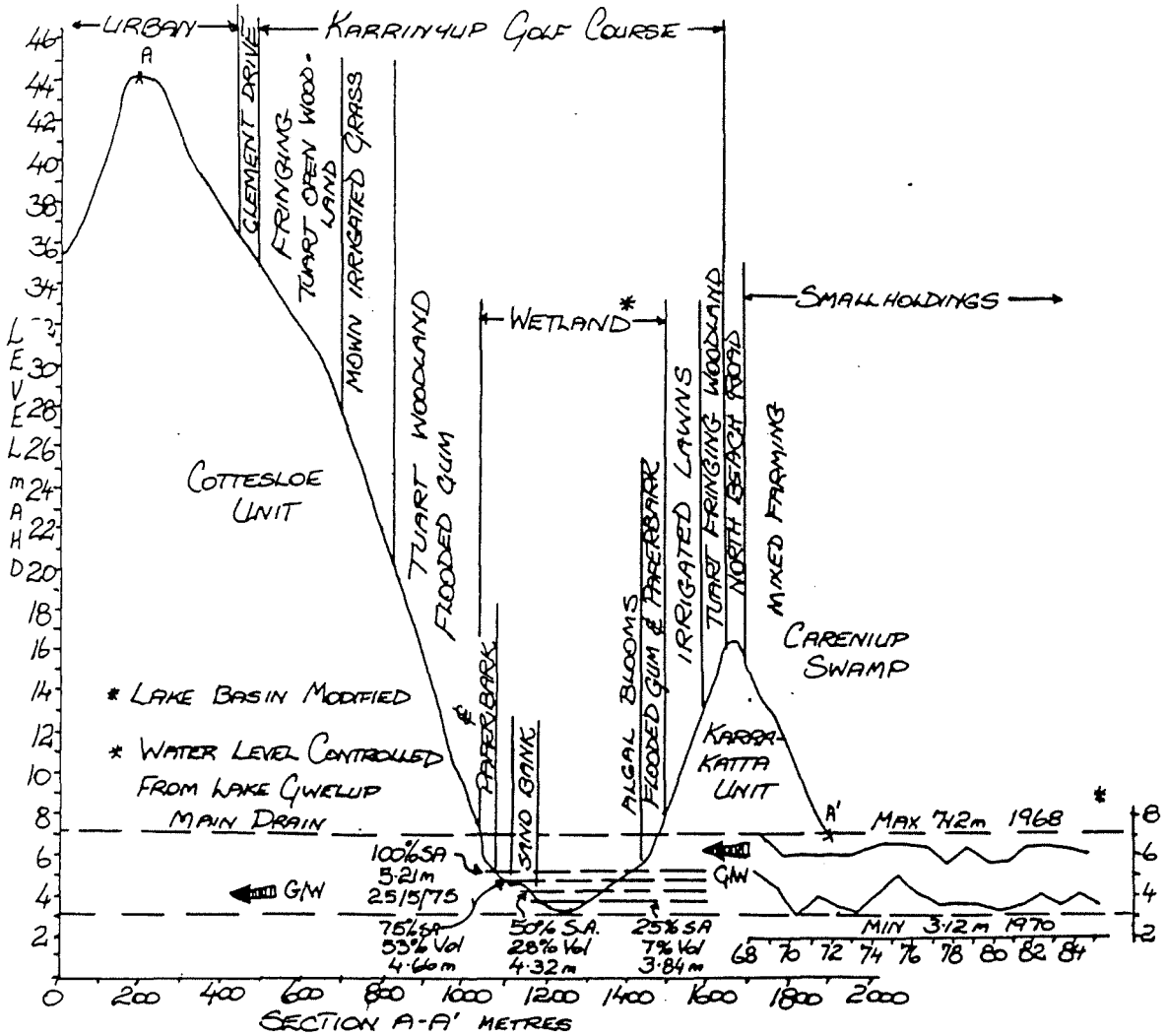

Figure 8.9 Lake Karrinyup: diagrammatic cross-section and water level record.

8.5.(c) AREAS

Total Reserve	approx 108 ha
Area of lake and fringing vegetation	17.4 ha
Open water	8.6 ha
Fringing trees	8.8 ha

8.6 LAKE GWELUP

8.6.1 GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Parks and Recreation
RESERVE NUMBERS: Owned by State Planning Commission
MANAGEMENT: City of Stirling
SYSTEM 6 RECOMMENDATION: M39
WAC CLASSIFICATION: LE,e.s.p.so
WATER RESERVE: Gwelup Public Water Supply Area
DRAINAGE: Main drain; local drainage
MINING: ?future peat

8.6.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Lake Gwelup has lake deposits of peat and peaty sands on predominantly leached sands of the Karrakatta soil association close to the boundary with the Cottesloe association.

8.6.3 AREAS

Parks and Reserves area (total)	74.5 ha
Lake area inside sedgeland margin/open water	18.5 ha
Sedgeland on lake margin	8.8 ha
Sedgeland north of lake	ca 1 ha
Woodland (tuart, marri & flooded gum)	21.6 ha
Modified by clearing & gardens	24.1 ha

8.6.4 HYDROLOGY (Figure 8.11)

The lake is situated below 8 m AHD with the lowest point on the lake bed being below 4.6 m AHD. It acts as a compensating basing in the main drainage system within the districts of Hamersley, Balcatta, Gwelup, Stirling and Carine, including much of the Gwelup Public Water Supply Area. Pumping and drainage of the area are managed to achieve a balance between maintaining the water table at acceptable levels and maximising infiltration.

Peak levels in the lake reflect surface runoff into the drainage network while levels in dry periods reflect the water table.

The record indicates lower maximum and minimum levels since 1975.

Outflow from the lake is controlled by the level of the outflow drain and the water level records since winter 1980 suggest that there is now fairly tight control with seasonal level variations ranging from around 6 m AHD to 7.7 m AHD. A proposal has been made to change the maximum controlled water level from 8.1 m to between 6.5 and 7.5 m (Dames and Moore, 1984).

Table 8.7. Lake Gwelup: water levels 1968-84.

i Maximum level: 8.1 m AHD (1968).

ii Number of years maximum lake levels have fallen within the specified ranges.

m AHD	1968-75	1976-84
>8.0	2	0
7.5-8.0	2	6
7.0-7.5	4	0
6.5-7.0	0	3

iii Minimum level: 4.49 m (1980).

iv Number of years minimum lake levels have fallen within the specified ranges.

m AHD	1968-75	1976-85
>7.0	1	0
6.5-7.0	2	1
6.0-6.5	2	3
5.5-6.0	2	3
4.5-5.0	1	1
<4.5	0	2

8.6.5 WATER QUALITY

Post-1975 levels of nutrients are lower than in earlier years. (Table 8.8)

On two occasions very low pH levels were recorded in winter following summers when the lake bed had dried out. A similar phenomenon has been observed at Lake Gnangara. It may be a consequence of mobilisation of sulphides deposited in peat following periods when the lake dried out in summer. Note that Teakle and Southern (1937) reported presence of acid peat on "Careniup Swamp" and Herdsman Lake.

8.6.6 LAND USE

The Lake Gwelup Regional Open Space is now being managed by the City of Stirling.

Land surrounding the lake has been used for farming; the remains of a vineyard can be found north of the lake. The area is now in transition from rural to urban, with development of recreational facilities around the lake. A recent student study provides some insight into people's perceptions of recreational values of the area (Gabelich, 1986).

Table 8.8. Lake Gwelup: summary of spring and autumn water samples 1970-84 (Water Authority of Western Australia).

PARAMETER	1970-1976			1976-84		
	n	mean	range	n	mean	range
pH	11	8.230	6.00-9.50	18	7.68	3.70-9.10
Total N (mg/L)						
autumn	5	1.650	1.40-2.10	8	0.96	0.55-1.45
spring	7	1.820	0.70-7.00	7	0.96	0.40-2.00
Phosphorus as P (mg/L)						
summer	5	<0.154	<0.01-0.44	9	<0.09	<0.05-0.20
winter	5	0.150	0.02-0.30	9	<0.08	<0.05-0.25
Total Dissolved Solids	13	609	460 - 1140	16	994	450 - 2220

Heavy Metals 1976-84 (mg/L).

Chromium generally <0.02; 0.04 winter 1978, 0.05 summer 1982
Zinc <0.01 - 0.13 high value winter 1982
Cadmium all values <0.01
Lead <0.04 - 0.07 high value 7/10/81
Copper <0.01 - 0.02
Mercury all values <0.0002

8.6.7 VEGETATION (Figure 8.10)

The vegetation surrounding the lake has undergone modification. Market gardens on the south and west of the lake are now being adapted to open space. Marri - jarrah woodland on the north and north-east, with some fringing melaleuca and acacia, provides opportunities to maintain some natural bushland, albeit heavily infested with weeds. There has been a marked increase of Typha in the lake and on its margins over the last few years.

While Typha presents some management problems and suggestions have been made of its implication in harbouring a mosquito nuisance, its role in the reduction of nutrient levels since 1976 should be investigated.

8.6.8 FAUNA

A number of studies have been made of the fauna of Lake Gwelup for planning studies (see Gobby, 1980, Dames and Moore, 1984) and by students engaged in student projects (see Veitch and Jones, 1976; Sinclair, 1982; Albone, 1985; and Buck, 1985). Van Delft (1988) provides notes about Lake Gwelup as a bird-watching site.

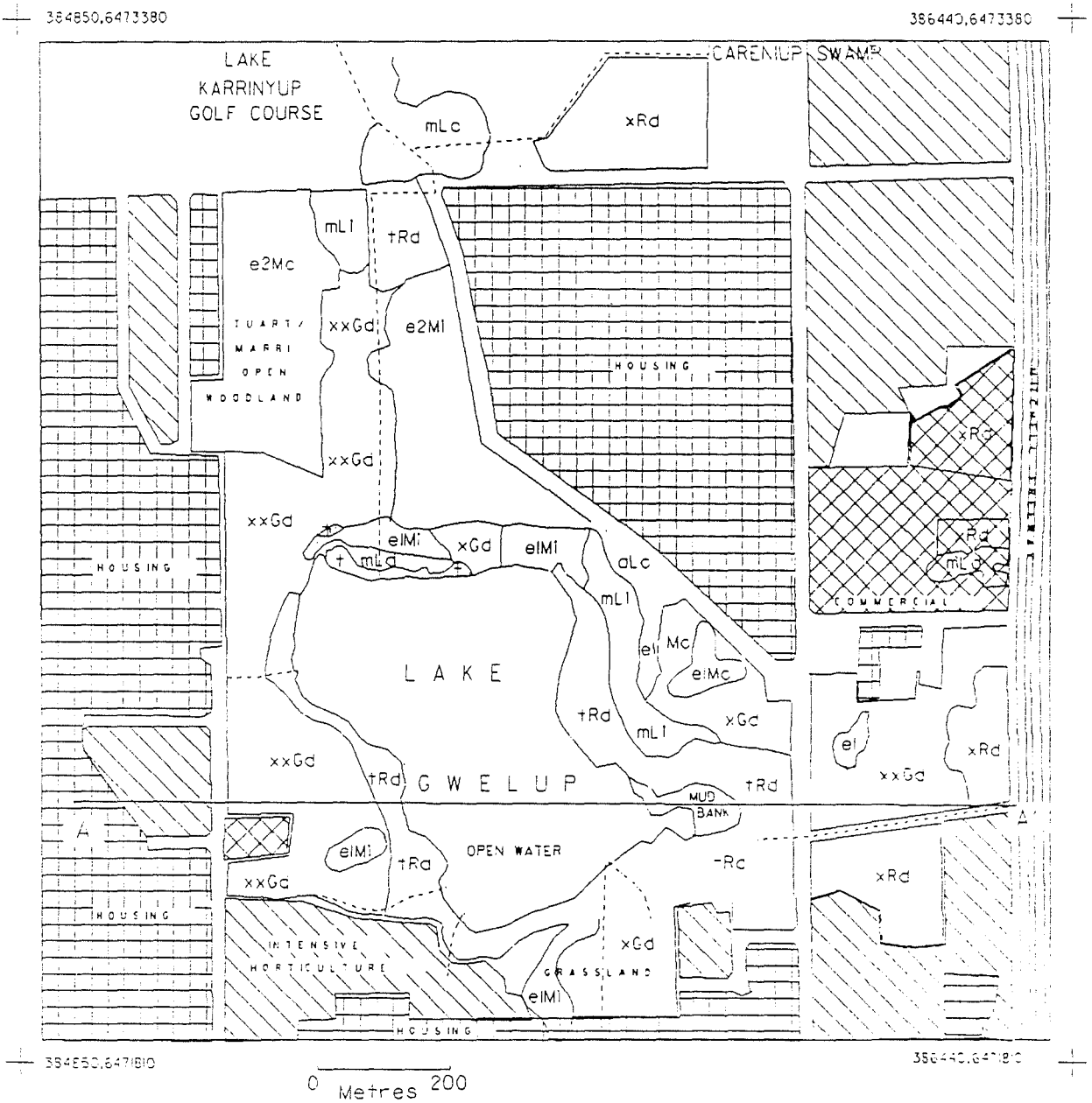

Figure 8.10 Lake Gwelup: wetland plant communities and surrounding land use.

