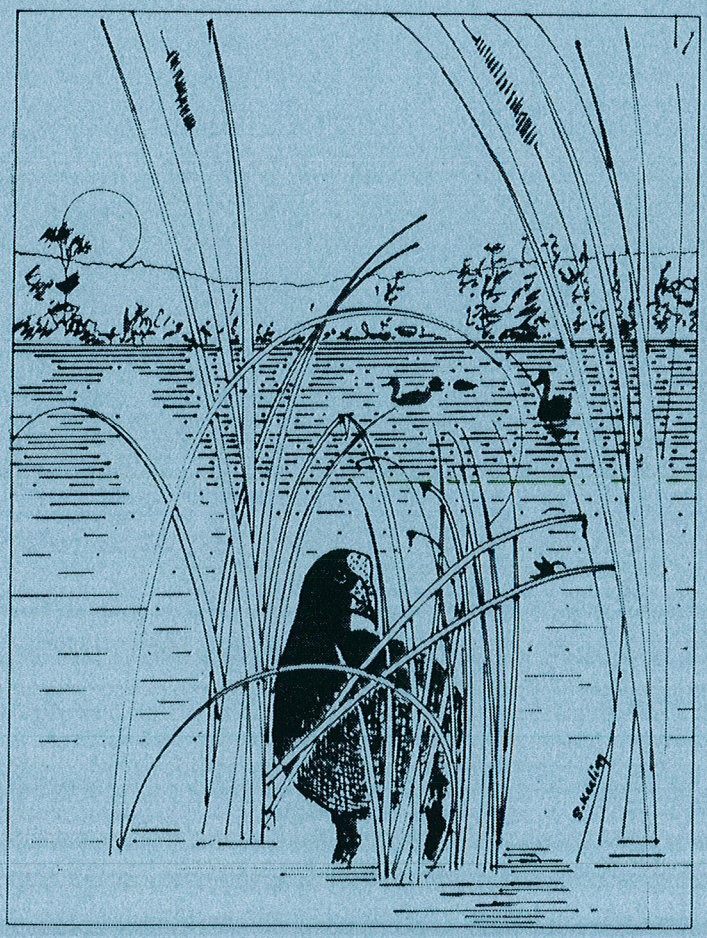
Department of Conservation and Land Management, W.A.

Forrestdale Lake Nature Reserve



Draft Management Plan
MARCH 1986

FORRESTDALE LAKE NATURE RESERVE

DRAFT MANAGEMENT PLAN

MARCH 1986

BY

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MANAGEMENT PLAN NO. 3

CONTENTS

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PREFACE

This management plan is one of a series of management plans produced by the Department of Conservation and Land Management. Completion of each plan involves three stages. First, the plan is published as a draft, and members of the local community (particularly reserve neighbours), government departments, tertiary institutions, conservation groups and the general public are encouraged to submit comments. The draft is then reviewed in the light of these comments, and an amended draft and summary of public submissions produced. This is the second stage, with the published submissions and amended draft being submitted to the National Parks and Nature Conservation Authority (NPNCA), the Minister for Conservation and Land Management and the Bush Fires Board for approval. Once these approvals have been obtained the third stage follows, with the plan being published in its final form. As such it constitutes a management plan in terms of Section 60 of the Conservation and Land Management Act (1984) and Section 34(1) of the Bush Fires Act (1954).

This plan for management will be effective for five years after which time it will be reviewed.

The plan details management programs for Forrestdale Lake Nature Reserve (No. A24781) and the adjacent Nature Reserve No. 37016. It proposes the addition of Reserve No. 37016 to Forrestdale Lake Nature Reserve. Therefore, throughout the plan, any reference to Forrestdale Lake Nature Reserve should be read as including Reserve No. 37016.

This draft plan has two major parts - A and B. 'Part A. The Reserve' identifies biological and physical resources, existing uses and conservation values, of the reserve. 'Part B. Plan for Management' details the management objectives and the strategies necessary to achieve these objectives.

In all management plans in this series, vegetation is described according to Muir (1977) (App. 1) and named according to Green (1985). The scientific and common names for mammals are according to Strahan (1983), reptiles according to Storr et al. (1981, 1983) and Cogger (1983) and frogs according to Tyler et al. (1984) and Cogger (1983). The Western Australiam Museum is also used as a reference. Birds are named according to Blakers et al. (1984).

SUMMARY

NATURE CONSERVATION VALUES

Forrestdale Lake Nature Reserve is one of the most important conservation areas in South-Western Australia for a number of reasons.

1. It is important locally, regionally, nationally and internationally, as a habitat and refuge for waterbirds. This importance stems from the role the lake plays as part of a network of wetlands, as effective wetland and waterbird conservation requires competent management of both individual wetlands, and the wetland system.

In winter, waterbirds move throughout the south-west, taking advantage of the many ephemeral wetlands, from which they retreat to the more permanent water bodies, in summer. Some species are thought to frequently move between the south-west and other parts of Australia while others, including the Long-toed Stint, migrate from as far north as Siberia, for the southern hemisphere summer.

Waterbird use of Forrestdale Lake varies seasonally, as is typical for many of the wetlands of the south-west. Numbers peak just before the lake dries in summer and again in winter, as the lake refills.

Based on the findings of the South-West Waterbird Project conducted by the Royal Australasian Ornithologists Union (RAOU 1986), Forrestdale Lake qualifies as a Wetland of International Importance on the grounds that it regularly supports more than one percent of the known Australian population of the Long-toed Stint. In addition, more than 10 000 waterfowl (Anatidae) used the lake in each year of the study. The project also identified fifteen species protected under the Japan Australia Migratory Bird Agreement treaty as occurring at Forrestdale (14 waders and the Great Egret). Furthermore, the RAOU survey identified the highest number of species, the third highest number of breeding species, and the third highest total number of waterbirds on any one occasion, at Forrestdale Lake.

Based on maximum counts during the study, the Reserve is rated as the most important in south-western Australia for the Long-toed Stint and the Clamourous Reed-warbler. It rated equally with another Reserve as the most

important for the Pacific Black Duck and Australasian Shoveler. Maximum numbers of the Pacific Heron, Red-capped Plover and Black-tailed Godwit were only exceeded by one other reserve in the south-west and it is also the only reserve to be visited by the Little Ringed Plover and Little Stint. In terms of its breeding species, Forrestdale Lake rates first for Dusky Moorhens, Purple Swamphens and Reed-warblers. It is also important for breeding by Hardheads.

2. In the local context, Forrestdale Lake is valuable, as most wetlands on the Swan Coastal Plain have been filled or drained for agriculture or urban development. The Nature Reserve contains a landscape, with associated plants and animals, otherwise poorly reserved in the Perth metropolitan area.

3. Forrestdale provides valuable habitat for 60 species of terrestrial birds. A number of species such as the Grey Shrike-thrush, the Scarlet Robin and the Golden Whistler, do not normally enter suburban areas.

4. The Nature Reserve supports the lined skink Lerista lineata, a gazetted rare and endangered species.

5. The Nature Reserve contains 24 species of orchids, which gives some indication of the diverse understorey, even though many parts of the reserve are choked by weeds.

6. Forrestdale Lake and surrounds provides a valuable educational resource, with its wetland ecosystem and associated wealth of birdlife.

MANAGEMENT ISSUES

Primary productivity within a lake system, and therefore its ability to support waterbird populations, is dependent on the presence of water and on water quality. The maintenance of water quantity and quality is directly affected by manipulation of groundwater and surrounding land-use practices.

If the Reserve is to remain an important refuge for the diversity of waterbirds already utilising the lake, particularly the Long-toed Stint, it is not only essential that competent management take place, but also that the

general public are aware of the lake's importance, and supportive of management objectives.

Thus, the main concerns in the management of Forrestdale Lake are water quality, water quantity and the fostering of positive public attitudes. To some extent, these critical issues are outside the sphere of day-to-day management. Both water quality and quantity are directly affected by surrounding land-use and local demands for groundwater. These practices are determined by public attitudes and preferences, and are minimally influenced by management of the Reserve itself.

Furthermore, much of the information necessary to make management decisions regarding water quality and quantity is lacking. Research is one way of providing many of the answers. In some cases, management strategies cannot be determined until the results of investigations are known. Much of the work is underway, while other studies are dependent on additional funding.

GENERAL MANAGEMENT OBJECTIVES

The primary objective of management of Forrestdale Lake Nature Reserve is to protect and enhance the area as a waterbird habitat for the range of species presently utilising the lake. Consideration must therefore be given to the requirements of various species including diving ducks and waders including some rare species. Secondary objectives include the following: retaining the area as a representative sample of Swan Coastal Plain wetlands; ensuring the continued presence of a diversity of native flora and fauna; managing the reserve (with reference to such things as the control of fire, midges and weeds) with an appreciation for the needs of neighbours and local residents; and ensuring recognition of the Reserve as a valuable research and educational resource.

To achieve these aims, with particular emphasis on the primary objective, management strategies have been based on the following considerations.

1. Water quality should remain consistent with the maintenance of a healthy aquatic ecosystem and ensure that the lake remains as a feeding ground and refuge for the suite of waterbirds it currently supports.

2. An annual pattern of water levels, suitable to the needs of the full range of waterbirds currently using the lake, should be established.

3. Bulrush (Typha) should be managed for the maximum benefit of the waterbirds and to prevent the lake from becoming a typha lake.

4. Guidelines for midge control are required and measures that have minimal impact on the environment need to be developed and implemented.

5. Fire protection measures should be established on the basis of the need to: protect human life, protect the conservation values of the reserve, limit the area affected by wildfire and protect the assets of reserve neighbours.

6. It is necessary to exclude the disease, dieback, from uninfected areas.

7. The spread of exotic pest species of flora and fauna needs to be controlled.

8. Rehabilitation works are necessary to encourage regrowth of natural vegetation where plants have been damaged or removed.

9. Data is required to further develop management strategies for the protection of waterbirds and the effects of the strategies advocated need to be monitored.

10. Public use should be limited to ensure protection of the conservation values of the Reserve.

11. The Reserve's classification should reflect the importance of the area as a conservation area for the protection of flora and fauna.

12. The boundary of the Reserve should be defined for management purposes.

13. The public should be encouraged to participate in management of the Reserve.

Where the implications of certain strategies are not known due to lack of information, emphasis has been placed on research.

In Part B of this plan each aspect requiring management is dealt with in a discrete section. Within each section the underlying strategies for achieving particular objectives are given first. These are followed by a rationale explaining why the particular management measures are necessary. The strategies needed to achieve the given objectives conclude each section.

PART A

THE RESERVE

1.0 LOCATION AND PHYSICAL FEATURES

1.1 The Study Area

Forrestdale Lake Nature Reserve (No. 24781) is an 'A' Class[+] Reserve located 23 km south of Perth and 15 km inland, in the local government authority of the City of Armadale (Fig. 1). The Reserve, with an area of 243.6 ha, is almost entirely bounded by Commercial Road, which although gazetted has only been partially completed to date (Fig. 2). An unnamed 'C' Class[+] Nature Reserve (No. 37016), with an area of 1.8 ha, abuts the north-western boundary of Forrestdale Lake Nature Reserve. Both Reserves are vested in the National Parks and Nature Conservation Authority (NPNCA) and are set aside for the 'Protection of Flora and Fauna and Recreation'.

1.2 The Physical Environment

Forrestdale Lake Nature Reserve lies on the Swan Coastal Plain on the eastern edge of a gently undulating dune system (the Bassendean dunes). These dunes, which have formed ridges parallel to the shores of Forrestdale Lake, are vegetated largely by banksia woodlands and low closed-forests of swamp paperbarks. The band of vegetation surrounding the lake, included within the Nature Reserve boundaries, varies in width from 1 m to 380 m. The lake occupies 81% (or 198.7 ha) of the total reserve area and varies in depth from dry to about two metres depending upon the season.

1.3 The Human Environment

1.3.1 Land Use

Private property adjoins the Reserve to the north, west and south (Fig.2). The land immediately to the west and south-west is used

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[+] 'A' class reserves remain declared as such until revoked by an Act of Parliament, while 'C' class reserves may be revoked or altered by gazettal of a Ministerial Notice. Therefore, any changes to the boundary, area or purpose of Forrestdale Lake Nature Reserve require approval by both Houses of State Parliament.

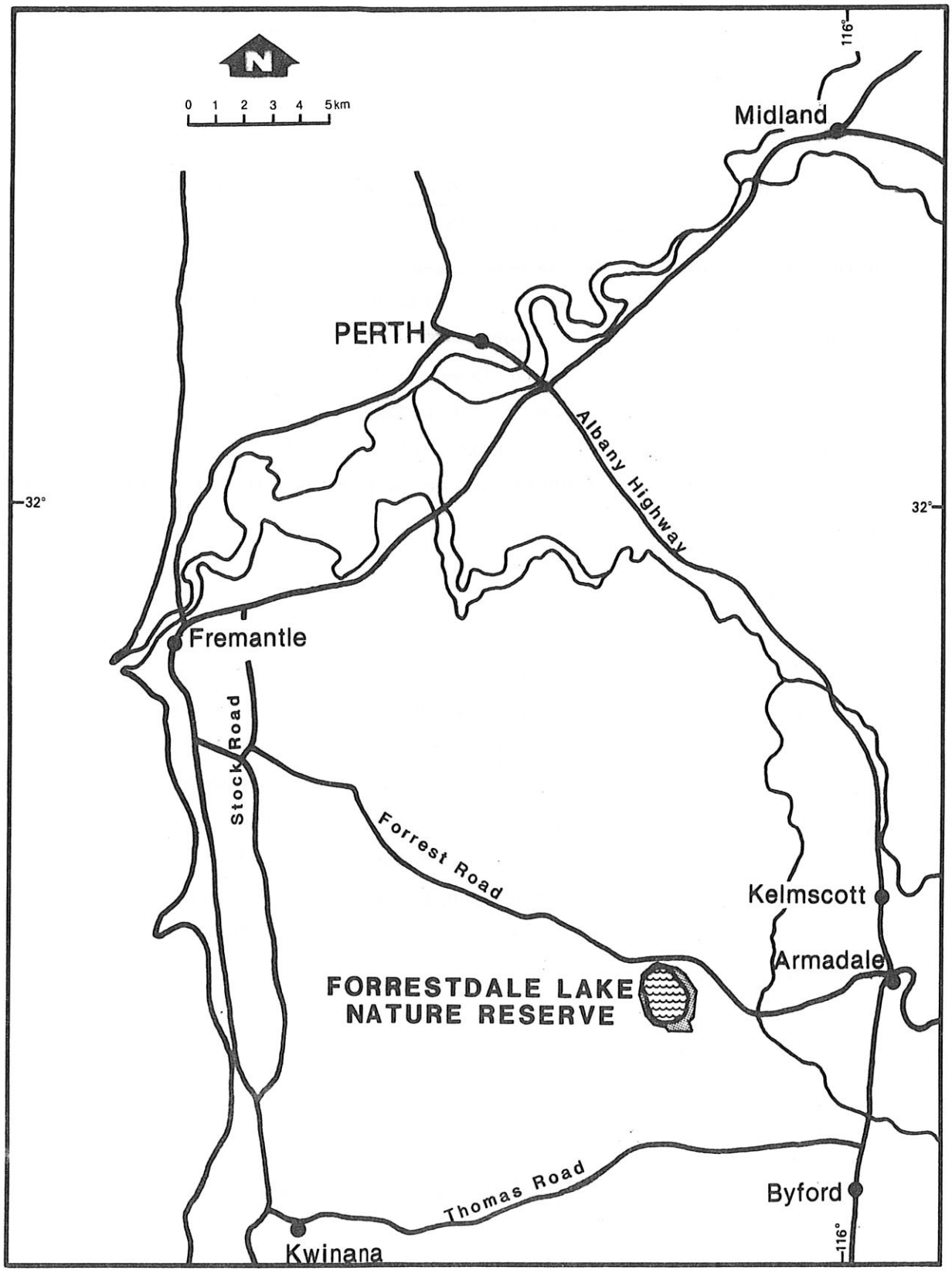

Figure 1. Location of Forrestdale Lake Nature Reserve.
(Source: Department of Conservation and Land Management, 1986.)