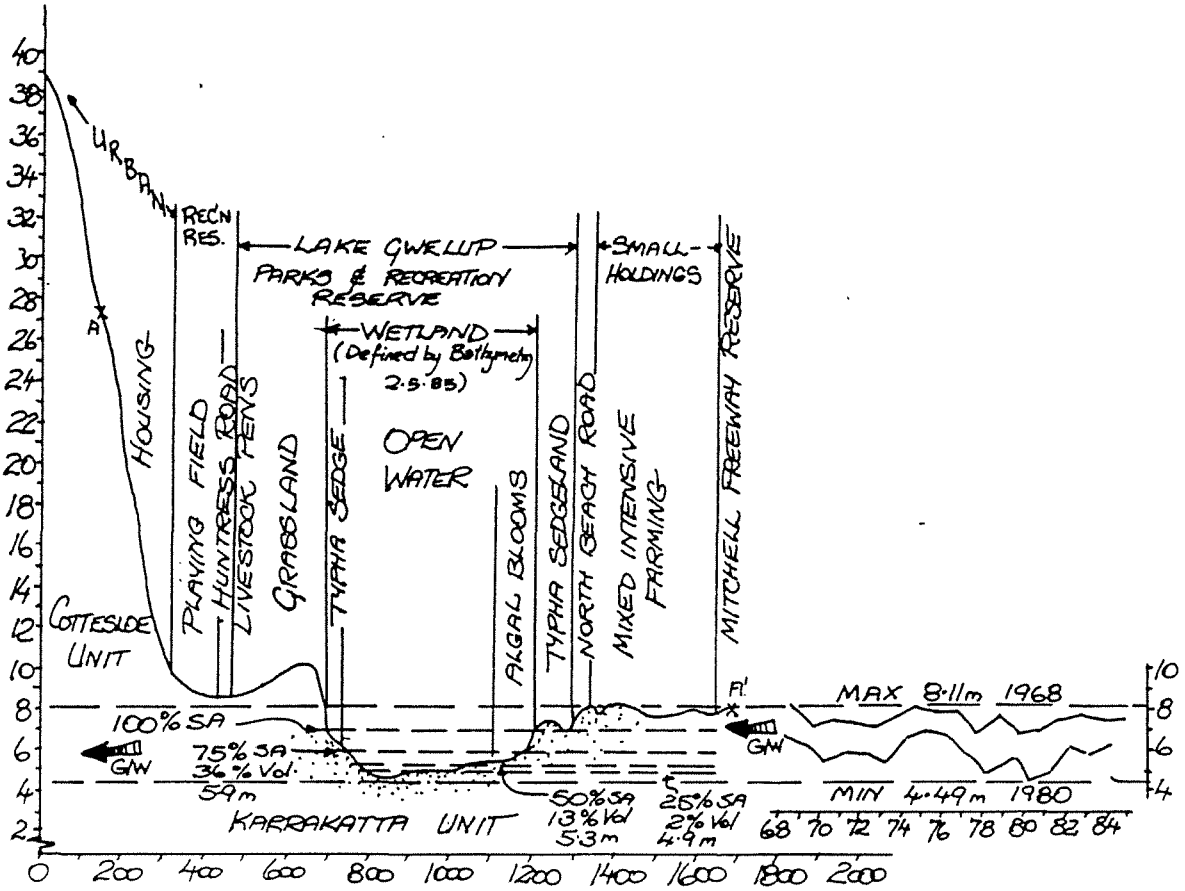

Figure 8.11 Lake Gwelup: diagrammatic cross-section and water level record.

8.6.9 MANAGEMENT ISSUES

Lake Gwelup is becoming an increasingly important landscape feature in the district and its social importance will grow. A balance between active recreation facilities on the western side and protection of natural bushland on the north and north-west will meet a range of social requirements.

There has been some demand for access to the open waters of the lake by canoeists, ski-paddlers and other potential users. While such demands are understandable as a consequence of a growing population at a distance from the rivers and estuary and a trend towards saturation of boating areas on the rivers, active boating on the lake could be expected to cause disturbance to wildlife habitats. Another matter to be taken into account is whether the lake waters meet acceptable standards for water contact sports. The widespread occurrence of Salmonella stereotypes in metropolitan wetlands is a factor to be considered (Iveson, 1979). A further factor is the possible risk of infection by the amoebae responsible for amoebic meningitis which occur in fresh waters during periods of high summer temperatures. Fairly careful monitoring of water temperature would be necessary to determine the suitability of lake waters for recreational immersion.

Recognising that Lake Gwelup is a significant landscape feature in the region, it is important to attempt to maintain open water in the lake throughout the year - if possible avoiding levels below 5.5 m. This would ensure a water area of 13-14 ha and a volume around 60 000 m^3. This would also ensure that the lake retained its function as a drought refuge.

Options to dredge the lake and use the spoil to construct islands have been considered. Such changes to the lake basin could maintain the landscape value of the lake and offer wildlife refuges as long as disruption of the lake sediments could be carried out without increasing seepage of water from the lake.

Other management issues are insect pest control and fire. Efforts to manage mosquito breeding by removing Typha should be carefully examined as Typha may be playing a role in limiting nutrient levels.

8.6.10 REFERENCES

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8.7 OSBORNE PARK SWAMPS

An extensive area of swampland is situated in the localities of Balcatta, Stirling and Osborne Park. These swamplands were developed as market gardens prior to World War 1 (Miller, 1980). Teakle and Southern (1973) describe the soils of Joondanna and Yambago Marshes in the area, with passing reference to land uses.

A large area of swamp in Stirling was filled using the sanitary land-fill technique. Bestow (1981) discussed the hydrogeology of the Gwelup area (see also Section 8.1).

These swamplands are being increasingly assimilated into the urban area.

8.7.(a) REFERENCES

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Miller, Connie (1980), 'After Summer Merrily'. Fremantle Arts Centre Press, Western Australia.

Teakle, L J H and Southern, B L (1973), The peat soil and related soils of Western Australia, Journ Agric Western Australia, 14 pp 332-358.

8.8 JACKADDER LAKE

8.8.1 GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Urban
RESERVE NUMBERS: 27766, 27697
PURPOSE: Recreation
MANAGEMENT: City of Stirling
SYSTEM 6 RECOMMENDATION: M42
WAC CLASSIFICATION: modified lake
WATER RESERVE: n/a
DRAINAGE: Main drainage; local drainage, pumping station

8.8.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Jackadder Lake is situated in lake deposits on the western side of the Karrakatta soil association. The topography shows a steep rise to a ridge of coastal limestone on the west; low relief on the eastern side indicates a relationship between Jackadder, Herdsman Lake and the Osborne Park Swamps.

8.8.3 AREAS

Area bounded by Jackadder Way, Blackbutt Road, Birchwood Avenue & Rosewood Avenue	13.80	ha
Area of water body (including island)	7.30	ha
Area of island	0.12	ha

8.8.4 HYDROLOGY (Figure 8.13)

Jackadder functions as a compensating basin in the main drainage system of the region as well as receiving local drainage. It is thus recharged largely by surface inflow with controlled water levels. No water level record is available.

8.8.5 WATER QUALITY

No water quality data are available. The lake is subject to blooms of blue-green algae in spring and autumn and there have been bird deaths from algal poisoning or botulism on the lake.

8.8.6 LAND USE

Jackadder Lake was used for agriculture in the past. It is now a modified lake within grassed parkland with introduced trees managed by the City of Stirling. A small island has been constructed as a roosting place for waterbirds. Model boats provide some active recreation. Feeding swans and ducks is a popular activity on the lake margins.

The lake is surrounded by residential development.

8.8.7 VEGETATION (Figure 8.12)

The lake is surrounded by irrigated grass with introduced trees. There are limited fringing sedges on the margins and on the island.

8.8.8 FAUNA

Observations on the bird life of the lake have been made by the RAOU in its Metropolitan Bird Project.

The lake is used by large numbers of common waterbirds including black duck, black swans, coots, introduced ducks and seagulls.

It is likely that birds, particularly swans, move between Jackadder, Herdsman and Monger and that Jackadder should not be considered in isolation from these other water bodies.

The lake is routinely treated with pesticide to kill the larvae of chironomid midges which breed in the lake.

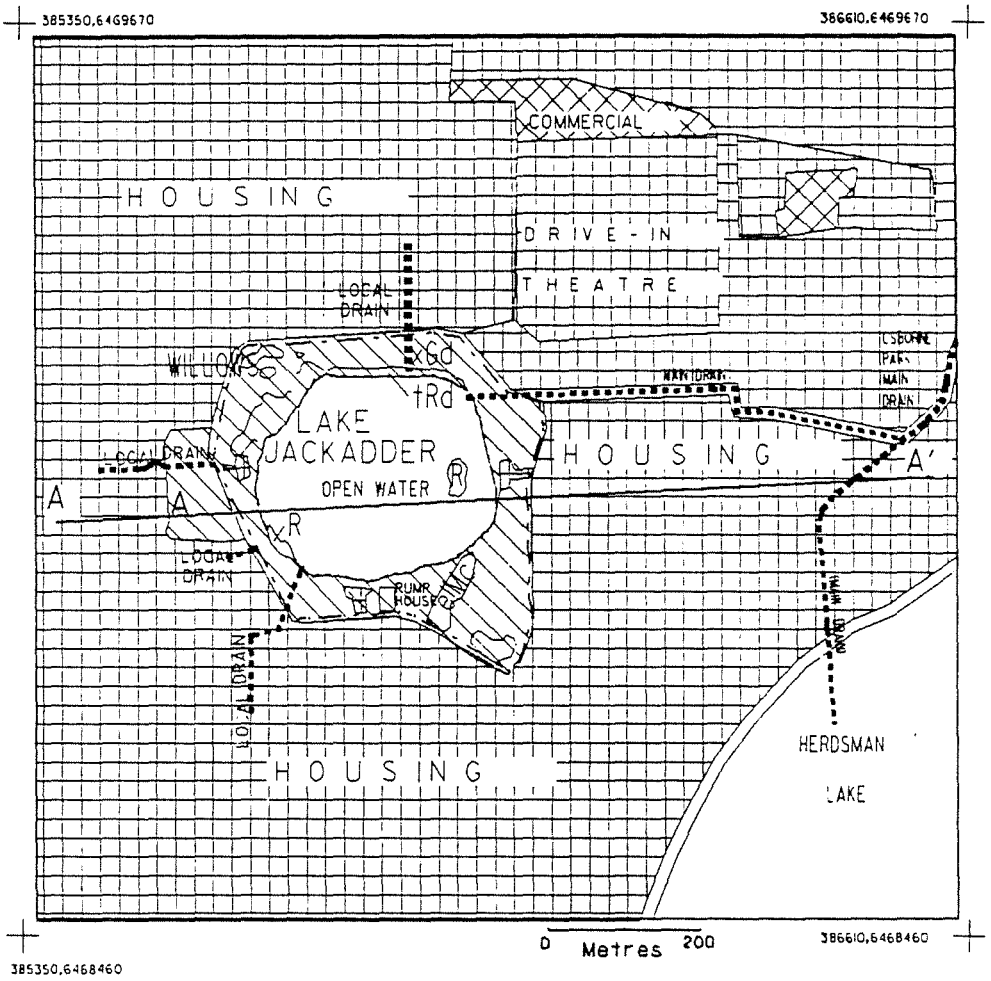

Figure 8.12 Jackadder Lake: plant communities and surrounding land use.

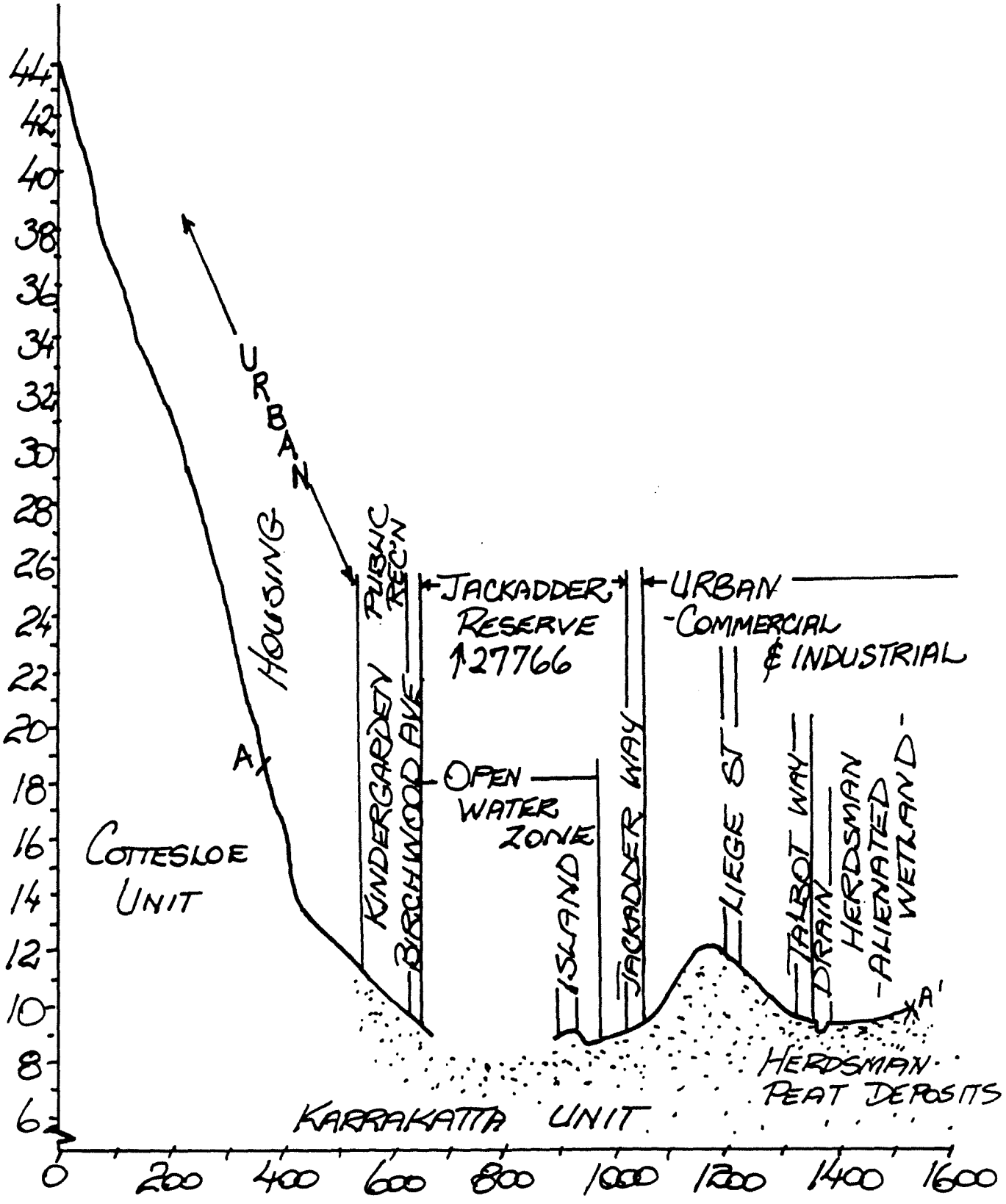

Figure 8.13 Jackadder Lake: diagrammatic cross-section.

8.8.9 MANAGEMENT ISSUES

As well as its significant drainage function Jackadder has social values. A visit to the lake will usually find many people making use of the lake's surroundings. For this reason, maintenance of reasonable water quality and of water levels which provide for the amenity of the locality should be the management priorities.

The achievement of good water quality and water throughout the summer would also enable the lake to provide a refuge for common waterbirds. Enhancement of the fringing vegetation could have the dual effects of improving water quality and increasing the range of habitats offered by the lake.

Maximum water levels do not appear to be a matter of concern. Control of minimum water levels by managing local authority use of bore water, and by alerting surrounding residents of drawdown effects of heavy private pumping might be feasible ways of protecting the amenity of this multiple purpose wetland.

It is understood that people who live near the lake consider that fringing vegetation obscures water views, provides shelter for vandals and traps litter. Nevertheless, establishment of fringing rushes and reeds along part of the lake foreshore would be beneficial in fixing some nutrients and improving bird habitat.

8.9 HERDSMAN LAKE

8.9.1 GENERAL INFORMATION

LOCAL AUTHORITY: City of Stirling
MRS ZONE: Parks and Recreation
RESERVE NUMBERS: Land owned by State Planning Commission, private and various other government agencies; various drainage and reserves including 31096 for Environmental Education and Conservation of Flora and Fauna.
MANAGEMENT: State Planning Commission under Improvement Plan 21; management role to be assumed by Department of Conservation and Land Management in late 1988
SYSTEM 6 RECOMMENDATION: M43
WAC CLASSIFICATION: LE.f.l.p.sc (modified)
DRAINAGE: Main drainage for a substantial area of suburbs to the north-east of the lake; compensating basin; local drainage.
MINING CLAIMS: Extraction of sand for landfill and disposal of peat as a means of lake bed modification.

8.9.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Herdsman is the largest lake in the region. Its basin is within an area bounded by the 15 m AHD contour which includes the wetlands of Osborne Park, Balcatta and Stirling, as well as Jackadder Lake, and extending to the south-west to include Perry Lakes. Herdsman Lake is separated from Mongers Lake by a ridge above 15 m AHD.

The lake basin contains substantial lake deposits within the Karrakatta soil association of the Spearwood Dunes. Teakle and Southern (1937) described the peat of the lake; it varies in nature indicating that it may have been laid down under varying conditions.

8.9.3 AREAS

Area bounded by Jon Sanders Drive, Moondine Road, Lakeside Road and Pearson Street is approx 340 ha.

8.9.4 HYDROLOGY (Figure 8.15)

The 8 m groundwater contour lies to the east of the lake and the 7 m contour lies to the west. Originally an expression of the water table, the lake now receives much of its input through surface drains. A drainage outflow to the ocean has been constructed on the western side. There are a number of accounts of efforts from the early 1920's to lower the water table of the lake sufficiently to allow for subdivision for market gardens and to make development of surrounding land tenable. The current groundwater inputs to the lake are not known. An understanding of the water balance of the lake would be a useful aid to management.

The lake has been investigated as a potential water resource (Environmental Protection Authority, 1982).

Excavation of the lake basin in keeping with the MRPA concept plan for the lake basin and subsequently the State Planning Commission Improvement Plan 2 is further modifying Herdsman Lake and increasing its diversity as a landscape and recreational feature.

8.9.5 WATER QUALITY

Quality of water samples taken from the lake since 1981 has been reported to the State Planning Commission. Apart from high nutrient levels and heavy metal levels which give rise to some concern there is evidence of algal blooms in the lake from spring onward. Thermal stratification of the deeper excavations in the lake basin may give rise to some concern about water quality.

8.9.6 LAND USE

The history of land use on Herdsman Lake has been documented in a number of publications, including MRPA Concept Plan 1976; City of Stirling history; The Environmental Review and Management Plan for the Herdsman Park Estate, 1981; Environmental Protection Authority, 1982; and Miller 1980. A Public Environmental Review of proposals to develop an area on the north-west sector of the lake was current in mid 1988.

The Metropolitan Region Scheme confirmed the pattern of development around the lake. Amendments to the zoned alignments of major roads affecting the lake margins were to be considered in 1988.

8.9.7 VEGETATION (Figure 8.14)

The vegetation of the lake basin has been severely altered by agricultural use of the area. Following reduction of rural activity the invasive Typha orientalis became the dominant plant species of the lake, with only remnants of swamp paperbark, flooded gum, jointed twig rush and other wetland species hanging on. Further modification of the vegetation is occurring as a result of the dredging and landscaping operations now in progress. Tree and shrub planting associated with the development of the Herdsman Lake parkland will increase the plant diversity on the lake.

Some concern is expressed from time to time that modification of the lake margins will reduce the bird habitat offered by the Typha fenland. Curry (1981) studied bird usage of the lake during 1980-81 and showed the relative value of habitats available. He recognised 10 habitat categories and documented the number of bird species using each habitat as follows (Curry, 1981):

1. Thickets of paperbarks Melaleuca rhaphiophylla - 9 species
2. Pasture and cultivated areas - 11 species
3. Open drains - 13 species
4. Banks of drains - 11 species
5. Thickets of Typha orientalis - 20 species
6. Meres - 31 species
7. Aerial - 20 species
8. Floreat Waters lagoon - 19 species
9. Floreat Waters shorelines - 46 species
10. Floreat Waters lawns - 14 species

8.9.8 FAUNA

The invertebrate and vertebrate fauna of the lake were sampled in 1981-82 and the results reported to the Metropolitan Regional Planning Authority.

An investigation of the environmental effects of spraying to control the Argentine Ant was carried out in 1986 (Davis and Garland, 1986). Further work is to be carried out.

The large and diverse bird fauna has been the subject of much discussion. A survey of the bird fauna for the year 1980-81 has been reported by Curry (1981). Observations on the fauna of the lake, particularly the bird fauna, will be greatly encouraged by the Wildlife Study Centre at the lake, now managed by the Western Australian Gould League. Van Delft (1988) provides notes about Herdsman Lake as a bird-watching site. The Royal Australasian Ornithologists Union has a considerable amount of waterbird data for this area.

8.9.9 MANAGEMENT ISSUES

The long-term management of the lake will be resolved by the completion of Improvement Plan 21 and implementation of the management plan currently being developed by the Department of Conservation and Land Management to ensure that integrated management of the lakes resources is achieved.

Management of the water inputs is required to avoid pollution, and make the best use of available water both for landscape and to provide appropriate conditions for waterbirds and maintain the lakes drainage function.

The Argentine Ant problem at the lake should be managed.

Any modification of the lake basin to complete the concept plan for the lake should be directed to maximising the already important wildlife values and to mitigating the effects of long-term environmental disturbance. Development on the north-west sector of the lake is currently under consideration (State Planning Commission and Sherwood Overseas, 1988).

The conservation value of Herdsman Lake is complemented by adjacent wetland areas such as Mongers Lake and Jackadder Lake.

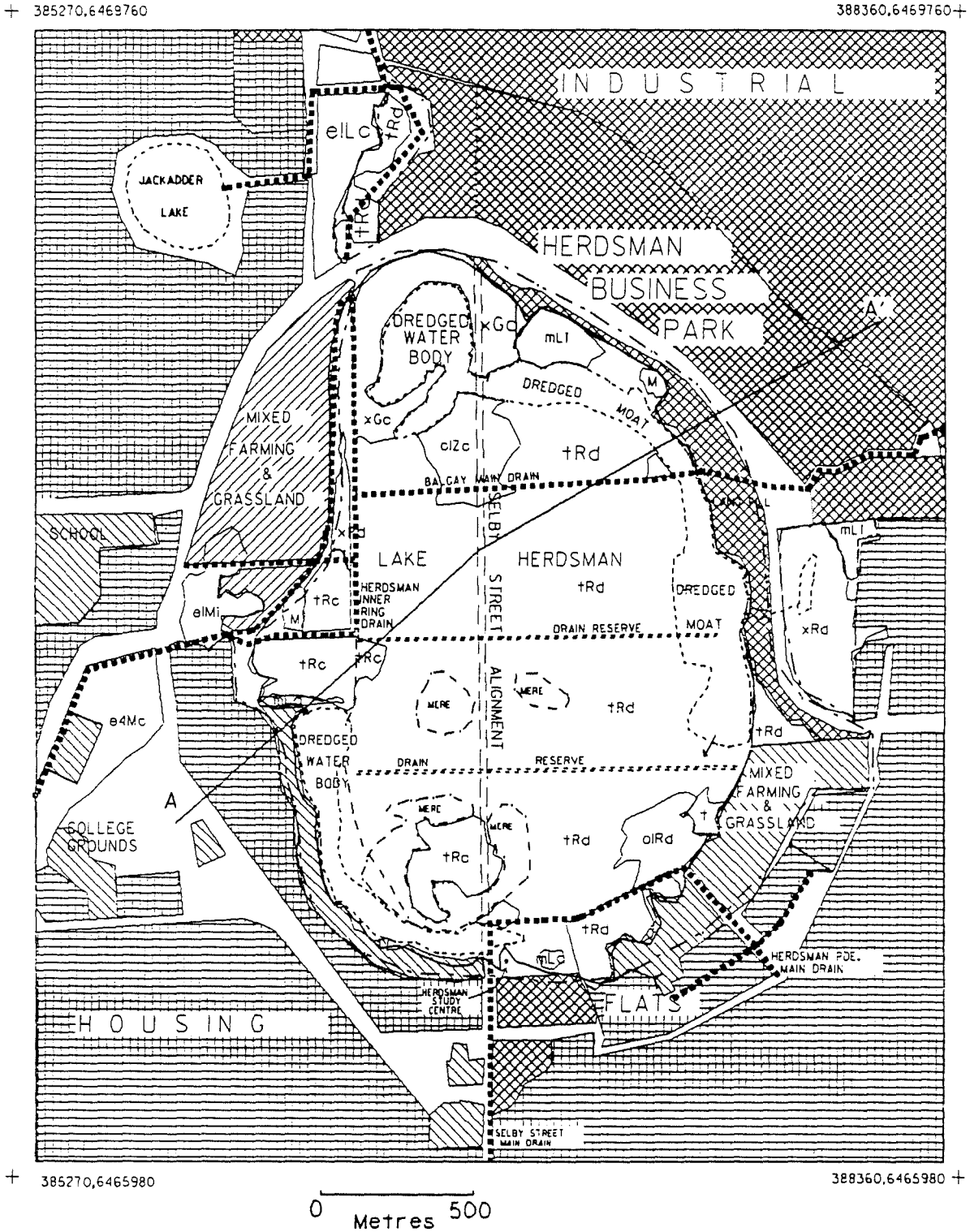

Figure 8.14 Herdsman Lake: wetland plant communities and surrounding land use.