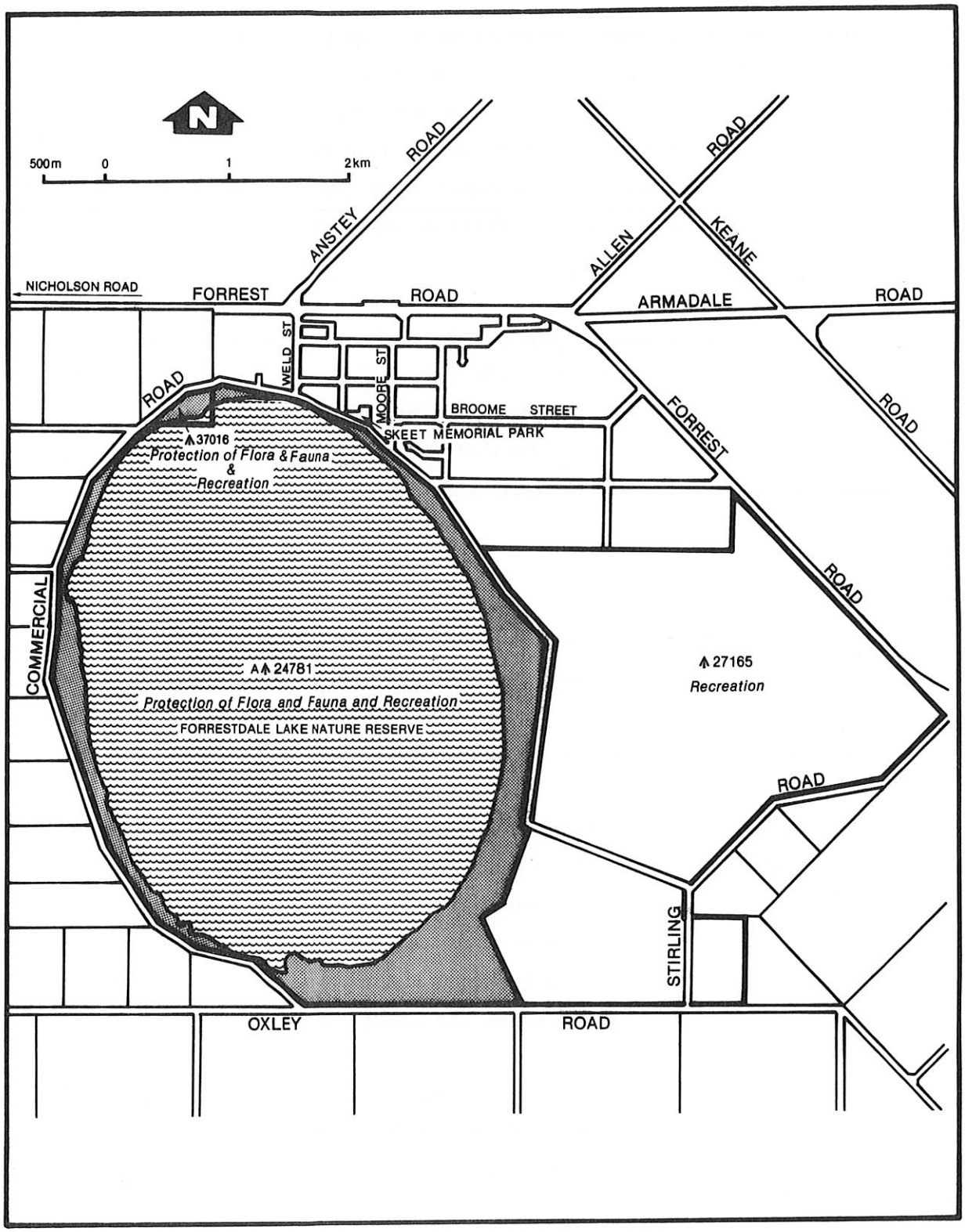

Figure 2. Forrestdale Lake Nature Reserve ('A' Class Reserve No. 24781 and 'C' Class Reserve No. 37016) cadastral information. (Source: Lands and Surveys 1:10 000 series.)

mainly by hobby farmers. Most of it is partially fenced and cleared or semi-cleared. The fenced areas are used for grazing. A kennel has been operating in this area for the last nine or so years (D. James, pers. comm., 1985). Further to the west, adjacent to Nicholson Road, a horse-training property and piggery have been in existence for some time. To the south of the Reserve the land is fenced and mostly cleared.

The Forrestdale townsite lies on the northern boundary of the Reserve, with Recreation Reserve No. 4370 (Skeet Memorial Park) providing some buffering between the townsite and the Reserve (Fig. 2). Recreation Reserve No. 27165, with an area of 138.4 ha and including a nine hole golf course, lies on the eastern boundary of the Reserve.

1.3.2 Zoning

Forrestdale Lake Nature Reserve is affected by the Metropolitan Region Scheme (Town Planning Department 1982), the Armadale Town Planning Scheme (Town Planning Department 1985) and the System Six Recommendations (Department of Conservation and Environment 1983).

Under the Metropolitan Region Scheme (MRS), the lake has been classified as a Waterways Reserve and, with the exception of an enclave of land zoned urban to the north-east of the lake, the surrounding land is zoned rural. Forrest Road, to the north of the Reserve, is an important regional road. Any proposals for the development of areas classified under the MRS must be referred to the State Planning Commission.

Under the Town of Armadale Town Planning Scheme No. 2, land to the west and south of the lake is zoned Rural 'C' and to the north-east Rural 'D'. These areas are described in the Planning Scheme as:

> 'Zone(s) intended for fostering of semi-intensive rural use of land compatible with landscape conservation in conjunction with residential hobby farm uses. Where compatible, such uses promoting tourism, recreation and non-noisy entertainment may be permitted.

'It is intended as common to all Rural Zone categories that the rural landscape and amenity shall be retained, that natural bushland shall be conserved and that upon closer subdivision or upon new development a high standard of servicing and amenity will be implemented.'

The Town Planning Scheme sets down guidelines for subdivision in the rural zone requiring the compilation of a subdivision guide plan. Development is subject to provisions covering clearing, firebreaks and lot size. The recommended minimum lot size for Rural'C' land is 4 ha and for Rural 'D', 2 ha.

A residential (single dwelling) zone is located to the north of the lake.

Certain uses are permitted within each of the zones and these are described in the Town of Armadale Planning Scheme No. 2. All land-use proposals within the City of Armadale are subject to the regulations detailed in the Town Planning Scheme, council discretion and approval by the State Planning Commission.

System Six Recommendation M95 also applies to Forrestdale Lake. This recommends that an area of approximately 435 ha, be managed as a regional park. The recommendation covers the Nature Reserve and land to the west, south and east (Department of Conservation and Environment 1983).

1.4 Implications for Management

1. Development of the land surrounding Forrestdale Lake Nature Reserve and within the waterways reserve is strictly controlled by the Town of Armadale Town Planning Scheme No. 2 and the Metropolitan Region Scheme respectively. Any proposals for development must be approved by the State Planning Commission and the City of Armadale.

2. Further development is expected on land adjacent to the Reserve. This may have implications for management during the currency of the management plan, by placing additional pressures on the Reserve.

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Town Planning Department (1982), Metropolitan Region Scheme. Town Planning Dept., Perth.

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2.0 HISTORY

2.1 Aboriginal Occupation

Aboriginals have occupied the south-west of Western Australia from 'time beyond the memory of man' (Hallam 1985). Little doubt exists that they occupied the land for at least 50 000 years and possibly 150 000 (Hallam 1985) before the arrival of Europeans in the early 1800's after which numbers dramatically declined (Atlas of Human Endeavour 1979; Berndt 1979).

There are conflicting reports regarding which tribe actually occupied the Forrestdale area. According to Tindale's map (1974) and the Atlas of Human Endeavour (1979), the Whadjuk Tribe (or Whadjug Tribe, as recorded in the Atlas), occupied the area north, east and south of Perth. The tribal map after Douglas (1968/76 in Berndt 1979) indicates the Pipelman Tribe and the map after Wilde (1981 in Hallam 1985) records the Beeliar or Canning Tribe. Aboriginals who occupied the south-west of the State have also been referred to as the Nyungar which was the language spoken in the south-west region.

These hunters and gatherers had a close relationship with the land and an intimate knowledge of its contents (Berndt 1979). They managed and maintained their environment through repeated and deliberate firing of some areas and exclusion of fire from others. Firing ensured that game was localised and abundant and encouraged plant regrowth or improvement of flavour (Hallam 1985).

Aboriginal 'tribes' did not wander at random over the face of the landscape as is sometimes suggested, but occupied an area around fixed resources, such as lakes and swamps (Hallam 1985).

Little information is available on Aboriginal activities within the study area although two sites in the immediate vicinity have been recorded by the Division of Aboriginal Sites of the Western Australian Museum and it is almost certain that Aboriginals utilized the lake's resources.

2.2 European Settlement

The first Europeans to settle at Lake Jandakot (later re-named Forrestdale Lake) were Alfred and William Skeet in 1885. The Skeets were granted a 'special occupation' licence for 100 acres adjoining the lake as well as licences to cut and sell timber. Once settled, the Skeets began clearing their property by hand. The area at this time was described by Popham (1980) as:

> '... rich swamplands ... closely covered by huge paperbark trees, many thirty feet high with a diameter of some three feet, the undergrowth beneath them dense with rough scrub and tanglewood creepers ...'

The Skeet's example was soon followed by others. The Lake Jandakot settlers cleared their land, experimented with crops and ran dairy cattle and poultry as viable commercial ventures (Popham 1980).

By 1898, the area surrounding the lake had been set aside as a Townsite Reserve and recommendations made regarding subdivision. At the time it was felt that the eastern portion of the reserve would be most suitable for suburban blocks, however the area was not immediately surveyed. The following year, the area was surveyed in response to further requests for subdivision into residential and 10 acre garden blocks. In a report to the Under Secretary for Lands in April 1899, the Surveyor General described the land as consisting of:

> '... undulating sandy country timbered principally with banksia, and with a few (sheoaks) and jarrahs. The soil is of a very inferior description, and in (his) opinion, in the whole of the (Townsite) Reserve there can hardly be found 10 acres of land suitable for gardening ...'

The Townsite Reserve was inspected again in April 1901 following requests by the Jandakot Agricultural Society to subdivide the land on the western side of the lake. The Society considered the land highly suitable for gardening blocks.

A sandy ridge bounding the lake on the western side was reported. To the west of the ridge, was some rich garden land, which was at about the same level as the water in the lake and was very boggy. It was considered difficult to drain and again subdivision of the area was not recommended.

Later surveys revealed that the area was in fact suitable for summer gardening but only when the swamp dried up. It was eventually opened for selection in 1903.

Soon after, in July 1907, the Jandakot-Armadale rail section was completed (Report of the Working of Western Australian Government Railways 1905-1906) for the purpose of transporting goods to the Fremantle Markets. By 1914 the rail service was still only used for goods transport despite requests from East Jandakot residents to provide a passenger service (West Australian letter to the Editor 12 July 1914).

Over the next few decades, the land continued to be taken up. However, many found it difficult to make a living from their 10-acre blocks and during the 1930's depression about 26 families were forced to leave (F. James, pers. comm., 1985). From the 1940's onwards the trend was reversed and people began moving back into the area (F. James, pers. comm., 1985).

The population in the Forrestdale area rapidly increased in the latter half of the 1960s as the townsite blocks to the north-west of the lake were taken up.

2.3 Nomenclature

The lake was originally known as Lake Jandakot (place of the whistling eagle - Serventy and Whittell 1976). The lake-side townsite was also originally known as Jandakot, however it was gazetted as East Jandakot and the main Jandakot townsite was gazetted further to the west.

The name of the lake-side township was changed in 1915 at the request of the local progress association, to avoid confusion with the nearby Jandakot. The name Forrestdale (after the explorer John Forrest) was gazetted on 16 April 1915. It was not until March 1974 that the name of

the lake was changed from Jandakot to Forrestdale, again at the request of local residents.

2.4 Clearing

The following discussion is based on interpretation of aerial (Lands and Surveys) photographs taken in 1948 (Fig. 3), 1953 (Fig. 4), 1963 (Fig. 5), 1974 (Fig. 6) and 1985 (Fig. 7).

By 1948, approximately 50% of the land surrounding the lake had been cleared or partly cleared and attempts had been made to drain the winter wet swamps to the west (Fig. 3). The small holdings on the western edge of the lake had been largely cleared, as had the lake-side belt of paperbark woodland. To the north-west, mainly alongside Forrest and Nicholson Roads, some clearing had taken place, apparantly for grazing. Land to the north-east was partly cleared while the low-lying swampland to the east and south-east remained uncleared.

The period 1948 to 1953 saw further clearing accompanied by the return of some areas to a semi-natural state particularly to the north-east of the lake (Fig. 4). As development accelerated over the next 10 years, large, previously untouched areas to the south of Oxley Road and north-west to Nicholson Road were cleared for farming.

Some areas which had partly recovered from clearing during the 1940's had, by 1963, undergone further clearing for farming and residential growth as a second wave of development swept through the area. Comparison of Figures 4 and 5 clearly illustrates the extent of clearing in the north, west and south.

By 1963 the Forrestdale area, particularly around the northern sector of the lake, was a mixture of cleared, partly cleared and uncleared land. Only the paperbark woodland to the west and swampland to the south-west was untouched. Some regeneration was apparent.

The extent of clearing over the next decade (1963-1974) was comparatively small, however, there was some expansion of the cleared areas on the western and southern edges of the lake. By 1974 the

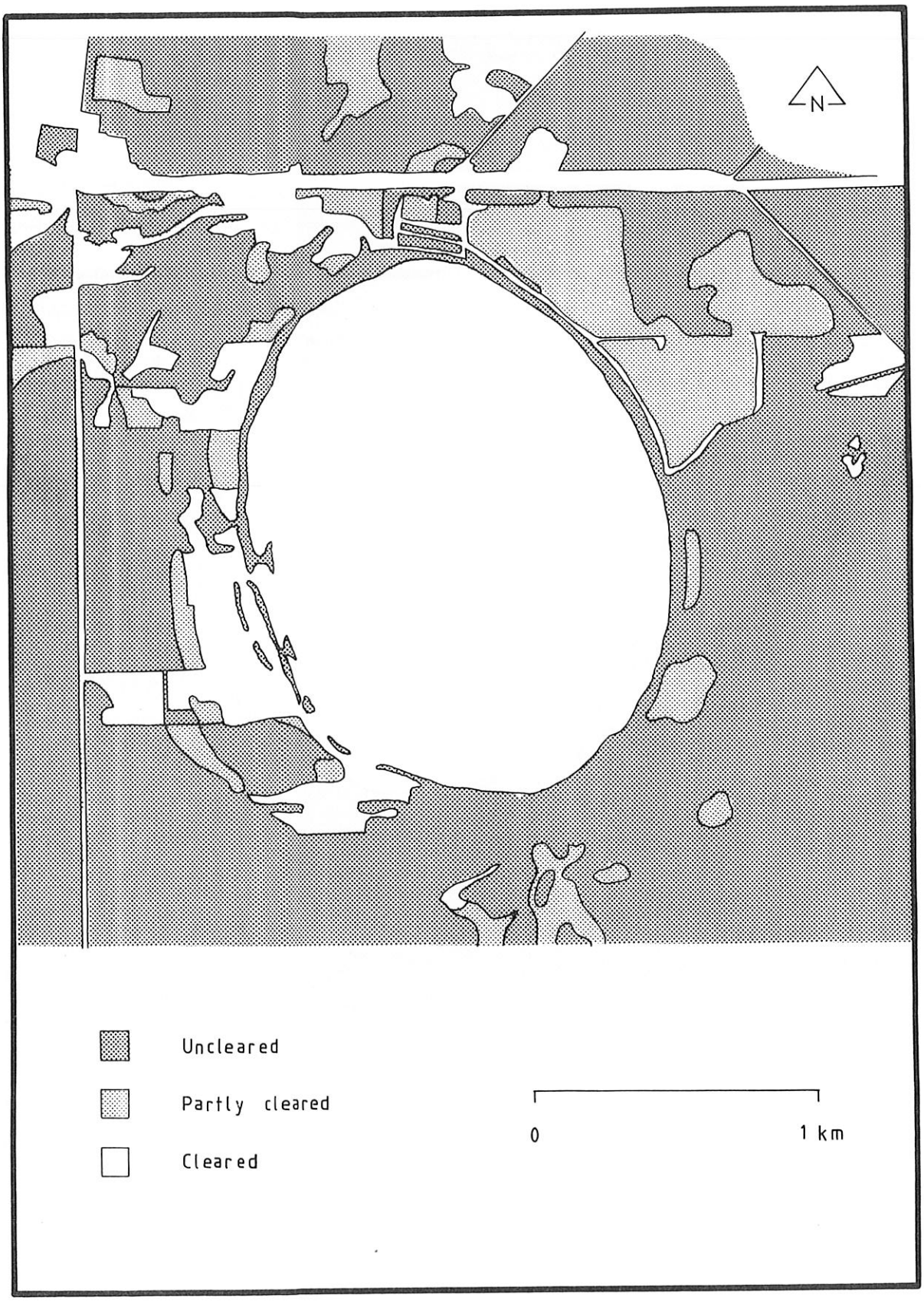

Figure 3. Clearing of land on and adjacent to the Reserve - 1948. (Source: Lands and Surveys 1:25 000 Metropolitan Street directory series of aerial photographs.)

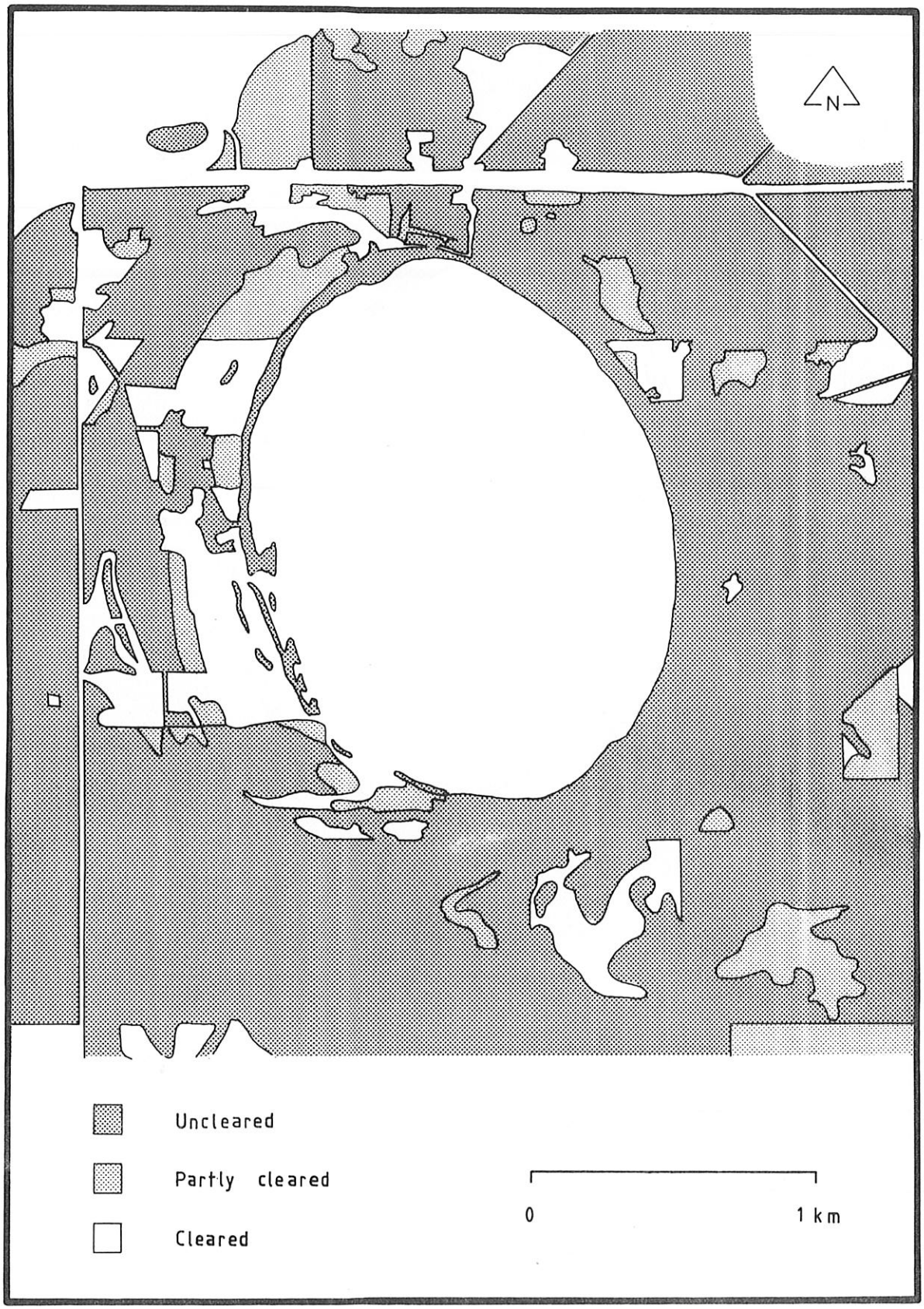

Figure 4. Clearing of land on and adjacent to the Reserve - 1953. (Source: Lands and Surveys 1:25 000 Metropolitan Street Directory series of aerial photographs.)

Figure 5. Clearing of land on and adjacent to the Reserve - 1963.
(Source: Lands and Surveys 1:25 000 Metropolitan Street Directory series of areial photographs.)

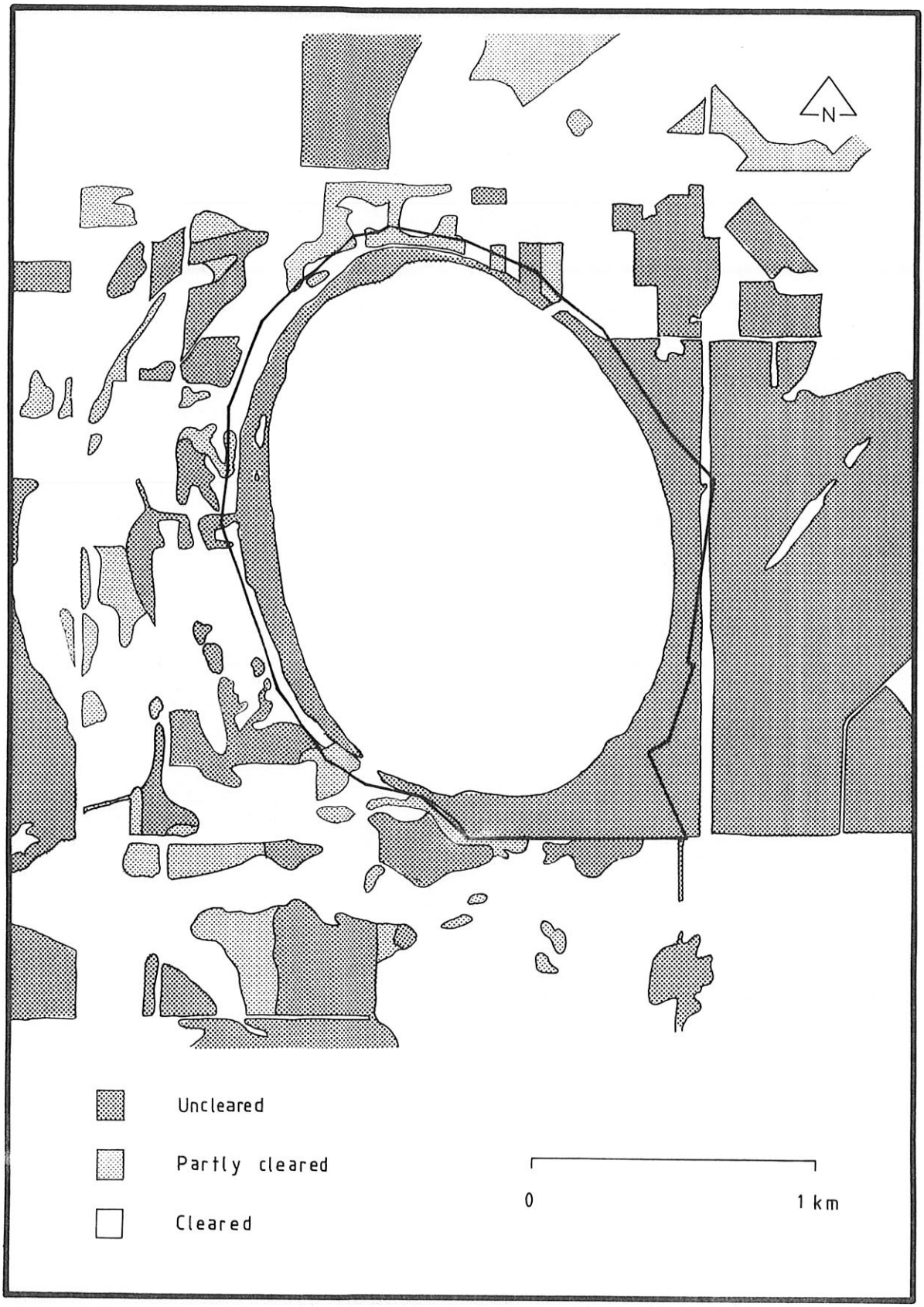

Figure 6. Clearing of land on and adjacent to the Reserve - 1974.
(Source: Lands and Surveys 1:25 000 Metropolitan Street Directory series of aerial photographs.)

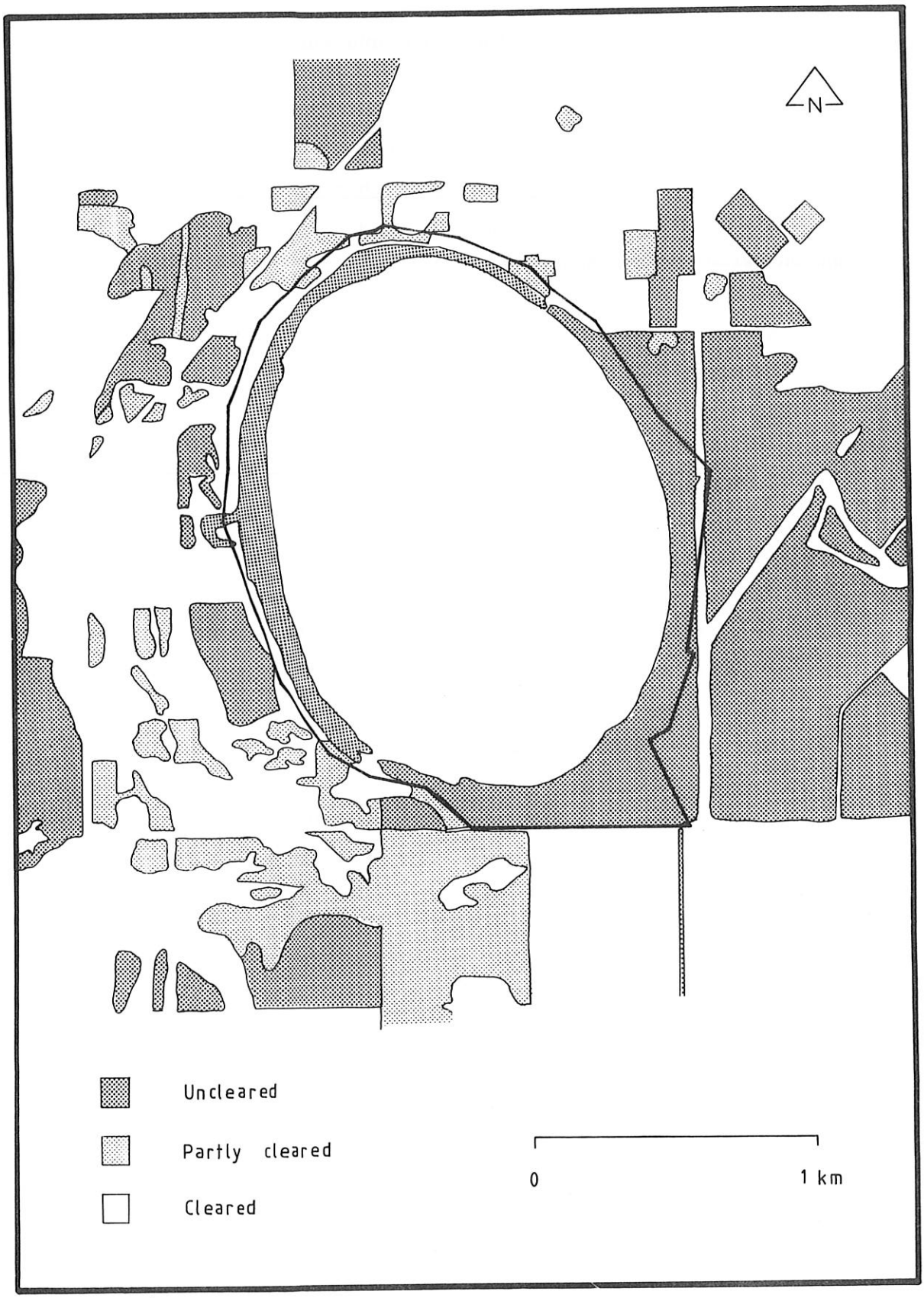

Figure 7. Clearing of land on and adjacent to the Reserve - 1985. (Source: Lands and Surveys 1:25 000 Metropolitan Street Directory series of aerial photographs.)

townsite had become well established and much of the bushland to the north had given way to housing and recreation facilities.

To the east, a path was cleared for a transmission line extending from Forrest Road south to Oxley Road, through previously untouched swamp and banksia woodland. This is apparent as a broad scar both on the ground and on aerial photographs.

Over the decade 1974-1985 the alternating pattern of clearing, with some areas showing signs of regeneration, continued.

The existing situation (Fig. 7) is one of a mosaic of cleared, partly cleared and uncleared land. To the east the scar created by the construction and maintenance of the State Energy Commission transmission line is still visible and a nine hole golf course is in operation. A circular track is also present but it is generally flooded during winter. All other areas support residential and/or farming developments.

2.5 Creation of the Nature Reserve

It was not until 1957 that interest developed in creating a reserve around and including Forrestdale Lake. In a letter to the Department of Lands and Surveys, the Shire of Armadale-Kelmscott requested the area to be gazetted as an 'A' Class reserve in the name of the Armadale-Kelmscott Road Board. It was intended that the Reserve be used for recreation, particularly sailing. The Western Australian Museum also expressed an interest in the area and noted in a letter to the Fauna Protection Advisory Committee (FPAC) that the lake was:

> 'a haven for many of our rarer types of birds ... (including rare) migratory visitors ...'

In May 1957, the Chief Warden of Fauna recommended vesting in the FPAC with the power to lease for 21 years, to cater for recreation needs. This recommendation was approved by the Department of Lands and Surveys on 16 August 1957, with 'A' Class Reserve No. 24781, containing about 602 acres (243.6 ha) being gazetted for the 'Protection of Flora and Fauna and Recreation' was vested in the FPAC with the power to lease.

On 7 January 1981, the 'A' Class Reserve was vested in the Western Australian Wildlife Authority (now replaced by the NPNCA) without the power to lease. On 16 January 1981, 'C' Class Reserve No. 37016 on the north-western edge of Reserve No. 24781 was also set aside for the Conservation of Flora and Fauna and Recreation and vested in the W.A. Wildlife Authority.

2.6 Implications for Management

1. Aboriginal sites are protected under the Aboriginal Heritage Act (1972). If aboriginal sites are discovered on the Reserve, it may be necessary to obtain permission from the W.A. Museum before active management (e.g. construction of firebreaks) can be undertaken.
2. Use of, and pressure on, the lake and immediate surrounds has increased with residential development. Restrictions on ad hoc movement throughout the Reserve are therefore necessary to protect flora and fauna.
3. Changes in adjoining land-use are likely to have led to increases in nutrients into the lake. Future changes in adjoining land-use may further affect nutrient levels. Any studies of nutrient budgets should be based on a recognition of this strong link.
4. Changes in the hydro-regime have occurred with the establishment of houses, roads, recreation facilities, and clearing and drainage practices. The Lake can not be returned to its original state, but manipulation of drainage and nearby land-use may be necessary to achieve the primary objective.
5. Clearing of the land surrounding the lake is likely to have contributed substantially to the siltation process. Removal of sediments would be costly and laborious, with unknown consequences. Limited funding and resources make this an unviable option during the currency of this plan.
6. The inclusion of 'recreation' in the purpose of the Reserve is no longer appropriate as changes in conditions (e.g. low water levels) over recent years have made the lake unsuitable for its original recreational purpose of sailing.

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3.0 CLIMATE

3.1 General

The Swan Coastal plain has a typical Mediterranean climate of mild, wet winters and hot dry summers. The mean annual rainfall over the period 1922 to 1984 in the Forrestdale area was 877 mm (recorded at Armadale - approximately 7 km to the east and being the nearest rain gauging station). Most of the rainfall occurs in the period April to October (Fig. 8). The mean maximum temperatures for Perth range from 30.7°C in February to a mild 17.9°C in July while mean minimum temperatures range from 19.0°C in February to 9.4°C in July and August (Fig. 8).

In summer, the low rainfall and high temperatures result in an evaporation rate of approximately 254 mm per month (Seddon 1972) compared with an average monthly summer rainfall of 26 mm. Therefore, during the summer months evaporation exceeds rainfall, a factor which contributes substantially to the drop in lake level from mid spring through summer.

Winds during winter shift from the west to the north. In summer, winds from the north-east and east veer to south-west, mostly in mid to late afternoon.

3.2 Implications for Management

1. During hot dry summers bulrushes around the lake edge create a fire hazard. This necessitates specific fire protection measures.

2. When the lake dries, access to the lake bed becomes possible. Depressions left by vehicle tyres create an ideal environment for the establishment of bulrush (Typha) seedlings. Restriction of vehicles entering the Reserve is therefore necessary since Typha invasion of the lake is a major management problem (see Section 6.4).