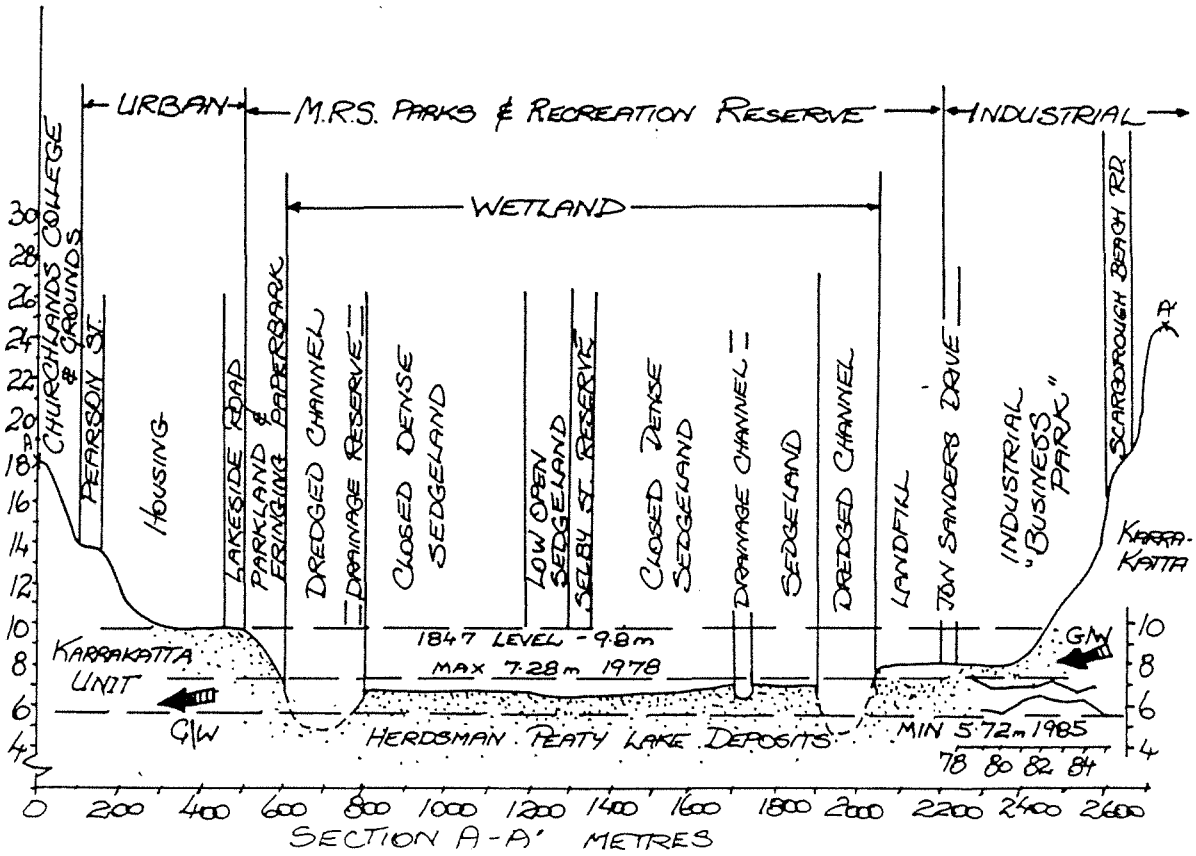

Figure 8.15 Herdsman Lake: diagrammatic cross-section and water level record.

8.9.10 REFERENCES

Curry, P (1981), A survey of the birds of Herdsman Lake 1980-81. Bulletin 105, Department of Conservation and Environment, Western Australia.

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8.10 LAKE MONGER

8.10.1 GENERAL INFORMATION

LOCAL AUTHORITY: Perth City
MRS ZONE: Parks & Recreation
RESERVE NOS: A8731
MANAGEMENT: Perth City Council
PURPOSE: Public Park and Recreation
SYSTEM 6 RECOMMENDATION : n/a
WAC CLASS: Le.f.l.p.o. (modified)
WATER RESERVE: n/a
DRAINAGE: Main and local drains

8.10.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Lake Monger is a much modified wetland situated in a shallow valley running north-west to south-east towards the Swan River. It is the most north-westerly of a complex of lakes and swamps now almost entirely filled. Seddon (1972) has described this lake system.

8.10.3 AREAS

Total area ("green area")	110 ha
Area of lake (including island)	71.3 ha
Area of island	1.3 ha
Area of open water	70.0 ha

8.10.4 HYDROLOGY (Figure 8.17)

The lake now receives a substantial part of its inflow through surface drains. It overflows through the Mounts Bay Main Drain to the Swan River.

The groundwater contribution to its water balance is not known. Maximum groundwater contours of the northern unconfined flow system are 14 m AHD on the north-east of the lake and 13 m AHD on the south-west. Water levels in the lake range between 13.2-13.4 m in winter and 12.4-12.8 m AHD in summer.

8.10.5 WATER QUALITY

Data on water chemistry of the lake waters have been reported by Gordon, Finlayson and McComb (1981). Edward (1964) reported on water and sediment chemistry at Lake Monger in the 1950's and a full year's record of nutrient levels is published in Aplin (1976). Monthly samples have been analysed for 1985-86 (Davis and Rolls, 1987).

All these sources indicate that the lake waters are highly enriched with nutrients.

8.10.6 LAND USE (Figure 8.16)

Pitt Morison (1979) presented a series of maps which show changes in Lake Monger since European settlement.

During the period 1950-1964, 101.2 hectares was reclaimed at Lake Monger with sanitary landfill, to an average depth of 1.2 metres (Public Health Department, 1974). Lake Monger is completely assimilated into the urban setting, being surrounded on two sides by residential development and on its third by the Mitchell Freeway. Its catchment is almost entirely sewered urban residential. Since settlement it has passed through a sequence of land uses from rural, to recreational, with sanitary landfill on the north-east. Miller (1980) provides a description from contemporary accounts of how Lake Monger appeared in 1830 and almost 100 years later during World War 1.

Lake Monger is now extremely important in the urban landscape. It is surrounded with irrigated lawns and ringed by paths. It receives heavy use for passive recreation with some active uses on the west. It is regularly visited by tourist coaches which stop to allow their passengers to feed the birds. Large amounts of bread are thrown into the water to feed the birds and this may considerably add to the nutrient loads in the water adjacent to feeding areas.

8.10.7 VEGETATION (Figure 8.16)

No vestige of the original vegetation remains apart from a few sedges around the lake margins. Most of the lake is surrounded with lawns and exotic trees. A weed community containing Arundo and castor oil bushes on the north-eastern shoreline is gradually being replaced.

A small island on the south-west supports Typha and sedges.

In the 1940's the lake was largely covered with water hyacinth (Eichornia) and since the eradication of this floating aquatic plant, the lake has been subject to blooms of benthic weeds and blue-green algae. These blooms have occurred for a number of years; Edward (1964) reported on occurrences and duration of blooms in the 1950's. Complaints about noxious smells from the blooms are received from time to time. The high productivity of the lake is reflected in the large bird populations it supports.

8.10.8 FAUNA

Chironomid midge swarms from the lake have caused a nuisance to residents for many years. The City of Perth monitors midge larval densities in the lake sediments and applies pesticide to control the midges as required (Blair, 1979; Van Leeuwin pers comm). Concern is now growing that pesticide applications are now less effective in controlling midges. The City of Perth is participating in a joint investigation to further the understanding of midge biology and control.

Edward (1964) described the chironomid midge fauna of the lake in detail. Davis and Rolls (1987) sampled the macrobenthic invertebrates of the lake during 1985-86. The lake supports large populations of a small range of species throughout the year.

Long-necked tortoises live in the lake and move up into suburban gardens to lay their eggs in the spring. Dr Barbara Porter has investigated the biology of tortoises in the lake.

The lake provides an important drought refuge for waterbirds, supporting large numbers of common species requiring relatively deep and permanent water. Many birds are fed by visitors to the lake. Some species, particularly Black Swans, move between Mongers, Herdsman and Jackadder. Swans nest in the more sheltered fenland of Herdsman Lake and bring their cygnets to Lake Monger. The conservation value of the Leederville, Wembley, Woodlands region of the Perth Metropolitan region is probably enhanced by the close juxtaposition of such dissimilar wetlands as Mongers, Herdsman Lake and Jackadder Lake, together with remnant market gardens on the margins of Herdsman.

Bird habitats provided by Lake Monger include: Deep fresh water (>50 cm deep); shallow fresh water (<50 cm); bare edges of lakes (in summer); grasslands: parkland lawns; reedbeds (limited area provided by the small island and shore on south-west side of the lake).

Van Delft (1988) provides notes about Lake Monger as a bird-watching site.

Deaths of birds from algal poisoning or botulism occur from time to time in summer. An account of such an occurrence was published by Grubb (1964).

The Royal Australasian Ornithologists Union has a considerable amount of waterbird data for this area.

Large, old carp and goldfish are noted in the lake from time to time, particularly when unsatisfactory water quality leads to deoxygenation.

8.10.9 MANAGEMENT ISSUES

Management Issues

Lake Monger is an integral and highly valued part of the urban environment. The City of Perth has prepared a draft management plan for Lake Monger.

Management objectives should include:

. control of runoff to sustain landscape and recreational amenity;

. reduction of nutrient levels in the lake, possibly by treating stormwater and by manipulating emergent plants on the north-eastern shoreline where seepage from the landfill site may contribute to nutrient enrichment; and

. continuation of Perth City Council's policy of basing its pest management on careful monitoring of midge populations.

Conservation Values

The lake offers little apparent habitat diversity - it has a very simple environment compared with Lake Claremont and Perry Lakes.

Nevertheless the lake supports very large numbers of birds and is an important drought refuge. There is very little cover but in spite of this there are considerable numbers of swans with clutches of cygnets.

Monger, Herdsman and Jackadder appear to have related functions as bird habitats.