3. The afternoon and evening south-westerly sea breeze carries midges into the residential area. A buffer of vegetation may prove effective (see Part B. 8.0 Rehabilitation).

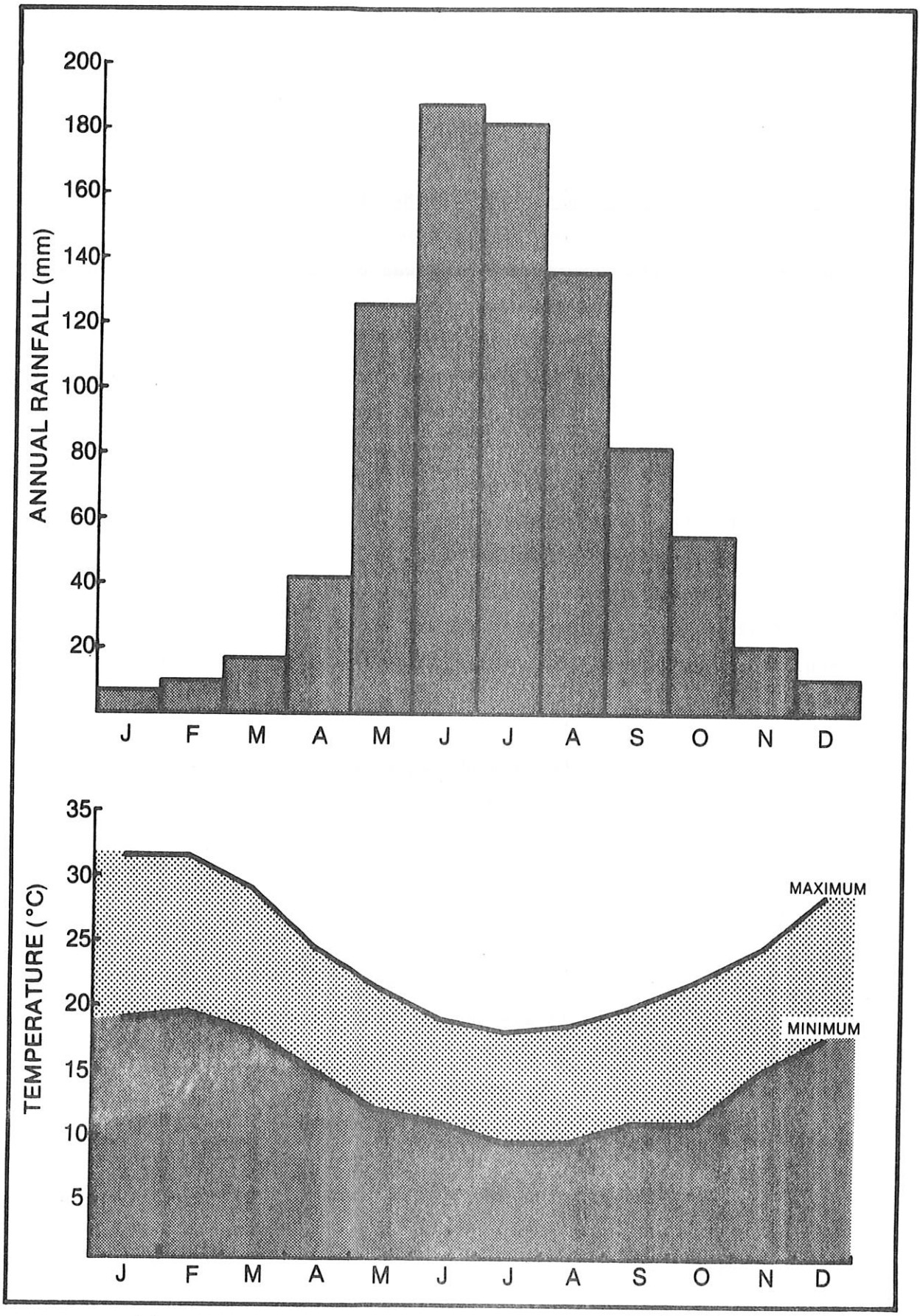

Figure 8. (a) Mean rainfall.

(b) Mean daily maximum and minimum temperatures.

(Source: Bureau of Meteorology, 1985.)

4. In summer strong sea breezes rapidly spread wildfires towards the residential area. Fire protection should consider this pattern.

5. Climatic factors are favourable for the spread of dieback disease, (Phytophthora cinnamomi) and appropriate precautions need to be taken.

Reference

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4.0 LANDSCAPE

4.1 Geology

Based on core samples of the lake's basin and surrounding area, Willis (1979) describes the basin's profile as having an uppermost deposit varying from sand around the margins to sandy organic mud in the centre. Underlying this is soft marly limestone over clayey sand. On the north-eastern margin of the lake, a rocky outcrop of lithified sandstone is present.

4.2 Geomorphology

The lake basin is thought to have previously been larger and connected to swampy areas to the west. A series of low-lying ridges along the western boundary of the lake, known as lunettes, may reflect deflation of the lake bed during a drier period dominated by easterly winds. This process of movement of the base material would have successfully reduced the size of the lake basin and isolated the lake from swampy areas to the west.

4.3 Landform

Forrestdale Lake is oval in shape and is located within gently undulating sand-dunes on the eastern-most fringe of the Bassendean dune system. The dunes consist of leached grey-white siliceous sands which rise to 5 m around the lake edge. To the west of the lake the dunes form distinct arcuate ridges or lunettes. Peats and peaty sands underlie ephemeral swamps in the intervening swales.

4.4 Implications for Management

1. The dunes surrounding the lake are highly susceptible to erosion following damage to groundcover. Thus, access to the Reserve by vehicles and horses, both of which damage the ground cover, should be minimised.

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5.0 HYDROLOGY

5.1 Drainage

There is no natural surface drainage to the lake although a number of artifical drains run into the lake from the north, west and south (Fig. 9). The only other surface contribution is from direct rainfall onto the lake's surface. The nearest natural surface drain is the Wungong Brook, approximately 4 km to the east, which flows north into the Southern River.

The artificial drain to the east is an overflow drain and lies 2.14 m above the base of the lake, however, no flow into this drain has been noted within the last 15 years (D. Hopkins, pers. comm. 1985). This drain also directs water northwards from the recreation area (Fig. 9).

5.2 Groundwater

The coastal plain geological formations contain unconfined groundwater, the upper surface of which is called the water table. In the southern Perth area, the water table varies in depth below ground level, ranging from 0 to 25 m, depending on topography. Where it intersects with the ground surface, wetlands occur. Forrestdale Lake is such a surface expression of groundwater.

Water entering the lake system comes mainly from rainfall, while losses are due to evapotranspiration, evaporation, infiltration into deeper formations (the reverse may also occur) and extraction by wells and bores. All these factors control the level of the water table (Willis 1979; Pollett 1981).

The Reserve lies on the eastern edge of the shallow unconfined aquifer known as the Jandakot Mound. The groundwater flow diagram (Fig. 10) shows the movement of the groundwater away from the crest of the mound, mostly in a westerly direction, although there is some movement to the north and north-west. The flow diagram also illustrates the flow of groundwater into Forrestdale Lake from both the Karnup and Armadale areas.

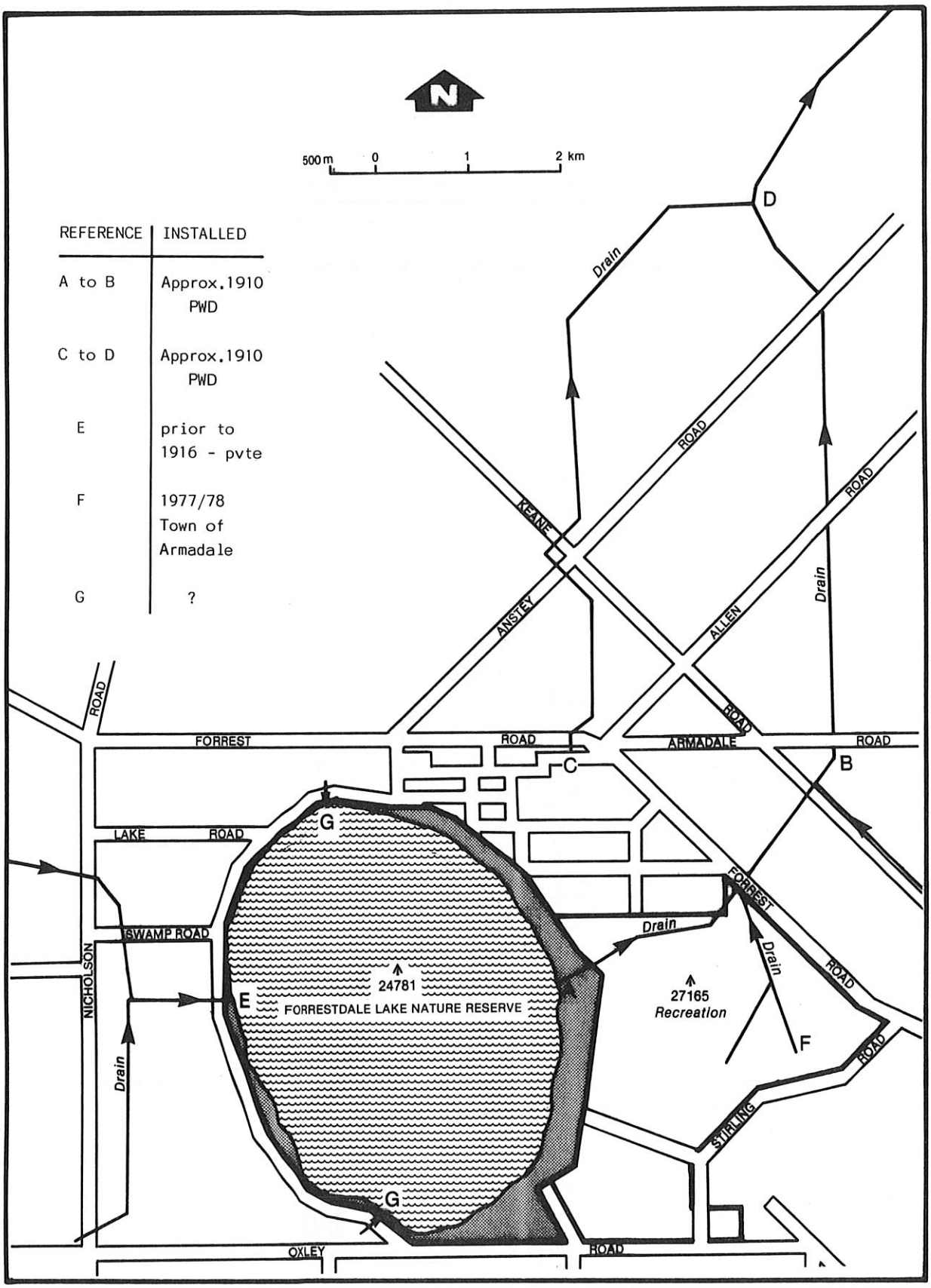

Figure 9. History of drainage in Forrestdale Lake area. (Source: Water Authority of Western Australia, 1985.)

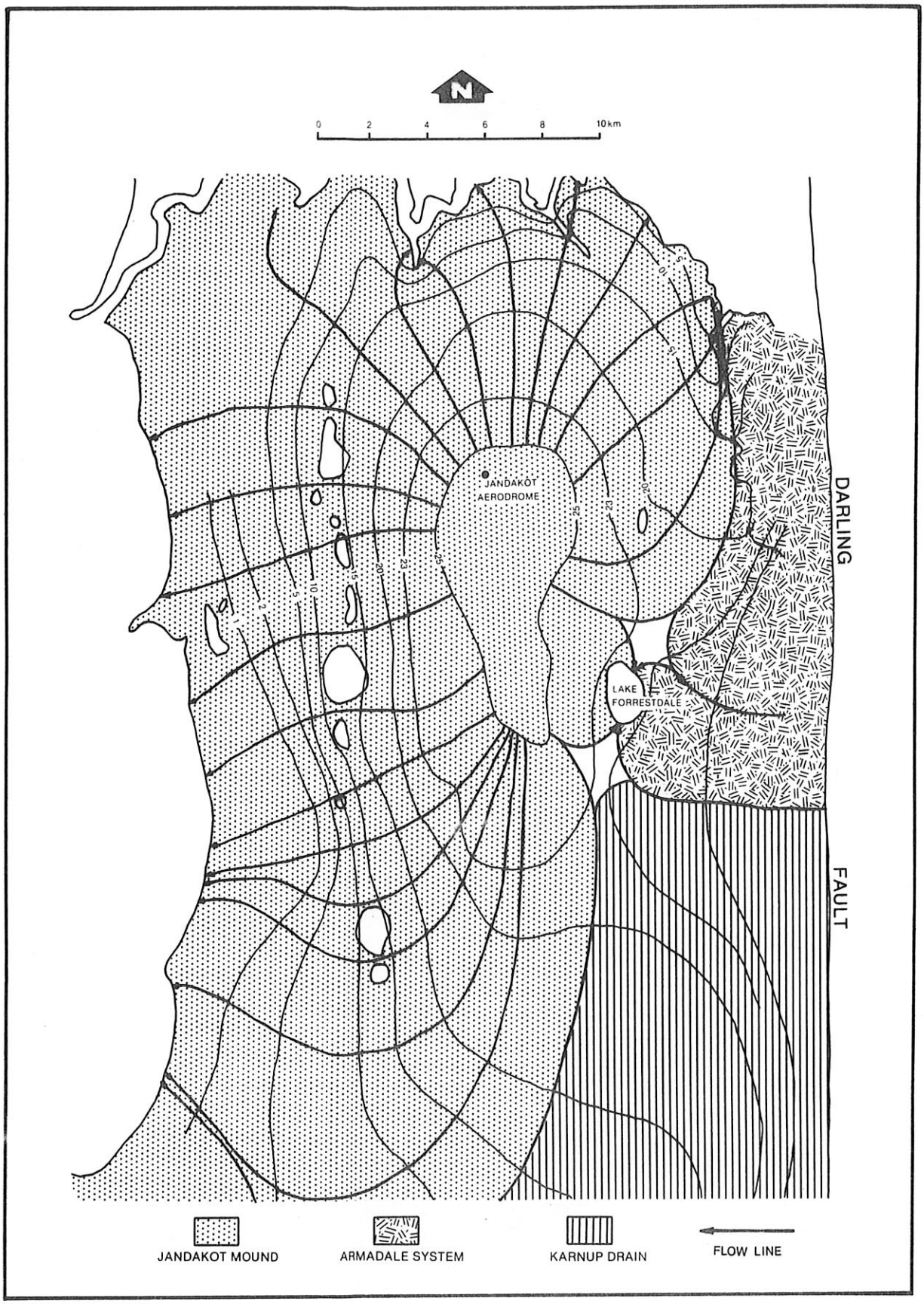

Figure 10. Groundwater flow-net. (Source: Geological Survey of Western Australia Record 1984/9 by W. Davidson, 1984.)

5.3 Water Levels

The changes in lake levels reflect changes in groundwater levels which in turn, are affected by rainfall, groundwater extraction, drainage, evaporation and evapotranspiration.

i. Rainfall

As illustrated in Figure 11, rainfall has been below average for 13 of the last 15 years. This is considered to have been a major factor in the drop in water level noted at Forrestdale over the last 10 to 15 years (Willis 1979; Water Authority of W.A., pers. comm., 1985).

ii. Groundwater

Groundwater levels fluctuate seasonally and are dependent on rainfall for recharge. In summer, evaporation and evapotranspiration are high, rainfall is low and withdrawal from wells and bores peaks, so that groundwater and lake levels fall in response. Conversely, in winter when rainfall is high and losses are low, a rise in the water table occurs.

A downward trend in lake levels was obvious before Water Authority groundwater extraction began in 1979 (Fig. 12), however it is likely that private and public pumping from the unconfined aquifer has contributed to this decline (Water Authority of W.A., pers. comm., 1985).

In the Perth region, private groundwater extraction from the unconfined aquifer amounts to an estimated 85% of the total amount extracted compared with 15% extracted by the Water Authority for public supply (Smith & Cargeeg 1986).

iii. Evaporation

The average annual evaporation in the Forrestdale area is approximately 2 000 mm or about twice the average annual rainfall. This process contributes significantly to the rapid decline in water level during summer.

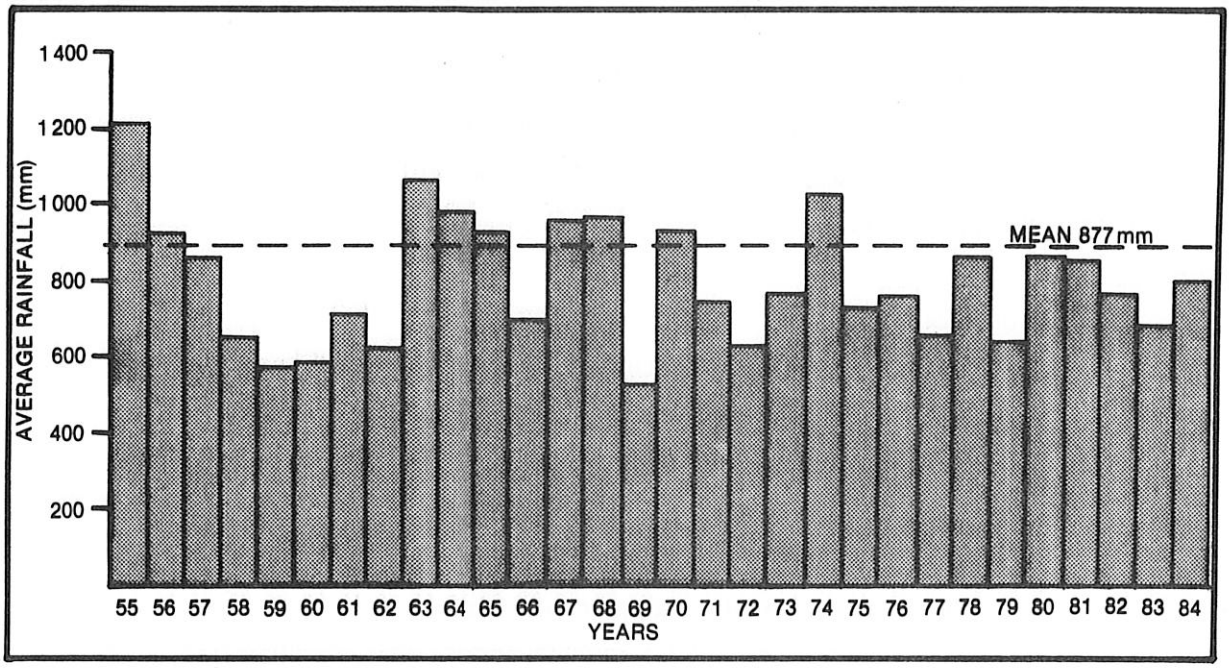

Figure 11. Annual rainfall from Armadale Station 1955 to 1984.
(Source: Bureau of Meteorology, 1985.)

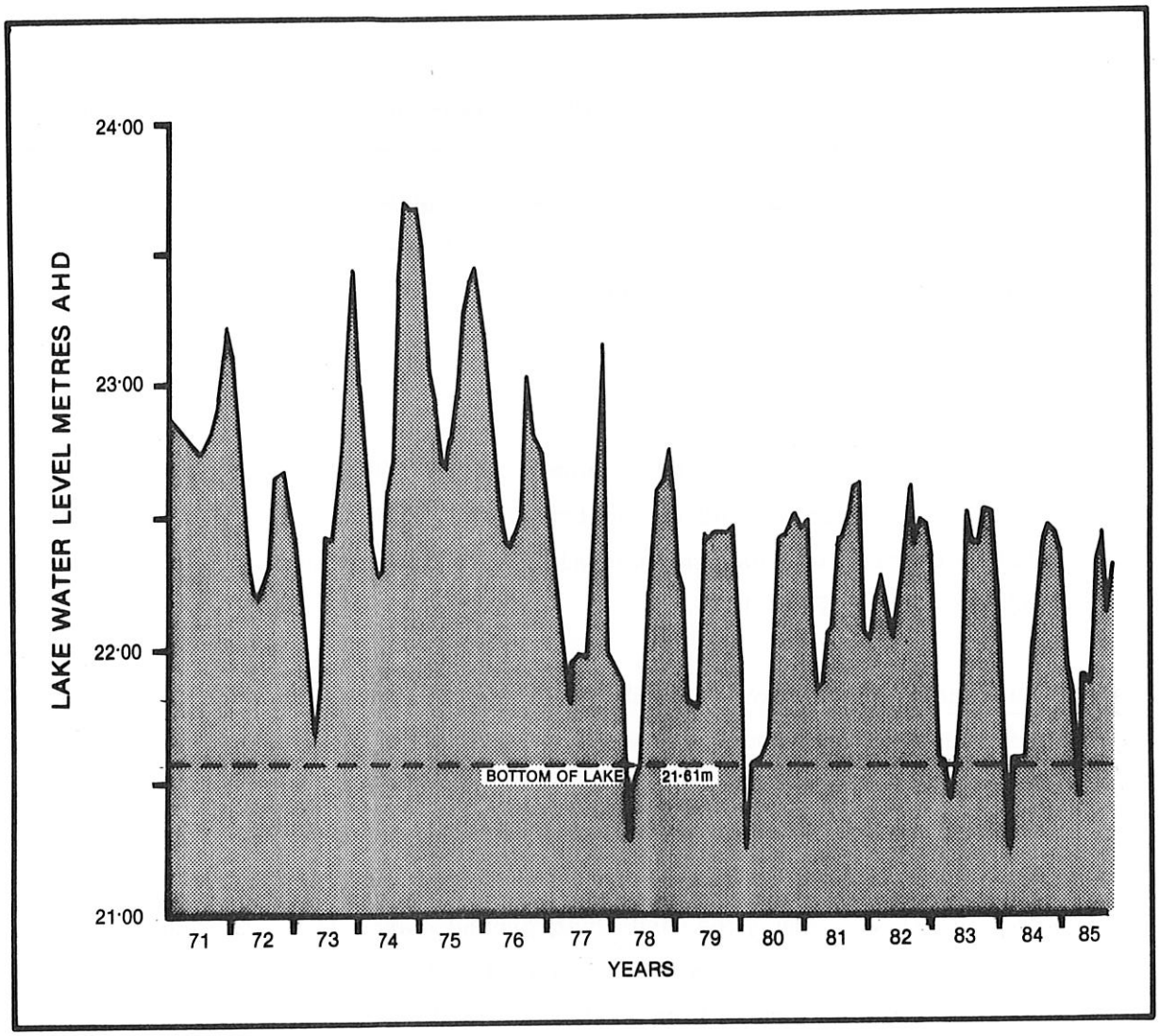

Figure 12. Forrestdale Lake levels indicated by groundwater levels in sump adjacent to lake. (Source: Water Authority of Western Australia, 1985.)

As the lake is a surface expression of groundwater where the land surface intersects with the water table, management of its water levels involves management of the regional groundwater system.

The Water Authority is currently undertaking a study of the regional groundwater system to quantify the relative importance of all gains and losses from the groundwater system. This includes extraction of groundwater through privately and publicly operated bores, and evapotranspiration from wetlands.

5.4 Public Water Supply Scheme

The Jandakot Public Water Supply Area (PWSA) and the Jandakot Underground Water Pollution Control Area (UWPCA), administered by the Water Authority of Western Australia, are located near the crest of the Jandakot Mound (Fig. 13).

Groundwater production from the shallow, unconfined aquifer, for public water supply, commenced in October 1979. The groundwater extracted by the Authority amounts to approximately one third of the total extracted, the rest being removed by private pumping (Water Authority of W.A., pers. comm., 1985). Extraction and water quality within the Public Water Supply Scheme area and Underground Water Pollution Control area are monitored and the operation and effects of the Scheme reported to the Environmental Protection Authority (EPA) annually.

The 1985 report to the EPA stated that:

> '... (Metropolitan Water Authority, now Water Authority of W.A.) pumping has not had a significant effect on groundwater levels in the region.'

Prior to extension of the Public Water Supply Scheme, the Water Authority has undertaken a detailed review of the groundwater system performance and groundwater availability within the Jandakot Public Water Supply Area. A more detailed assessment of the affect of drainage and pumping on the levels of Forrestdale Lake should be available in early 1986 as a result of this work.

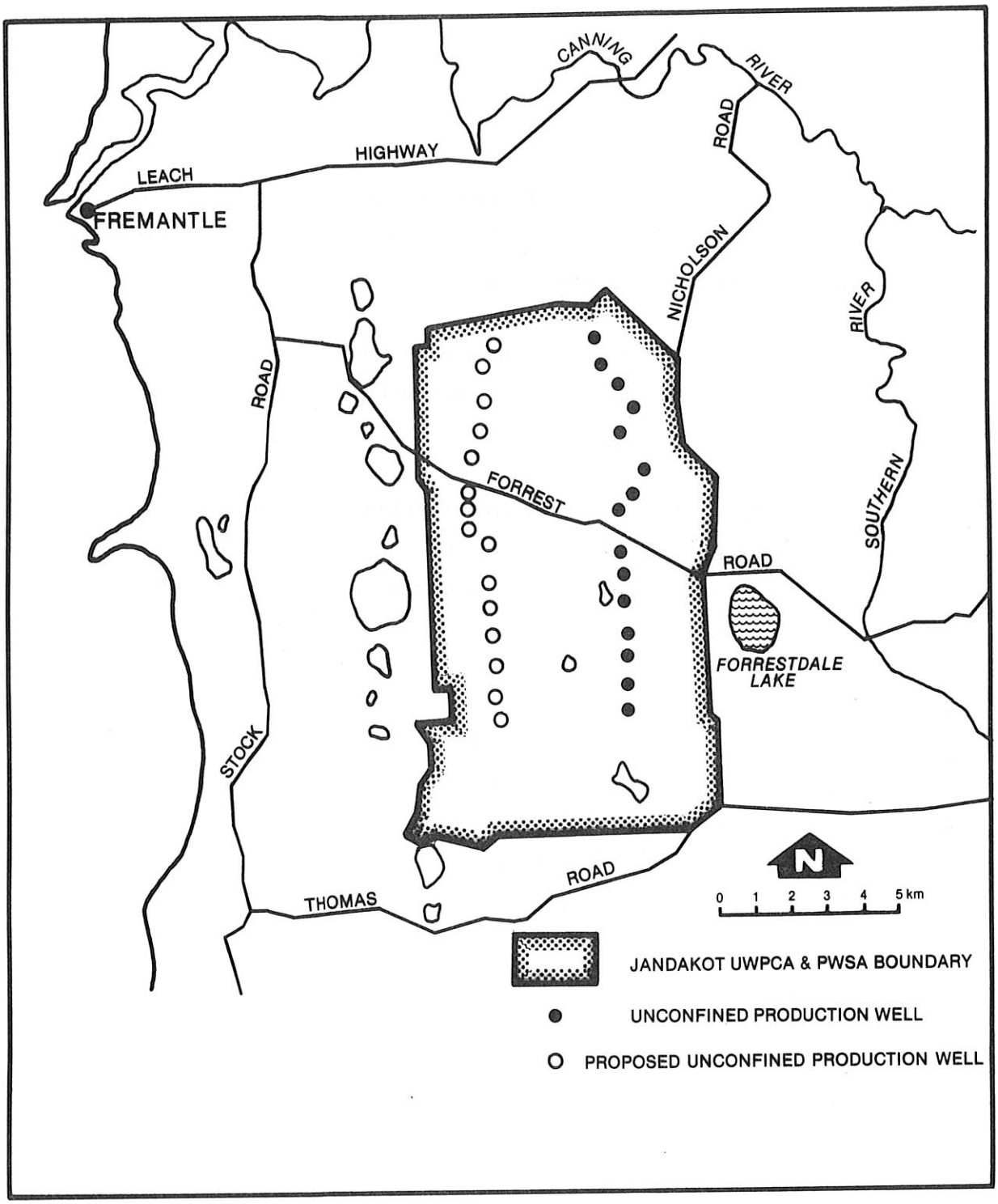

Figure 13. Location of the Jandakot Public Water Supply Area (PWSA) and Underground Water Pollution Control Area (UWPCA). (Source: Water Authority of Western Australia, 1985.)

5.5 Water Quality

5.5.1 Nutrient Status

Nitrogen and phosphorus are two essential plant nutrients usually responsible for algal blooms. These nutrients are made available either by external input or by recycling within a given ecosystem.

Sampling at the lake has been undertaken twice yearly since 1971 by the Water Authority although sampling was not possible on some occasions due to drying.

Vollenweider's (1971) table for nutrient levels is widely used for classifying water bodies. Using this standard, the Water Authority's data suggest that the lake is 'polytrophic', as phosphorus levels are frequently very high (i.e. exceed 100 $\mu g l^{-1}$). The data also show consistently high values for organic nitrogen levels.

The data also indicate large fluctuations in the levels of phosphorus and nitrogen in the system (Fig.s 14 to 16). Phosphorus levels range between 12 000 $\mu g l^{-1}$ and less than 50 $\mu g l^{-1}$ with a mean level of approximately 300 $\mu g l^{-1}$. Similarly, both organic and inorganic nitrogen levels fluctuate from 13 600 $\mu g l^{-1}$ to 100 $\mu g l^{-1}$ and 1 000 $\mu g l^{-1}$ to 50 $\mu g l^{-1}$ respectively.

The marked reduction in fluctuations coincide with the substantial increase in Typha. The extensive growth of the bulrush may be related to nutrient levels, however, no conclusions can be drawn at this stage from the limited data.

Baley and Williams (1973) state that:

> 'most uncontaminated lakes contain less than about 40 ($\mu g l^{-1}$) of total phosphorus in their surface waters.'

By this, and other standards set by authorities such as the Victorian Environment Protection Authority (EPA), the nutrient concentrations recorded in Forrestdale Lake are excessively high and unacceptable. No standards have been set in Western Australia for wetlands.

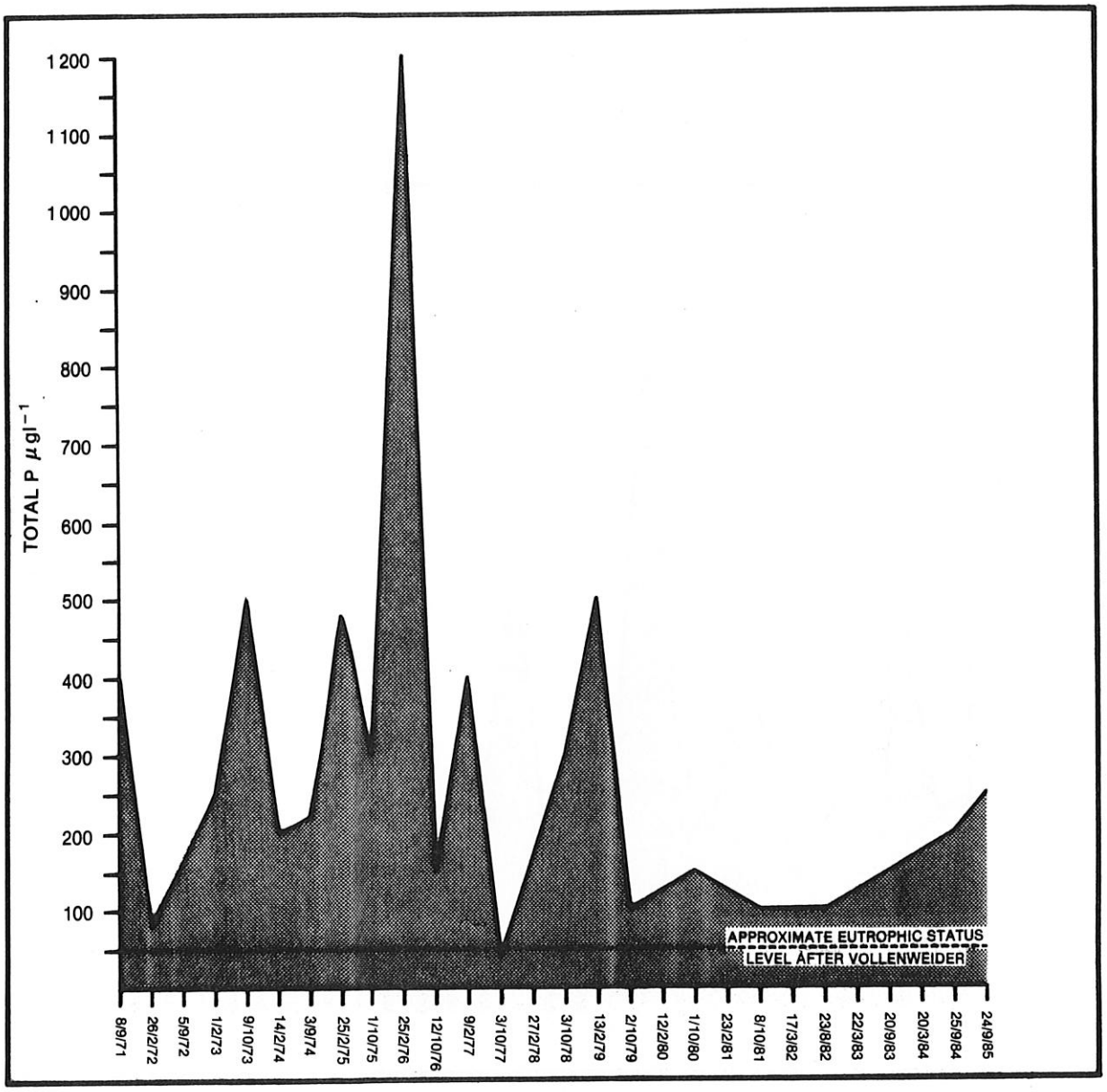

Figure 14. Total phosphorus (μgl^{-1}).