8.10.10 REFERENCES

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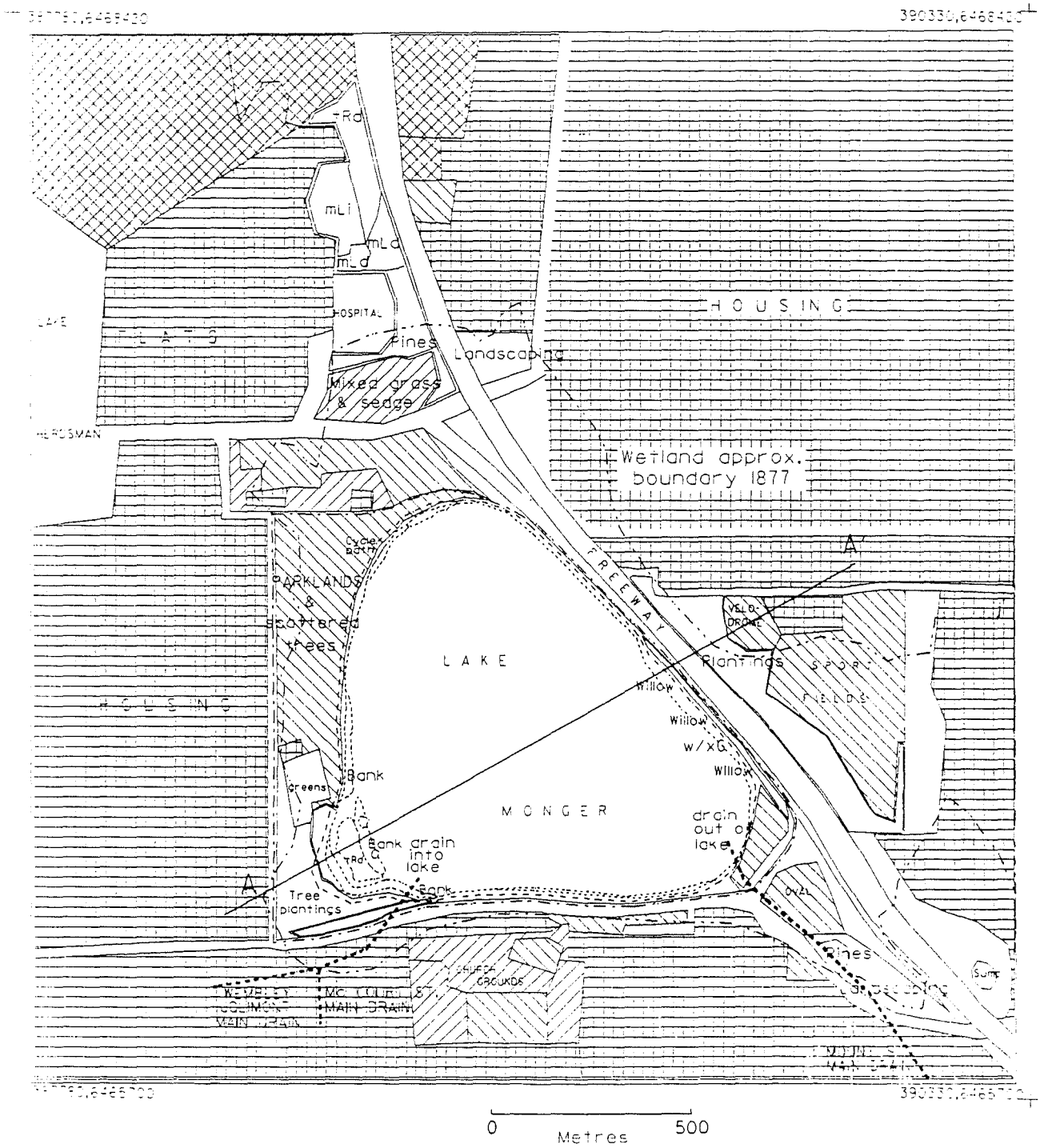

Figure 8.16 Lake Monger: wetland plant communities and surrounding land use.

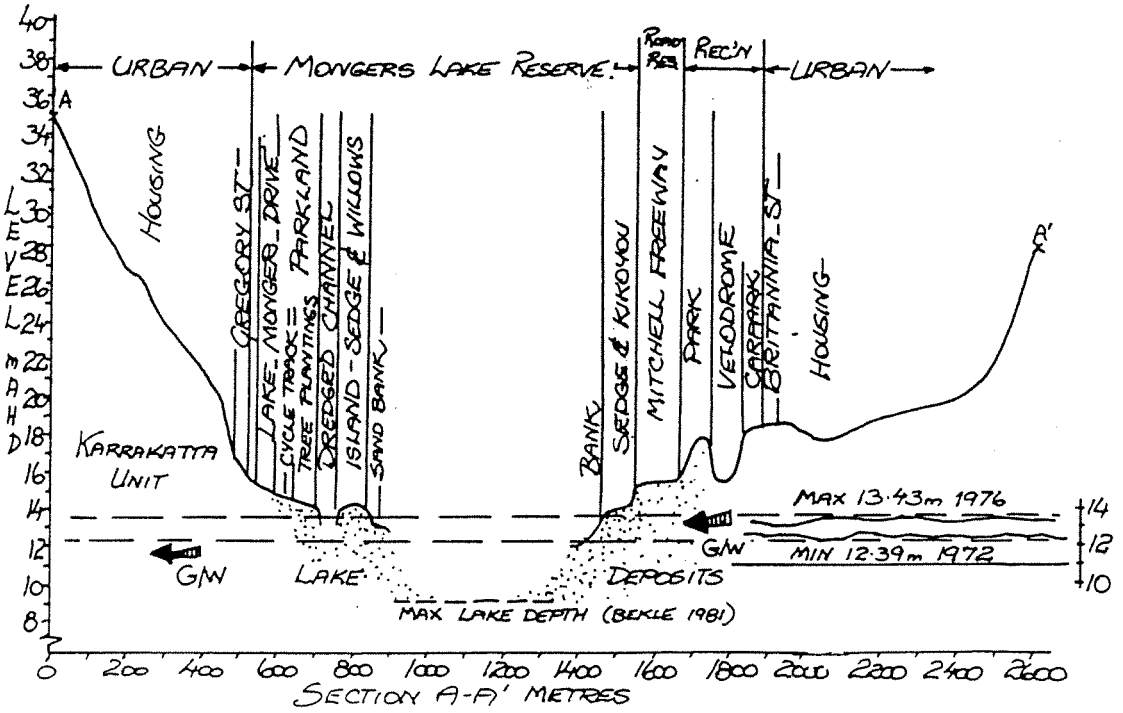

Figure 8.17 Lake Monger: diagrammatic cross-section and water level record.

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Spillman, K (1985), 'Identity prized: a history of Subiaco'. University of Western Australia Press, Nedlands.

Van Delft, R (1988), 'Birding sites around Perth'. University of Western Australia Press, Nedlands.

8.11 HYDE PARK LAKES (Figures 8.18, 8.19)

The Hyde Park Lakes have been much modified, with all native vegetation being replaced by exotic species. The lakes are remnants of the lake system which extended from Lake Monger towards the Swan River. The parkland is a feature of the urban setting and its social value is high.

Conservation value of these small lakes is limited but the shelter provided by the vegetated islands should not be discounted as habitats for common bird species.

8.12 MABEL TALBOT PARK (JOLIMONT LAKE)

This is a small area with drainage as its principal function. The surroundings of the water body have been landscaped and the area is doubtless greatly valued by the residents of the area. However, we considered that its relevance to the study was limited. Its obvious drainage function means that it is unlikely to have water supplies significantly reduced.

Spillman (1985) outlines the history of the drainage function of Jolimont Lake, providing details of the serious flooding which occurred in and around the lake from the early part of the century. Van Delft (1988) provides notes on Mabel Talbot Park as a bird-watching site.

8.12.(a) REFERENCES

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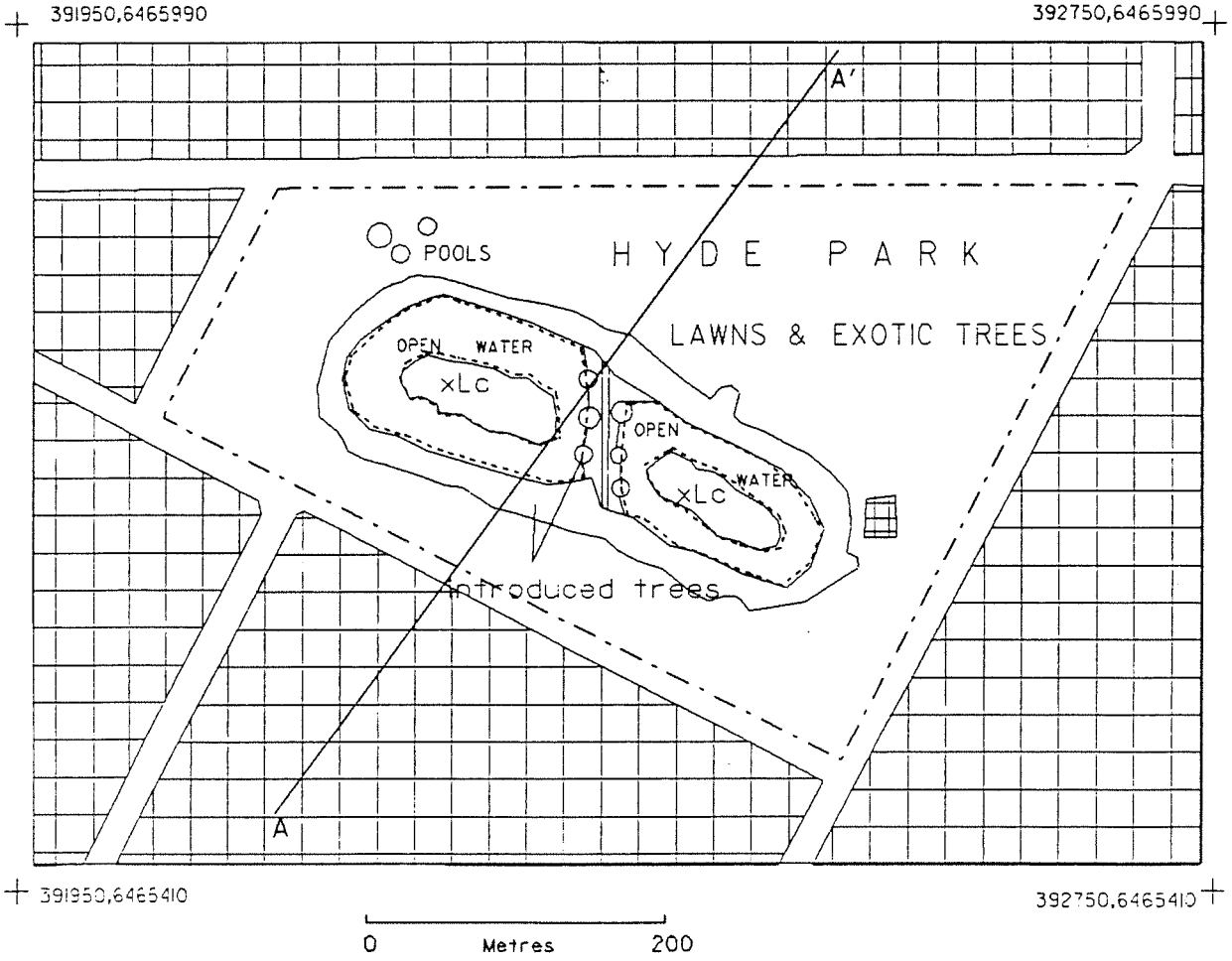

Figure 8.18 Hyde Park Lakes: vegetation and surrounding land use.

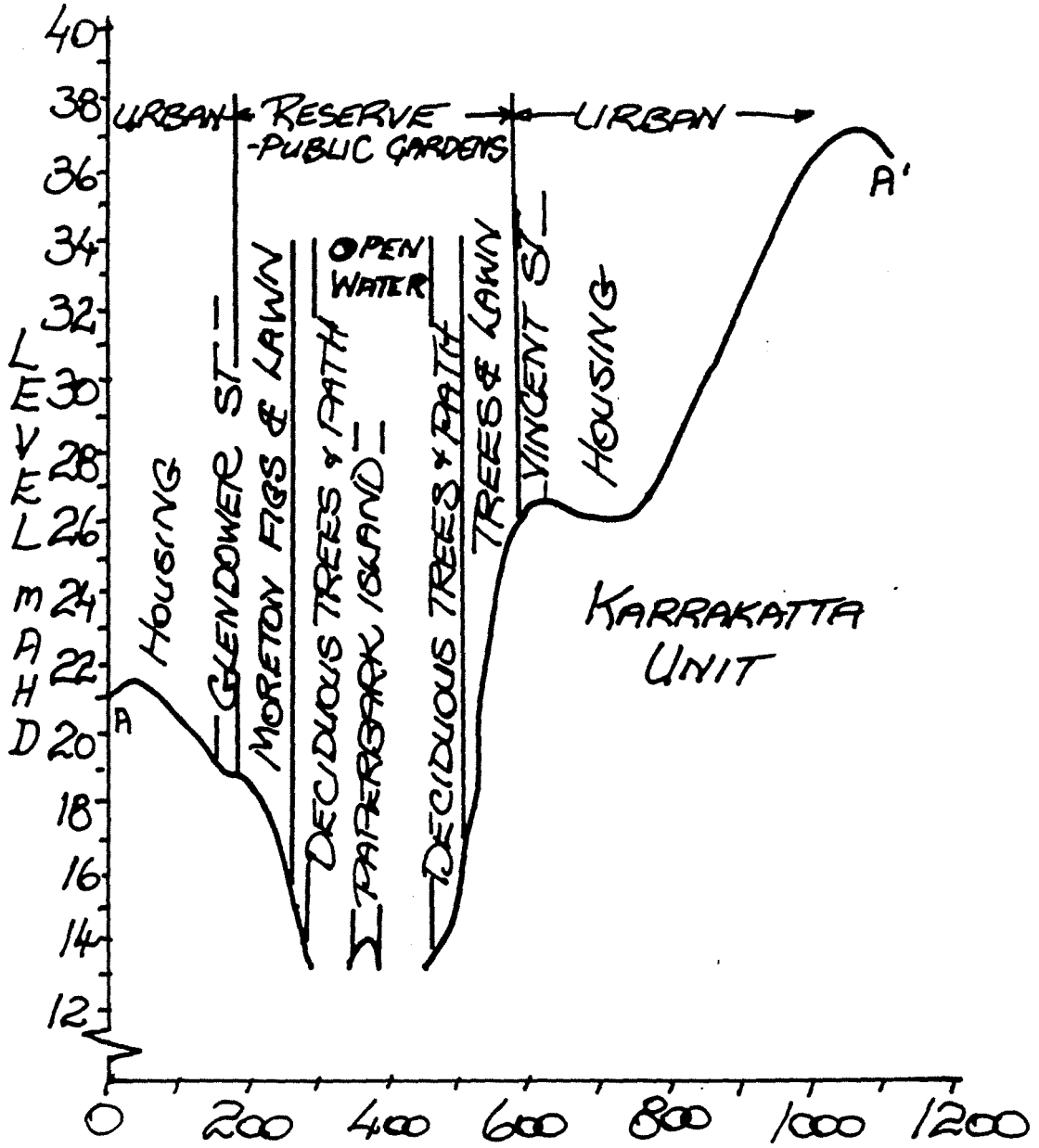

Figure 8.19 Hyde Park Lakes: diagrammatic cross-section.