(Source: Water Authority of Western Australia, 1985.)

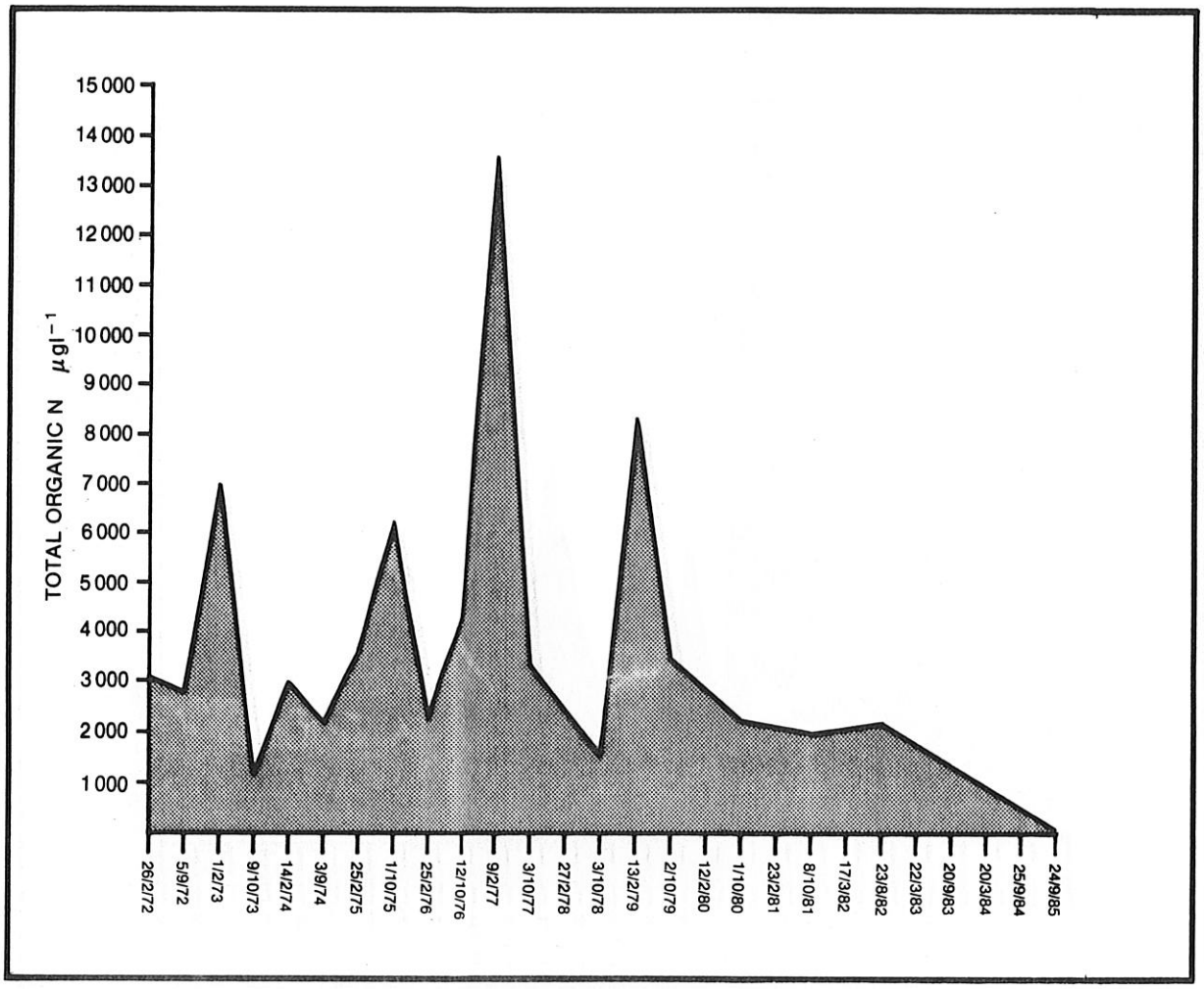

Figure 15. Organic Nitrogen (μgl^{-1}).

(Source: Water Authority of Western Australia, 1985.)

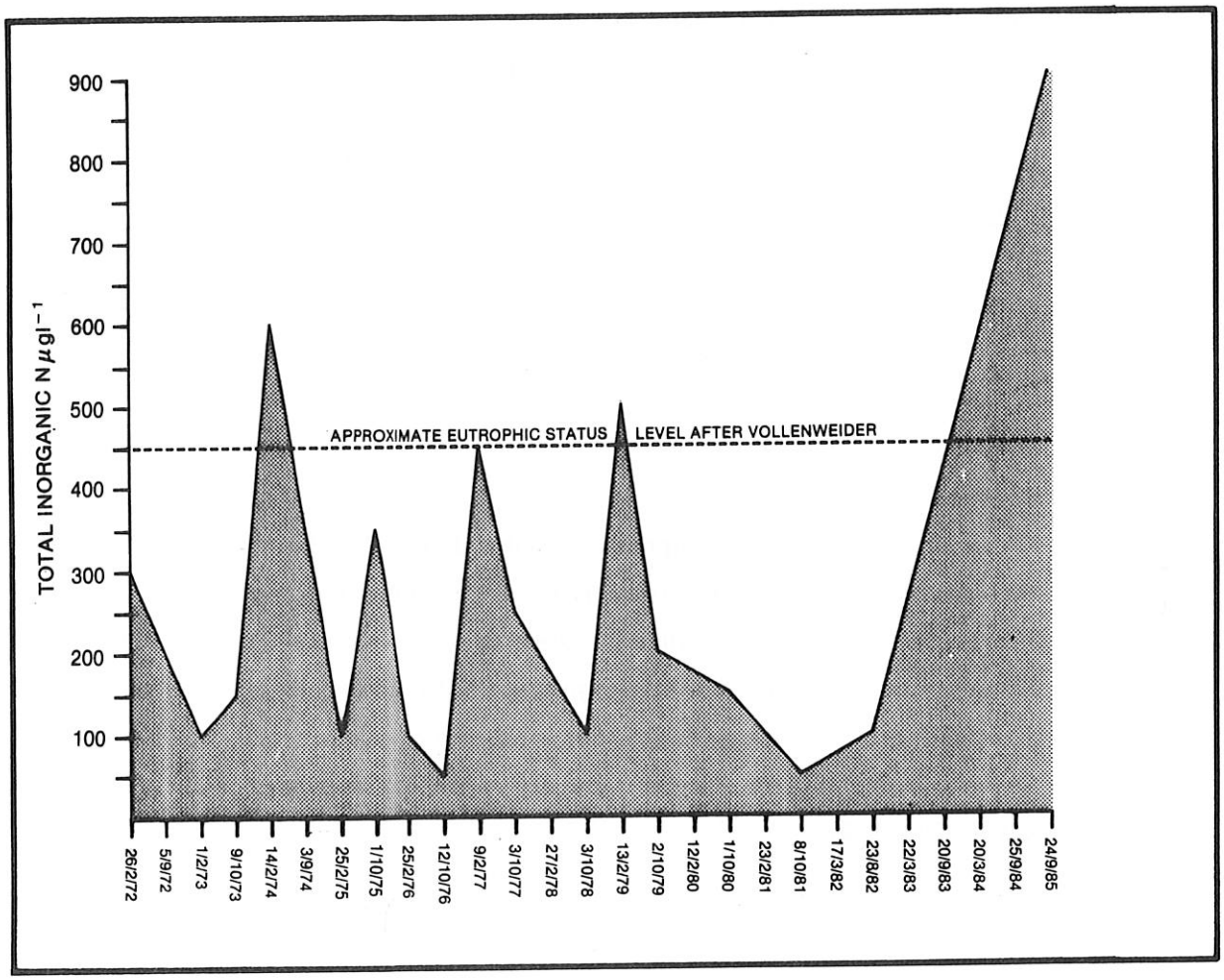

Figure 16. Inorganic nitrogen (μgl^{-1}).
(Source: Water Authority of Western Australia, 1985.)

The limits set by the Victorian EPA for 'the protection of aquatic ecosystems' were, in 1985, less than 50 μgl^{-1} for total phosphorus and less than 500 μgl^{-1} for total nitrogen.

The extensive growth of Typha and blooms of blue-green algae strongly suggest that the system is nutrient enriched. The problems associated with these blooms are discussed in Section 5.5.4 Blue-green Algae.

The large bird population currently using the lake, show the benefits that can accrue from an enriched and hence a highly productive system. In the absence of local data, water quality standards, cannot be set.

5.5.2 Nutrient Sources

Nutrients entering the lake are likely to come from the following sources:

i. Agricultural Land-use

The surrounding area supports hobby farms, a dog kennel, at least two piggeries and a poultry farm. Fertiliser practice is unknown. The Bassendean Sands, which underlie most of the Forrestdale area, have been shown to be very susceptible to leaching of phosphorus from super phosphate applications (Hodgkin et al. 1980). Once leached, phosphorus moves readily into groundwater and could thus enter the lake.

ii. Urban Septic Tank Leachate

Studies have shown that septic tank leachate can contribute approximately 1 kg of phosphorus per person per year and 5.5 kg of nitrogen per person per year to the groundwater (Whelan et al. 1981). This is a potential source of nutrients for urban lakes. There are over 150 residences at Forrestdale serviced by septic tanks.

iii. Urban Run-Off

Urban stormwater run-off frequently contains elevated levels of phosphorus and nitrogen, the phosphorus emanating from detergents and the nigrogen largely from lawn fertilizers.

It is not known how much urban effluent from sources other than septic tanks enters the lake, however, from inspection, it appears that at least half of the residences on the north-eastern side may drain to the lake.

Atkins and Hosja (pers. comm., 1985) estimated that the average loading in urban run-off per person, from four areas surrounding the Swan and Canning Rivers, was 0.019 kg phosphorus per year and 0.34 kg nitrogen per year.

At an occupancy rate around 2-3 persons per house in over 150 houses in the immediate area adjacent to the reserve, this would mean an annual phosphorus contribution of 5-7 kg and a nitrogen contribution of 90-130 kg. These are significant levels of nutrients.

iv. Application of Insecticide

Each year the lake is sprayed two or three times with an organo-phosphorus insecticide (Abate) to control midge numbers. It is estimated that each application contains approximately 1 kg of phosphorus which is available for plant growth.

Nutrients are also made available, within a given system, through recycling. The mechanisms by which phosphorus and nitrogen are recycled are given in Figure 17.

5.5.3 Sediments

Sediments can be a major sink for phosphorus (Sloey et al. 1978 and Donlan et al. 1981 in Chambers 1984).

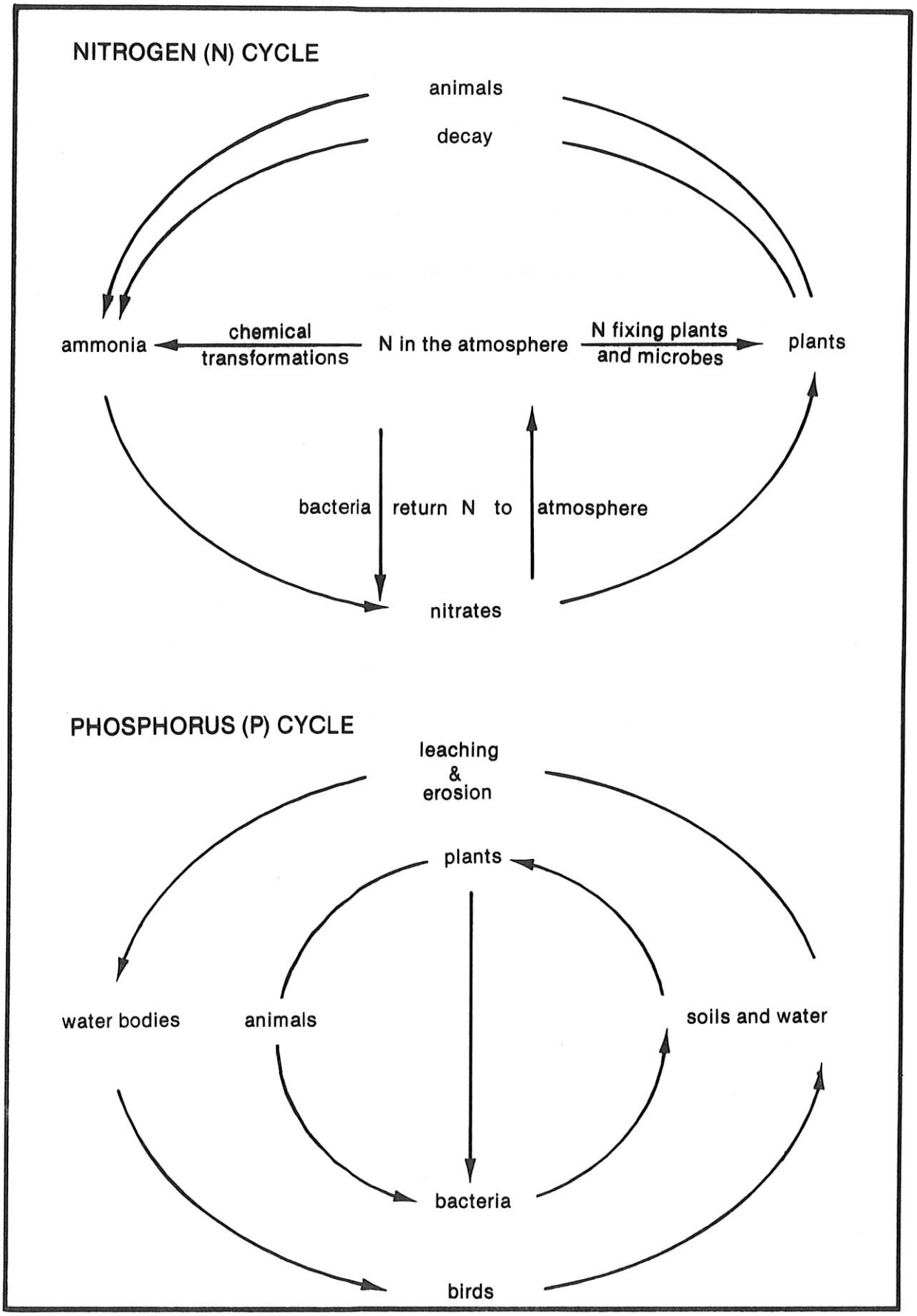

Figure 17. Nitrogen and phosphorus cycles.
(Source: Department of Conservation and Land Management, 1985.)

With reference to the Peel-Harvey estuarine system, Gabrielson (1981) noted that:

> 'Sediments are capable of acting as a buffer to the system, particularly with respect to phosphorus (Pomeroy et al. 1965; Stirling and Wormwalk 1977). If changes are made to the system, e.g. the removal of biomass, the sediments may respond by becoming a net source of phosphorus rather than a sink.'

It is not known what role the sediments in Forrestdale Lake play, but with such high phosphorous levels in the water, it could be significant.

5.5.4 Blue-green Algae

Under ideal conditions (i.e. a good supply of phosphorus, warm water and high light intensity) explosive growth or blooms of blue-green algae can occur in lakes. Several species of blue-green algae are toxic and can adversely affect humans, waterfowl and livestock (Aplin 1967).

Blue-green algae are not normally visible to the naked eye, however, under favourable conditions when a bloom occurs, the water becomes discoloured and there may be a strong pesticide-like odour (Algae Odour Control Working Group 1975). When the algae senesces, unpleasant sulphurous odours can be produced and oxygen depleted. The latter occurrence can have a catastrophic effect on the benthic biota. Furthermore, some blue-green algae 'fix' nitrogen, that is, convert atmospheric nitrogen into organic nitrogen compounds, which dramatically increases the nitrogen levels within a lake system.

5.5.5 Botulism

Botulism is a bacterial poisoning caused by a toxin produced by the bacterium Clostridium botulinum. There are three types of botulism, only one of these, type C, affects birds. The bacterial cells of type C botulism can form a highly resistant spore which may remain dormant for years. Once conditions are favourable the spores germinate and multiply. Ingestion of these spores by birds can result in paralysis or death.

Botulism is considered to be a warm weather disease. It has been found to occur when water temperatures are around 28°C, when there is sufficient organic matter to satisfy its food requirements. Botulism is not believed to be pathogenic to humans (Department of Fisheries and Wildlife n.d.).

During February 1974 Forrestdale Lake was slightly affected by botulism. Nine birds died and another twelve were treated and subsequently released. No other outbreaks have been recorded.

5.6 Implications for Management

1. Artifical drains in the area have significantly altered the hydro-regime. Any alterations to this system of drains flowing into the Lake required the joint decision and responsibility of the Department of Conservation and Land Management and the Water Authority of Western Australia.

2. The overflow drain to the east lies 2.14 m above the base of the lake which is therefore the maximum depth the water can currently reach.

3. Water levels are controlled by a number of factors including climatic conditions, groundwater extraction and drainage. Land-use practices on the surrounding landscape limit options for artifical control.

4. The Water Authority review of the Jandakot Water Supply Scheme will contribute to a better understanding of the Scheme's effects on lake levels. Any decision to change the amount of groundwater extracted is the responsibility of the Water Authority of Western Australia and is likely to depend on public demand for groundwater.

5. If the lake is to continue as a refuge for waterbirds, it is essential that it receives a reliable supply of water. Minimum levels have been set (Part B. Section 2.0 Water Levels).

6. Nutrient levels in the lake need to be maintained within a range that will ensure no adverse affects on the waterbirds. Investigations are required to determine these optimum levels.

7. The role of bulrushes in nutrient cycling in the lake is not understood, thus investigations are necessary before large scale removal of the bulrushes is undertaken.

8. Given the existing low water levels, if the spread of bulrushes is to be prevented, then the on-going costs of Typha control must be accepted (see 10.4 Bulrushes).

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6.0 SOILS AND VEGETATION

6.1 Soils

The lake bed is dominated by peats and clays, while the surrounding dunes are composed of leached grey-white siliceous sands (Fig. 18).

6.2 Vegetation

There are four dominant vegetation associations on the Reserve. These are, moving from higher to lower in the landscape - banksia woodland, acacia thickets, paperbark forest and bulrush stands on the lake margins (Fig. 18).

A total of eight associations have been recognised (Fig. 19) and these are described below:

1. Firewood (Banksia menziesii) and slender banksia (B. attenuata) LOW WOODLAND A to LOW FOREST B, 5 to 15 m in height, with emergent christmas trees (Nuytsia floribunda) over OPEN LOW SCRUB A/B understorey composed of zamias (Macrozamia reidlei), pineapple bush (Dasypogon bromeliifolius), Jacksonia furcellata, J. sternbergiana, woolly bush (Adenanthos cygnorum) and summer fringe-myrtle (Calytrix angulata). DENSE HERBS including Stylidium repens, blowfly grass (Briza maxima), Loxocarya fasciculata and L. pubescens, occur throughout the understorey.

2. Firewood and swamp banksia (B. littoralis) LOW OPEN WOODLAND B to 5 m in height, over LOW OPEN SCRUB B to 1.5 m in height, composed of zamias, blackboys (Xanthorrhoea preissii) and prickly moses (Acacia pulchella). This association includes: a dense to open storey of LOW GRASSES, including blowfly grass and veldt grass, (Ehrarta longiflora); HERBS, including Arnocrinum preissii and golden conostylis (Conostylis aurea); and OPEN LOW SEDGES, particularly the large flowered bog rush (Schoenus grandiflorus). This degraded association is confined mainly to the deep grey sands of the Bassendean dunes, on the eastern edge of the lake.

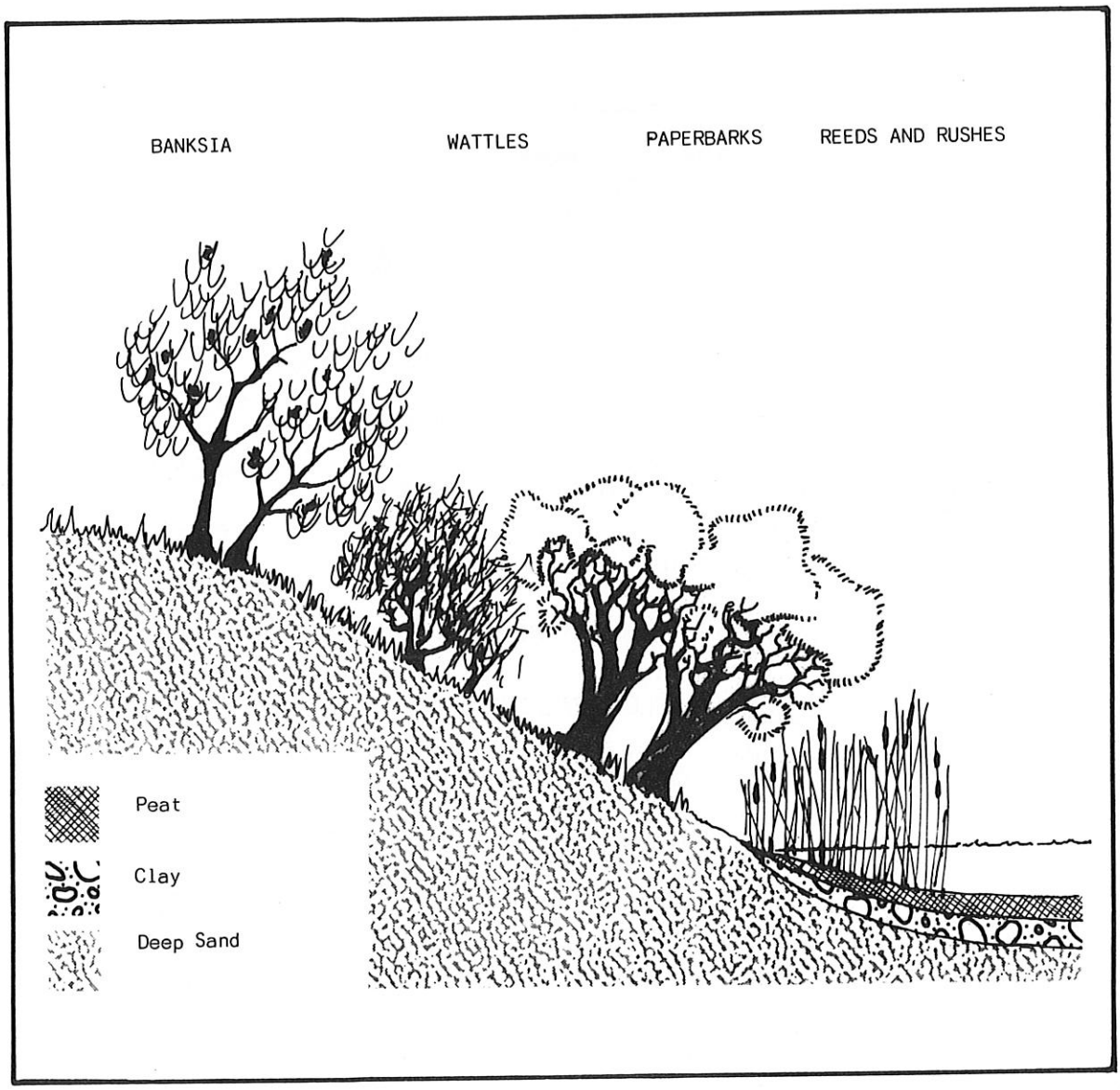

Figure 18. Vegetation and Soil profile. (Source: Department of Conservation and Land Management, 1985.)

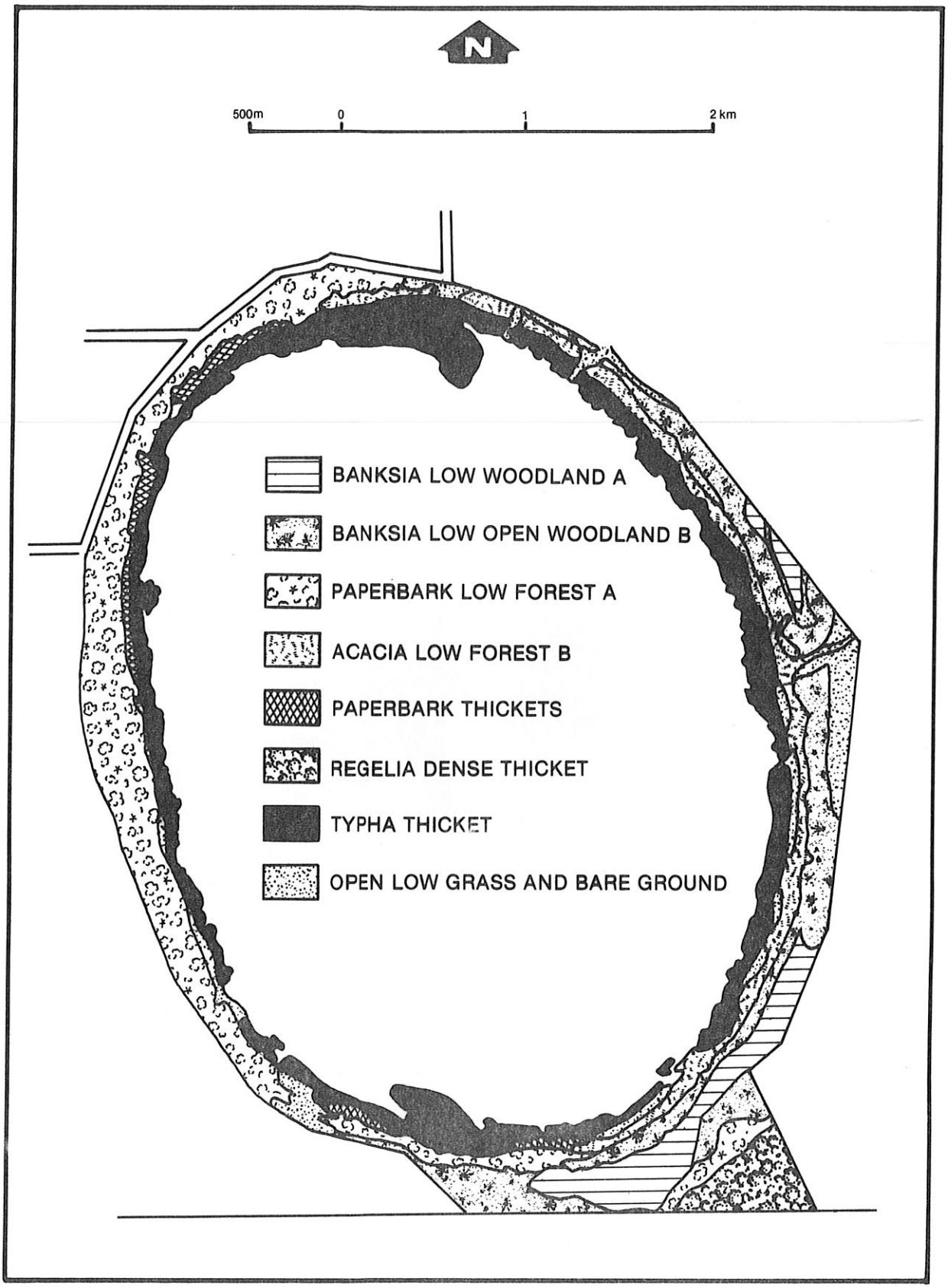

Figure 19. Vegetation associations. (Source: Department of Conservation and Land Management, 1985.)

3. Paperbark (Melaleuca rhaphiophylla and M. preissiana) LOW FOREST A, 5-15 m in height, with emergent golden wreath wattles (Acacia saligna), flooded gums (Eucalyptus rudis) and grey honey myrtles (Melaleuca incana). Flooded (swamp) gums occur primarily on the western and south-eastern edge of this association. The understorey of LOW SCRUB A, 1 to 2 m in height, is composed of woolly bush and Jacksonia sp. with OPEN DWARF SCRUB C of golden conostylis, Dasypogon sp., wattles and blackboys. The remaining groundcover consists of weed species. Most of the weed species found on the Reserve occur in this vegetation type. A thick and expanding infestation of arum lillies dominates much of the understorey on the western boundary of the lake. Patches of pampas grass (Cortaderia selloana) are scattered throughout. Since the removal of a tall stand of flooded gums on the boundary of Commercial Road to the north-west in October 1985, there has been a major increase in weed species in the paperbark woodland. Figs (Ficus sp.) now dominate the middle storey in a narrow band on the western boundary of the Reserve adjacent to Commercial Road.

   Scattered patches of petty spurge (Euphorbia terracina) and inkweed (Phytolacca octandra) occur along the western edge of the paperbark association and a few castor-oil plants (Ricinus communis), are present on the northern boundary. Other introduced species have also been recorded within this association.

4. LOW FOREST B, less than 5 m in height, composed of wattles, paperbarks, sheoaks (Allocasuarina fraseriana) and christmas trees. Very OPEN LOW GRASS understorey of introduced species.

5. Paperbark THICKETS, to 3.0 m in height, consist almost exclusively of the one species. This association appears to have emerged after fire or as part of a succession process. Little understorey exists.

6. DENSE THICKET of Regelia ciliata to 2 m in height, with emergent Banksia species and christmas trees occurs over HEATH B, 1.0 to 1.5 m in height of Verticordia densiflora, Hakea varia, Calothamnus sp., Hypocalymma sp. and Acacia sp. over LOW GRASSES,

HERBS, and LOW SEDGES (including Lepidosperma longitudinale and Lyginea tenax).

7. Typha THICKETS, to 2.5 m in height.

8. OPEN GRASSLANDS AND 'bare ground'. Includes all tracks and areas so heavily degraded that trees and the lower strata have been removed or destroyed. These bare areas are the result of grazing, fire, horses and vehicular use; the most vulnerable areas being the dune ridges. In this association the groundcover consists of veldt grass, wild oats, cape weed, thistles and other weed species with occasional native species.

Appendix 2 contains a comprehensive plant list for Forrestdale Lake Nature Reserve.

6.3 Aquatic Vegetation

The algae present in Forrestdale Lake have been described by Van Alphen (1983). Appendix 3 lists the species. During a study of the invertebrates in the lake in 1985, a dense mat of submerged vegetation was noted over most of the lake bed. It was dominated by the algal species Chara and the aquatic flowering plant Ruppia polycarpa.

6.4 Bulrushes (Typha)

6.4.1 General

Bulrushes (Typha sp.) are tall reeds growing in stands around the margins of the lake. Typha is the only genus in the family Typhaceace. This genus contains approximately 20 species, two of which occur in the south-west of Western Australia. These are T. domingensis and T. orientalis, both of which are commonly known as bulrush, cumbungi or yangets.

T. domingensis is endemic to the south-west, however the origins of T. orientalis are uncertain. Several botanists suggest that this species was introduced to Western Australia around the time of European settlement (N. Marchant, pers. comm., in Watkins and McNee 1985).

T. orientalis has successfully colonized and spread at Forrestdale Lake. In only 7 years it has spread from a small patch on the southern perimeter to surround the lake (Fig.s 20 to 22). In summer, as the lake dries, the Typha dries and becomes a fire hazard. The bulrush, however, plays a useful role as a nesting site for waterfowl and possibly as a mechanism in water quality control (See Part B Section 3).

The rapid colonization of the Typha at Forrestdale Lake and concern that its spread could reduce waterbird habitat and adversely affect fringing vegetation, prompted a study of the species and investigations into its control. Most of the information in the following section has been taken from the subsequent report produced by Watkins and McNee (1985).

6.4.2 Biology

T. orientalis is an aggressive colonizer of wetlands with a muddy substrate, especially following disturbance such as cultivation of the soil surface. It colonizes from seed and rhizome growth. Experiments have shown that high rates of germination occur at low water depths and that plants 4-6 cm high can tolerate flooding with clear water to a depth of about 50 cm (Weller 1975). The maximum depth tolerated by mature plants varies but 2 m has been reported (Finlayson et al. 1983). Less than 30 cm is optimal.

Typha plants produce a large number of seeds. Prunster (1941) estimated that T. orientalis produces 336 000 seeds per flower and estimates of its fertility success rate range from 67% (Prunster 1941) to 95% (Wilson 1977). According to Prunster, a one-metre square of mature T. orientalis can produce six million fertile seeds. These seeds are very light and easily transported by wind.

6.4.3 History of Spread

Typha did not appear around the margins of Forrestdale Lake until 1968 despite indications that the bulrush grew in low-lying areas just to the west as early as the 1950s.