8.13 PERRY LAKES

8.13.1 GENERAL INFORMATION

LOCAL AUTHORITY: Perth City Council
MRS ZONE: Parks and Recreation Reserve
RESERVE NUMBERS: City of Perth, Freehold.
MANAGEMENT: City of Perth
SYSTEM 6 RECOMMENDATION: n/a but see M47 Bold Park
WAC CLASSIFICATION: LE.f.sm.p/s.o (modified)
DRAINAGE: receives local drainage

8.13.2 PHYSIOGRAHY AND GEOLOGICAL SETTING

The Perry Lakes are situated in interdunal swales east of the high coastal dunes of Bold Park. The two eastern Perry Swamps were shaped to provide areas of open water in the open space around the Perry Lakes Stadium in preparation for the 1962 Commonwealth Games. A third small seasonal wetland, west of Perry Lakes Drive, known as 'Hidden Perry' or 'Camel Lake' has been less modified.

8.13.3 AREAS

Total area of reserve (east of Perry Lakes Drive) .....approx 77 ha

Areas of south-eastern lake:

Total	6.6 ha
Fringing rushes	1.9 ha
Open water] proportion changes seasonally	3.1 ha
Mudflats]	1.4 ha
Island	0.2 ha

Areas of north-western lake:

Total	6.0 ha
Fringing rushes	0.5 ha
Open water] proportion changes seasonally	3.7 ha
Mudflats]	1.6 ha
Island	0.2 ha

8.13.4 HYDROLOGY (Figure 8.21)

Table 8.9. Western Perry Lake: water levels 1963-84.

i Maximum level recorded - 5.32 m AHD (before 1964).
ii Number of years maximum lake levels have fallen within the specified ranges.

LEVEL m AHD	1963-1975	1976-1984
4.6-5.0	8	0
4.2-4.6	5	2
3.8-4.2	0	4
3.4-3.8	0	3

Table 8.9. Western Perry Lake: water levels 1963-84 (Cont'd).

iii Minimum water level recorded - 2.82 m AHD 1980.
iv Number of years minimum lake levels have fallen within the specified ranges.

LEVEL m AHD	1964-1975	1976-1985
4.4-4.8	2	0
4.0-4.4	4	0
3.6-4.0	5	1
3.2-3.6	1	2
2.8-3.2	0	7

These summary tables demonstrate that both winter maximum and summer minimum water levels have fallen markedly since the mid 1960's. Of recent years, maximum water levels have been about half a metre below minimum levels in the mid 1960's.

It is likely that the relatively high water levels in the lakes about the time they were developed reflected effects on the water balance of the area brought about by clearing of vegetation and increased runoff from residential developments in Floreat, Jolimont and Daglish in the 1950's. Falling groundwater levels since then can be attributed to generally below-average rainfall, and increased extraction of groundwater for private gardens and for park management.

Public concern has been expressed about low water levels and bird deaths at Perry Lakes in most summers since 1977-78 and there have been many demands to prevent the lakes drying in summer. Suggested remedies have included piping water from the outflow of Herdsman Lake.

Bore water has been used to recharge the lakes. However, this practice can cause a further problem as pumping from bores close to the lakes causes local drawdown of the water table which, in turn, results in increased seepage from the recharged lakes back to the unsaturated soils around them. Heavy pumping of groundwater to maintain irrigated lawns can also lower the water table locally and increase seepage from lakes, particularly if the lake sediments are relatively poor in organic material and thus porous.

There is, therefore, a dilemma if there are demands for irrigated parklands as well as fully charged lakes in areas where the water table is falling through the combined effects of low rainfall and high private pumping. Community priorities have to be established.

In the case of Perry Lakes, the City of Perth has recognised the need to limit the use of irrigation in the parkland surrounding the lake.

In January 1986 the City of Perth held a public meeting about the matter. In a follow-up report the Council has put forward its proposed approach to managing the area and to ensuring that the lakes retain some water throughout summer. The initiatives proposed included:

. lowering the floor of half of each lake to allow for a minimum water depth of 300 mm; and

. management of water applications to turf in the open space to reduce the amount of groundwater pumped for park management.

Other initiatives included:

. increased tree and shrub planting around the lake with development of trails to manage access to the lakes; and

. establishment of a Friends of Perry Lakes club to involve interested members of the public in management of the Perry Lakes Open Space.

8.13.5 WATER QUALITY

Dr Ian Lantzke and his students (Western Australian College of Advanced Education: Claremont Campus) have sampled Perry Lakes water for a number of years.

8.13.6 LAND USE

Following use of the land around Perry Swamp for rural activities until about thirty years ago, use of the areas surrounding the lakes for recreation is now well established.

Perry Lakes Open Space is an extremely well-used parkland. It has the capacity to absorb very intensive activities such as "Garden Week" as well as providing scope for many recreational activities. The Open Space with its lakes thus has enormous social value. Apart from their landscape value, the lakes receive stormwater from the surrounding residential area and function as infiltration basins.

8.13.7 VEGETATION (Figure 8.20)

Enhancement of native vegetation around the lakes is seen as a way of reducing water requirements and managing access to the lakes.

8.13.8 FAUNA

The lakes with the surrounding bushland provide a range of habitats for waterbirds and bush birds. The lakes provide some drought refuge in summer but concern is aroused when the lakes dry up - hence the Perth City Council's efforts to manage the problem. Van Delft (1988) provides notes on Perry Lakes as a bird-watching site. The Royal Australasian Ornithologists Union has a considerable amount of waterbird data for this area.

8.13.9 MANAGEMENT ISSUES

Refer to previous sections, and in particular Section 8.13.4.

8.13.9 REFERENCE

Van Delft, R (1988), 'Birding sites around Perth'. University of Western Australia Press, Nedlands.

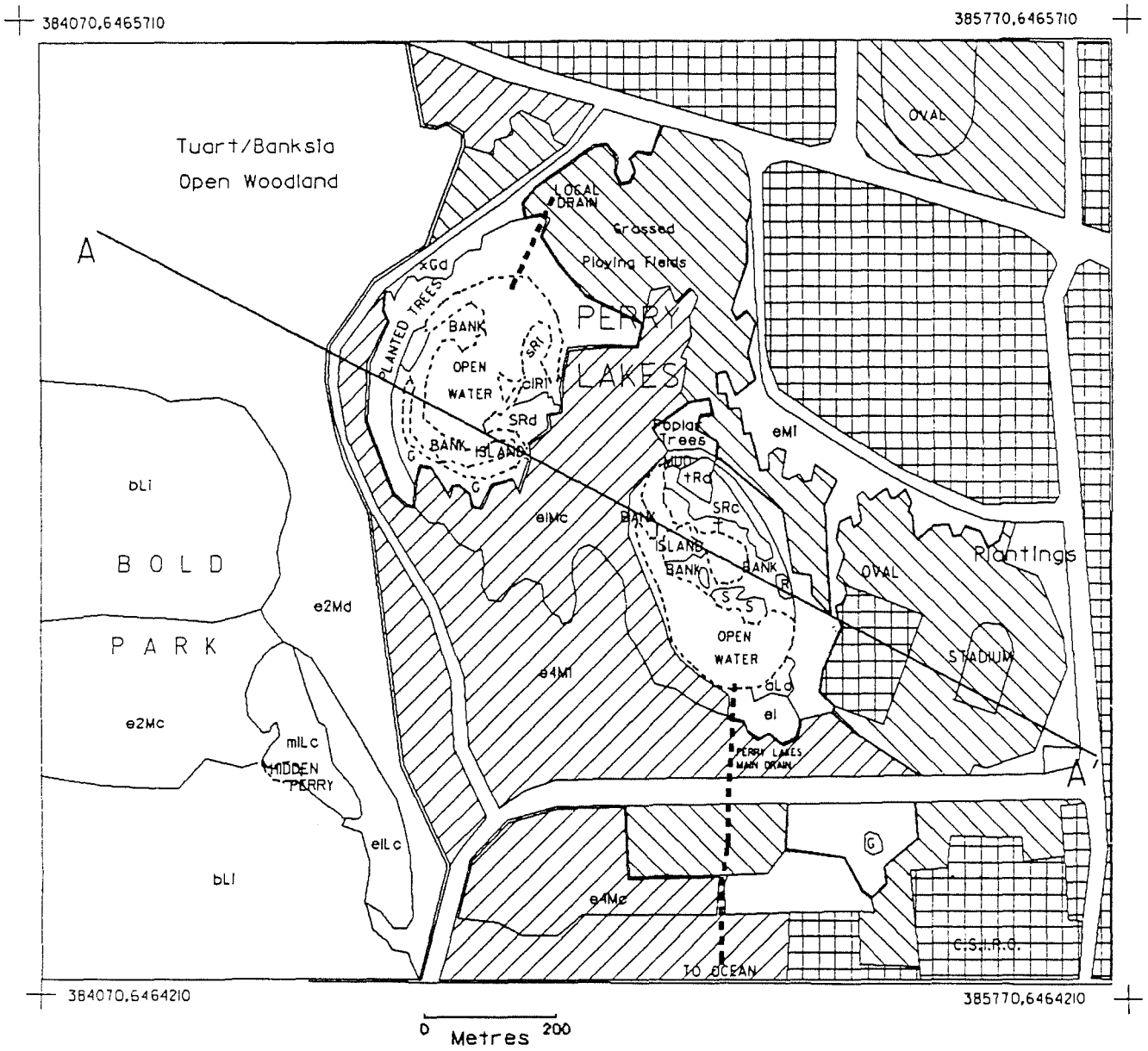

Figure 8.20 Perry Lakes: wetland plant communities and surrounding land use.

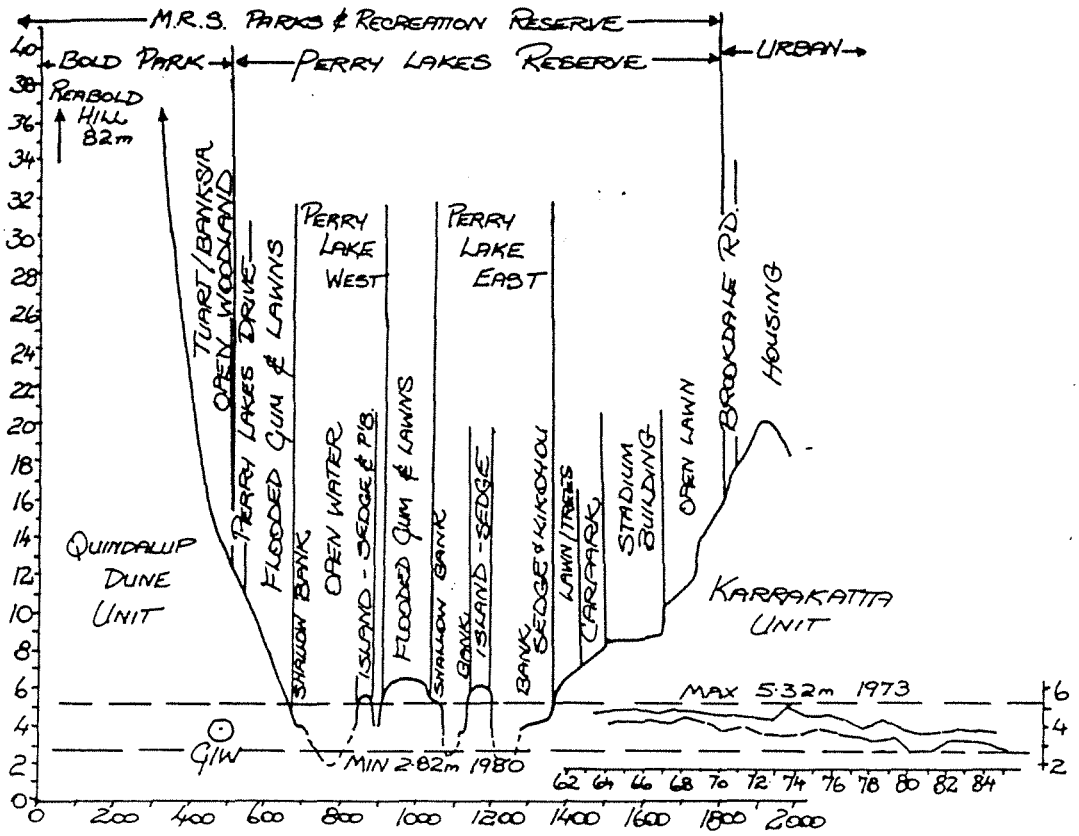

Figure 8.21 Perry Lakes: diagrammatic cross-section and water level record.

8.14 SHENTON PARK LAKE

8.14.1 GENERAL INFORMATION

LOCAL AUTHORITY: Subiaco
MRS ZONE: PARKS AND RECREATION
RESERVE NO: A8630
MANAGEMENT: Subiaco City Council
SYSTEM 6 RECOMMENDATION : n/a
WAC CLASSIFICATION: ornamental
PURPOSE: Recreation
DRAINAGE: Main and local drains

8.14.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING

Shenton Park Lake is the more northerly of two small areas of swamp deposits in a shallow valley below 15 m AHD which extends north from Matilda Bay on the western side of Kings Park.

8.14.3 AREAS

Total area of reserve	9.06 ha
Area of lake	2.78 ha
Area of island	0.15 ha
Water area	2.63 ha

8.14.4 HYDROLOGY (Figure 8.23)

Shenton Park Lake plays a key role in the main drainage system of the region.

The hydrology of Shenton Park Lake has been subjected to detailed study as part of a wider study of the hydrology of the Nedlands peninsula (McFarlane, 1985).

8.14.5 WATER QUALITY - Refer to next section.

8.14.6 LAND USE (Figure 8.22)

Shenton Park Lake exemplifies the changes that European settlement and urban development have imposed on coastal plain wetlands. The steps in this process for Shenton Park Lake have been clearly documented by Spillman (1985). From a reed swamp which dried out in summer and was utilised by Aborigines as a hunting place and camping ground, it became a stopping place for travellers between Fremantle and Perth known as Dyson's Swamp during the nineteenth century. After 1913, as the surrounding area was increasingly cleared for residential development, the water table rose and the swampland increased in size. There followed a period of severe flooding which was centred on the swamp and which was not overcome until after 1929, following completion of a drainage network and installation of a pump station. The swamp was used as a rubbish dump in the 1930's as part of efforts to reclaim and modify it.

Spillman described various plans to beautify the area over the years. Some of these plans met with opposition from conservationists in the 1960's. By the 1970's Shenton Park Lake had become part of a tailored urban parkland, much valued by residents of the surrounding area, but with a limited range of resources and habitats for wildlife.

Problems associated with management of the lake were manifest during the very dry summer of 1977-78, when birds died around the lake from the toxic effects of algal and bacterial growth as the water evaporated. At this stage the lake had reached the opposite extreme from the floods of the 1920's. These problems were exacerbated by the legacy of the rubbish tip, which enthusiasts began to excavate in search of old bottles. Well-meaning efforts to feed the birds provided large amounts of stale bread, some of which rotted in the shrinking volume of water, no doubt adding to the poor water quality of the lake.

Similar problems arise at many other wetlands around Perth which have undergone a comparable sequence of events, ie

. use as a water resource and for agriculture;

. increase in size as the water table rises as a result of clearing of vegetation;

. efforts to fill and or drain to overcome flooding problems or to increase land values (filling with rubbish provides a legacy of nutrients and other products of breakdown of rubbish which will have an ongoing influence on the water quality of the wetland);

. modification, beautification and assimilation into urban parklands - this process complicated by the obvious problems that people may not agree on matters related to aesthetics, wildlife values and economics of parks management;

. falling water levels as a result of increased use of groundwater and/or reduced recharge of groundwater; and

. efforts to maintain or preserve the lake by deepening and/or topping up with borewater.

The function of Shenton Park Lake in the urban drainage pattern of the area remains critical. It is a compensating basin in the main drainage system of Hollywood and Shenton Park and is linked to the main drain network of West Perth, Leederville, Subiaco, Daglish and Perry Lake.

Controversy generated by drain modification and maintenance during 1986 shows that Shenton Park Lake continues to be a focus of community interest.

8.14.7 VEGETATION - Refer to previous section.

8.14.8 FAUNA - Refer to Section 8.14.6

8.14.9 MANAGEMENT ISSUES

Stresses

Because of its history and position in an urban setting Shenton Park Lake will continue to be subject to stresses which include:

. nutrients from drainage waters and runoff from parkland;

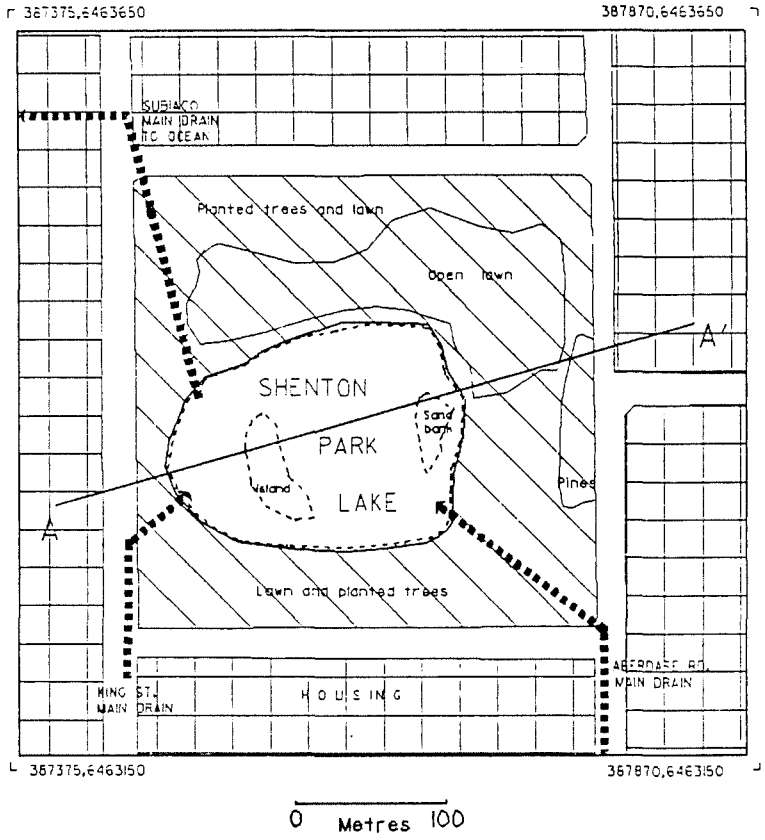

Figure 8.22 Shenton Park Lake: surrounding land use.

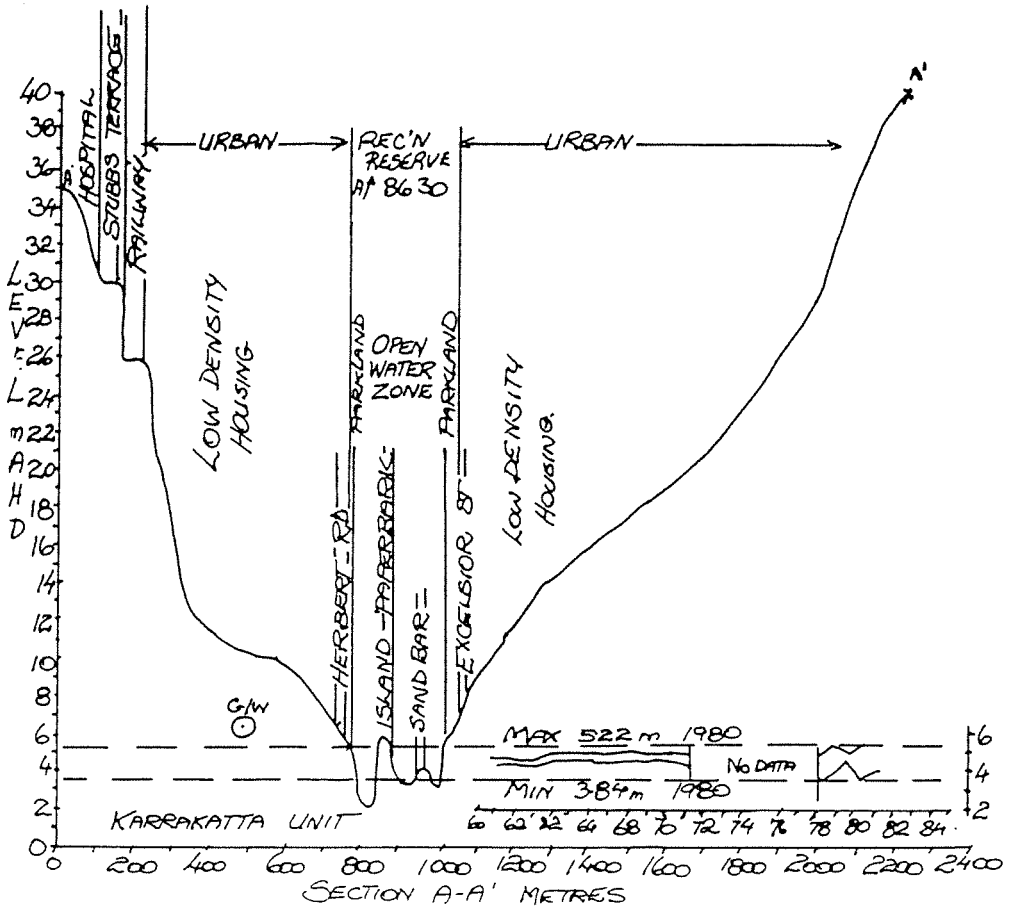

Figure 8.23 Shenton Park Lake: diagrammatic cross-section and water level record.

. water level strongly influenced by rainfall events, related to its function in the main drainage system of Hollywood, Shenton Park;

. nutrients and other products from old rubbish tip;

. low summer water levels reflecting increased use of groundwater.

Comments on Conservation Values

(1) Steep banks of the lake affect its accessibility to wildlife, especially when the water level is low.

(2) The relative lack of vegetation cover on the island and lack of fringing vegetation limit the habitats available for birds.

(3) The lake is relatively isolated from wooded areas and other parklands.

(4) The parkland retains no indigenous vegetation.

(5) The bird fauna of the lake consists largely of common species, such as Black Swans, Coots, Black Ducks and feral ducks.

8.14.10 REFERENCES

McFarlane, D J (1985), Effects of urbanization on groundwater quality and quantity in Perth, Western Australia. PhD Thesis, University of Western Australia.

Spillman, K (1985), 'Identity prized: a history of Subiaco'. University of Western Australia Press, Nedlands.

8.15 LAKE CLAREMONT (BUTLER'S SWAMP)

8.15.1 GENERAL INFORMATION

LOCAL AUTHORITY: Town of Claremont
MRS ZONE: Parks & Recreation Reserve
RESERVE No: owned in fee simple by Town of Claremont
PURPOSE: Recreation
MANAGEMENT: Town of Claremont
SYSTEM 6 RECOMMENDATION: M48
WAC CLASS: WATER RESERVE: n/a
DRAINAGE: local drainage
OTHER: Possible subdivision of playing fields close to the lake - zoned residential

8.15.2 PHYSIOGRAPHY AND GEOLOGICAL SETTING:

The lake is in an interdunal depression in the Spearwood dune system, within the Karrakatta association, close to the interface with the Cottesloe association.

8.15.3 AREAS

Approximate total area:	68 ha
Area of lake	18.3 ha
Area of rushes	3.6 ha
Dead trees	4.4 ha

8.15.4 HYDROLOGY (Figure 8.25)

Water inflow to the lake is from groundwater; the source is now partially compromised by surface drains.

The hydrological regime has been altered by urbanisation. Water levels rose in the 1920s (Evans and Sherlock, 1950) reflecting urban growth in the hinterland plus, probably, high rainfall in the 1920's and early 1930's. Road alignments and allotment boundaries reflect the situation prior to the water level rise, as do the skeletal paperbarks and flooded gums which have died as a result of soil water logging.

Water levels have been low in recent summers: the lake has been dry during several summers since 1979.

Extensive sanitary landfill on the eastern side of the lake may have affected groundwater inflow. Use of bore water for the maintenance of the Lake Claremont golf course and playing fields may also be a factor affecting water levels.

Table 8.10. Lake Claremont: water levels 1962-84.

i Maximum level 2.93 m AHD.
ii Number of years maximum lake level has fallen within the specified ranges.

m AHD	1962-75	1976-84
2.5-3.0	4	0
2.0-2.5	10	1
1.5-2.0	2	8

iii Minimum level 0.56 m (1980).
iv Number of years minimum lake level has fallen within the specified ranges.

	1962-75	1976-84
2.0-2.5	1	0
1.5-2.0	9	0
1.0-1.5	5	7
0.5-1.0	0	3

The lake water level displayed a rising trend between 1962-67, a falling trend between 1968-80 and levels have been rising slightly or stable between 1981-84.

The lowest summer water level was less than 0.6 m AHD in 1980. The Perth Urban Water Balance Study documents salt water intrusion in the unconfined aquifer west of Lake Claremont (Water Authority of Western Australia, 1987).

8.15.5 WATER QUALITY

Summer concentrations are high relative to winter concentrations. This is markedly true for total dissolved solids.

Table 8.11. Lake Claremont: summary of autumn and spring water samples (Water Authority of WA data).

PARAMETER	1970-75			1976-84		
	N	MEAN	RANGE	N	MEAN	RANGE
pH	11	8.61	7.60-10.00	16	8.74	8.10-10.2
Total N mg/L						
autumn	5	9.68	4.90-14.10	6	11.72	7.90-16
spring	6	4.46	0.25- 7.60	7	2.59	2.00- 3.25
Phos as P mg/L						
autumn	5	0.27	0.10- 0.52	7	1.50	0.60- 4.20
spring	5	0.20	0.08- 0.30	8	<0.28	<0.05- 0.40
Total Dissolved Solids mg/L						
autumn	5	2767	1644-4720	7	5186	3355-8730
spring	6	1486	658-2570	9	1964	1510-2396

Heavy metals range of values since 1976.

Cromium	all values less than 0.02 mg/L
Zinc	15 values >0.02: 1 value <0.05 mg/L
Cadmium	All values <0.01 mg/L
Lead	range <0.04 - 0.12 mg/L (high value Feb 1979)
Copper	range <0.01 - 0.03 mg/L
Mercury	all values < 0.0002 mg/L

8.15.6 LAND USE

Butler's Swamp has been utilised for farming since the 1850s (Evans and Sherlock, 1950). Rising water levels in the 1920s saw the end of farming. Since that time much of the lake has been reclaimed by landfill. The landfill has been developed as a golf course. Land on the south and south-west of the lake is used for playing fields with commercial uses on the south-east. There is a limited area of tuart woodland on the north and north-west of the lake.

8.15.7 VEGETATION (Figure 8.24)

Evans and Sherlock (1950) documented land use and vegetation changes on and around Butler's Swamp prior to 1950. Since that time a trend to tailoring the landscape around the swamp has followed the gentrification of the name from Butler's Swamp to Lake Claremont.

There is a small area of tuart woodland on the north-west of the lake, and a small amount of fringing woodland.

8.15.8 FAUNA

Lake Claremont as a place offering a range of habitats for birds has been well documented, eg Emory et al.,1975; Morris and Knott, 1979; Rook, 1963; Van Delft, 1988). The Royal Australasian Ornithologists Union has a considerable amount of data on waterbirds for this area.

8.15.9 MANAGEMENT ISSUES

Stresses

Lake Claremont is subject to a number of environmental stresses including:

. sanitary landfill - implications for water quality;

. groundwater use for open space and private users;

. Typha expansion (see note in System 6 account); and

. drainage.

Management Issues

The water quality in Lake Claremont has higher levels of nutrients than other lakes in the western suburbs. This may be attributable to the sanitary landfill. Water quality will remain a consideration for management. Table 8.12 gives a comparison with three wetlands not affected by landfill. Mean nutrient levels in water from four lakes pre 1976 and 1976-84, are compared with levels measured in groundwater (Cargeeg, McFarlane and Smith, 1983).

Table 8.12: Total nitrogen and phosphorus levels in four western suburbs lakes.

BACKGROUD TAMALA LIMESTONE	GWELUP	CARINE	KARRINYUP	CLAREMONT
Total nitrogen 3.34* mg/L				
summer pre 1976	1.65	1.6	2.87	9.68
summer 1976-84	0.96	1.37	2.32	11.72
winter pre 1976	1.82	1.5	1.64	4.46
winter 1976-84	0.96	0.7	0.74	2.59
Phosphorus mg/L 0.08*				
summer pre 1976	<0.154	0.30	0.39	0.27
summer 1976-84	<0.09	<0.09	0.18	1.5
winter pre 1976	0.15	<0.11	0.13	0.20
winter 1976-84	<0.08	<0.17	0.11	<0.28
AREA (HECTARES)	27.3	24.8	17.4	18 (25.6 ha in 1950)

*Values from Cargeeg, McFarlane and Smith (1983).

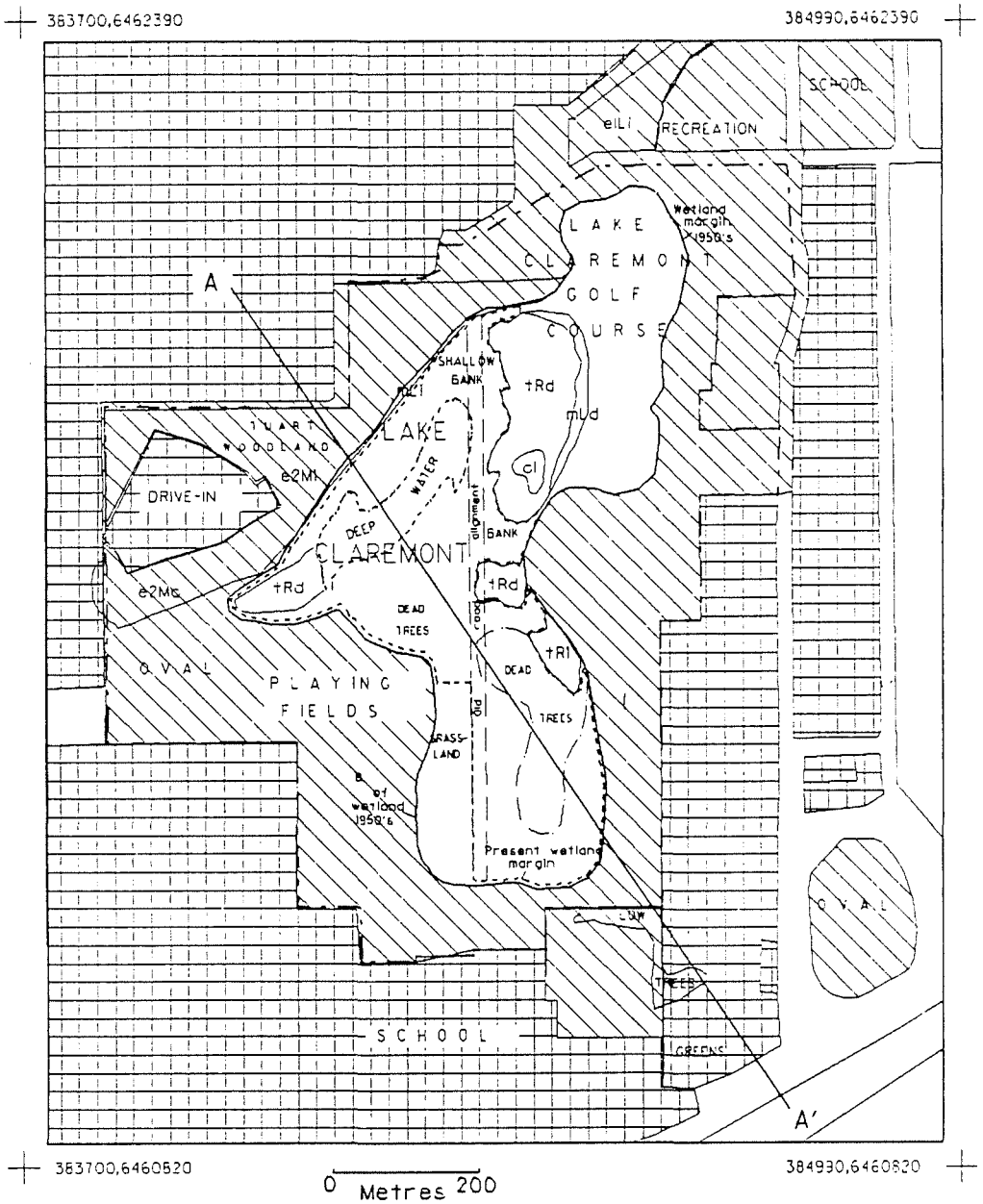

Figure 8.24 Lake Claremont (Butler's Swamp): wetland plant communities and surrounding land use.

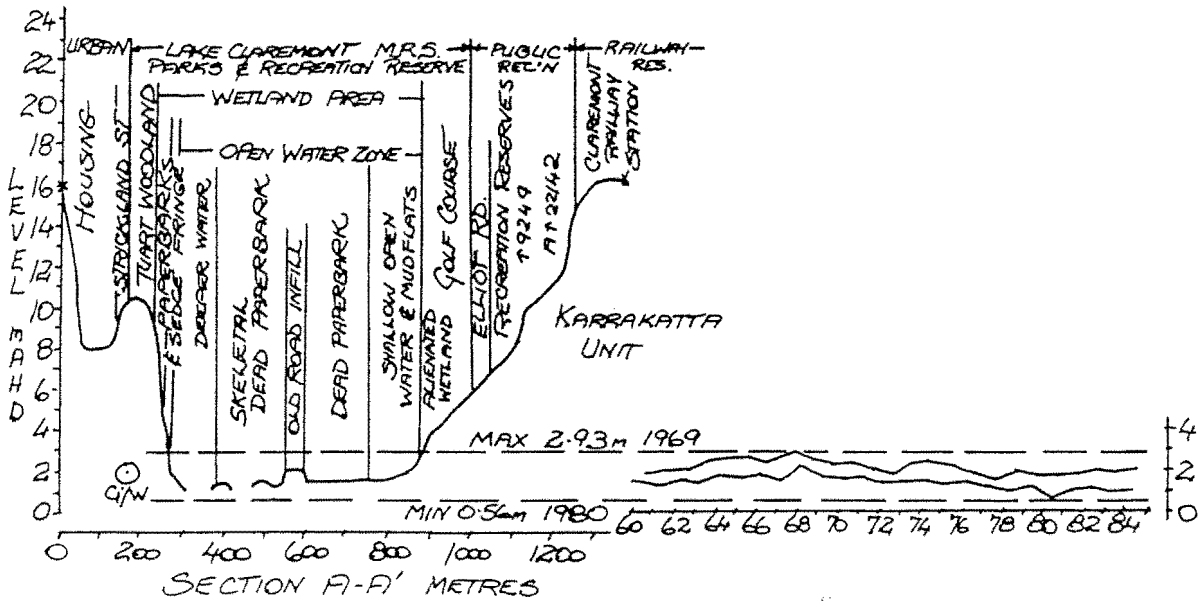

Figure 8.25 Lake Claremont (Butler's Swamp): diagrammatic cross-section and water level record.

The lake has significant social value and also functions as a refuge for waterbirds. Management objectives should include maintenance and enhancement of these values. To this end surface water should be retained in the lake throughout summer. This may require careful consideration of water inputs, draw on groundwater and management of drainage waters. Management should also investigate manipulation of emergent vegetation, particularly along the face of the landfill site, to utilise nutrients and thus improve water quality.

8.15.10 REFERENCES

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END OF SECTION