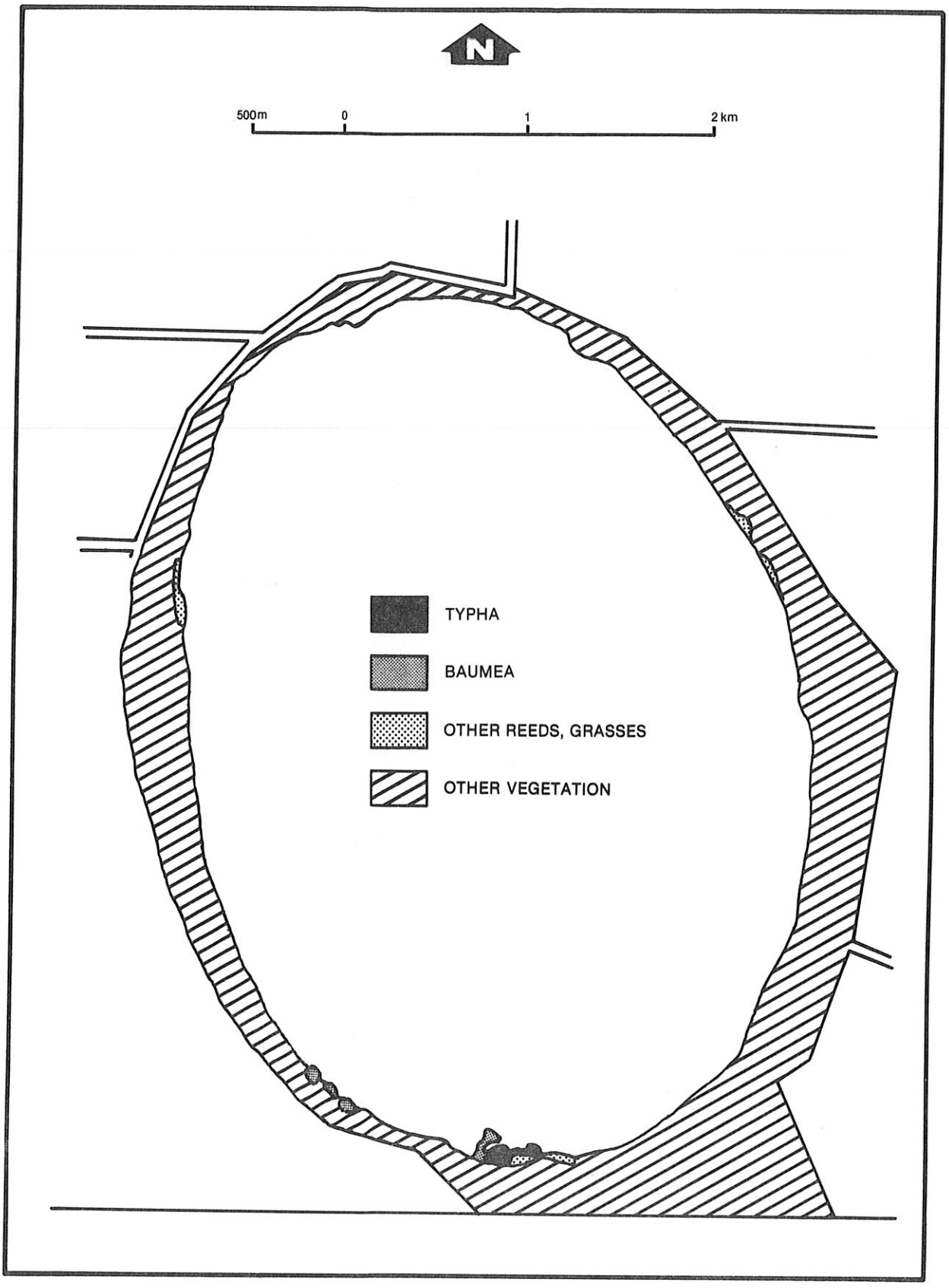

Figure 20. Vegetation of Forrestdale Lake - 1976. (Source: Watkins and McNee, 1985.)

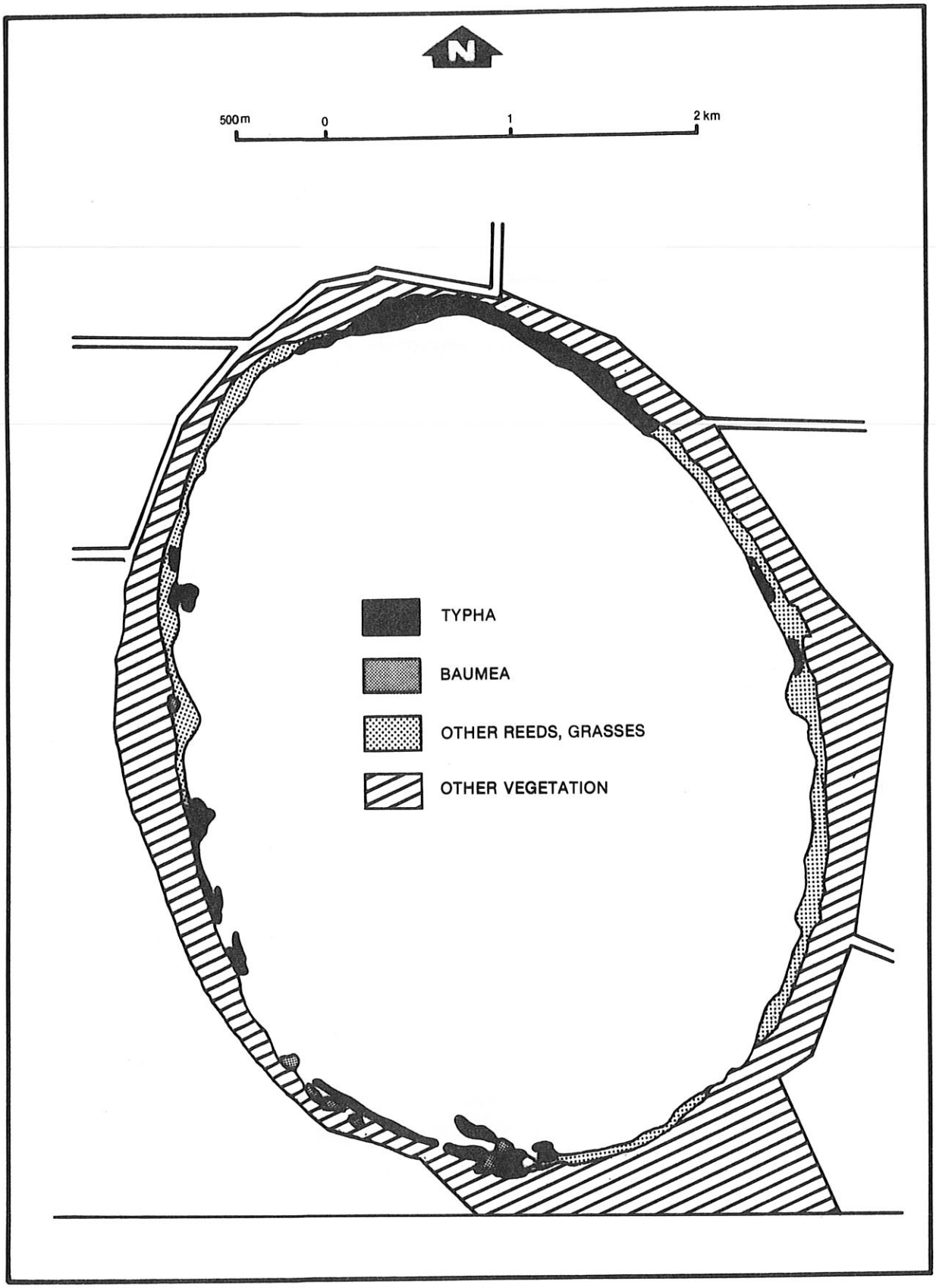

Figure 21. Vegetation of Forrestdale Lake - 1980. (Source: Watkins and McNee, 1985.)

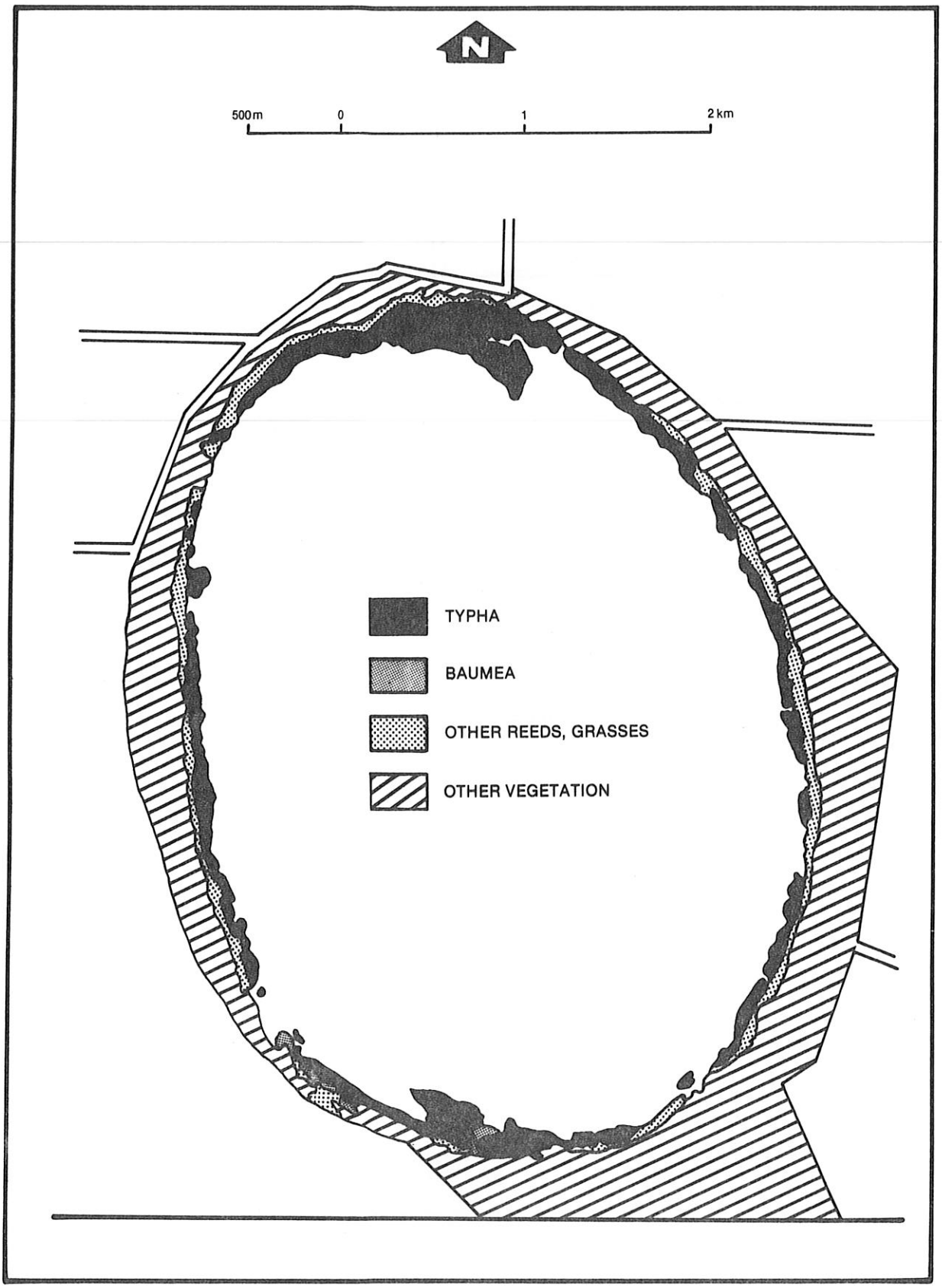

Figure 22. Vegetation of Forrestdale Lake - 1984. (Source: Watkins and McNee, 1985.)

Prior to invasion by Typha the lake's edge was dominated by a species of fine reed (probably Juncus sp.) and a few small patches of Baumea articulata (D. James, pers. comm., 1985, Skeet family photographs, History House, Armadale in Watkins & McNee 1985). Baumea grows in a thin belt on the inner edge of the paperbark stands to the west and Scirpus grows where Typha is absent.

From 1968 to 1978 growth of the bulrush was relatively slow, however during the following four years the Typha stands expanded dramatically (Fig.s 20 to 22). A large stand established at the northern end of the lake and later smaller stands developed on the western and eastern edges. Figure 22 shows the extent of the Typha in 1985.

6.5 Dieback

Dieback is the common name given to the disease caused by the microscopic soil-borne fungus Phytophthora cinnamomi (the cinnamon fungus). The fungus produces small mobile spores that are spread in water, and large spores that will survive in soil and plant material. The spores infect plant roots and as the fungus establishes, it rots the roots. Some plants, including banksias die rapidly after infection, but trees such as jarrah often die gradually, hence the common name for the disease - 'dieback'.

Management must aim to prevent the introduction of the fungus into uninfected areas and minimize spread in infected areas, as once the fungus is introduced it cannot be removed.

Vehicles play a major role in the spread of the fungus and management, therefore, must either exclude vehicles, or where access is essential, ensure that vehicles are thoroughly cleaned down before moving from an infected to an uninfected area.

An officer from the Department of Conservation and Land Management has carried out a survey for dieback on Forrestdale Lake Nature Reserve. Results indicate that the south-east area of the Reserve is dieback affected, however, the extent of the area affected will not be known until a more extensive survey is carried out.

6.6 Implications for management

1. The degraded state of the vegetation is a result of trampling, vehicle use, frequent burning and rubbish dumping (which contributes to weed invasion). There is a need to restrict vehicle movement onto the Reserve.

2. The sand ridges are highly susceptible to erosion because of damaged vegetation. Control of ad hoc movement throughout the Reserve by horses and vehicles is therefore necessary.

3. Unchecked growth and expansion of Typha is likely to reduce the waterbird habitat and native flora species habitat. Control of the spread of Typha is essential.

4. Total exclusion of Typha will not be possible as seed stores exist close to the lake, nor would it be desirable as Typha provides shelter and nesting habitat for some birds and its removal could adversely affect the water quality status.

5. Dry Typha stands pose a fire risk to adjoining land owners and to reserve vegetation. Measures are necessary to control fires in the Typha.

6. Typha colonises rapidly in shallow water. Therefore (given the low level of the lake), if colonisation of the lake bed by the bulrush is to be prevented, the cost of continuing control work must be accepted.

7. Precautions are necessary to minimise the spread of dieback to uninfected areas.

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7.0 FAUNA

7.1 Waterbirds

Forrestdale Lake is an important habitat for local and migratory bird species, some of which are transequatorial migrants that are subject to international treaties. Several waterbird surveys have been carried out at the lake. The most comprehensive was part of the South-west Waterbird Project completed by the RAOU in 1985. The project began in 1981 and results of 97 surveys have been compiled (Appendix 4).

A small peak in numbers of individuals using the lake occurs in early winter due to the persistence of shallow mud-flats as the lake slowly fills. In summer, bird numbers reach their maximum as occurred in January 1983 when 17,484 birds were recorded on one day - the largest number recorded in any one survey. The summer peak is attributed to the influx of waterbirds from drying wetlands in the surrounding district (RAOU 1986).

Colour-marking of waders has confirmed that birds move between feeding areas at Forrestdale and the Swan Estuary. Movement between Forrestdale and Thompsons Lake is also likely as drying of these respective sites often occurs weeks apart and comparisons of species and numbers show many similarities.

A total of 63 species have been identified, 19 of which breed at the lake and 14 of which breed outside Australia.

A few species, noted in March 1957 by K.G. Buller, from the Western Australian Museum, were not recorded during the period (1981-1984) of the RAOU surveys. These included the Royal Black-billed Spoonbill (Platalea regia), the Australasian (Brown) Bittern (Botaurus poiciloptilus) and the Whimbrel (Numenius phaeopus). Both the Royal Spoonbill and the Whimbrel (a migratory species) are rarely seen in the south-west, while the Australasian Bittern appears to be nomadic, sometimes disappearing from a site (Blakers et al. 1984). At the time of the RAOU survey the Marsh (Swamp) Harrier, was breeding at the Reserve. Within Western Australia, this bird normally breeds only around the southern tip (Blakers et al. 1984).

Studies by the RAOU (1985) have shown that South-western Australia is the strong-hold for the Long-toed Stint in Australia and that Forrestdale Lake is the most important reserve for this species. During the summer of 1980-81, prior to the commencement of the study, at least 80 of these birds were seen at the lake. This is the greatest number counted at any one site in Australia, however, counts at Forrestdale decreased with each year of the study raising fears that Long-toed Stints are affected by disturbance or deterioration of the lake, or the world population is declining.

Of the areas surveyed by the RAOU during the course of the study, Forrestdale Lake supports the greatest numbers of Pacific Black Duck, Australasian Shoveler and Clamorous Reed-warbler. It is also the only reserve to be utilised by the Little Ringed Plover for more than one summer.

Only two other reserves surveyed by the RAOU had greater counts of the Glossy and Straw-necked Ibis, Black-winged Stilt, Wood Sandpiper, Red-necked Stint and Curlew Sandpiper. Counts of more than 1000 Hardheads were made and Forrestdale Lake is the most important coastal reserve for Pink-eared Ducks..

Based on maximum counts, the lake rates second in the south-west for the Pacific Heron, Red-capped Plover and Black-tailed Godwit. The Pacific Heron and Godwit feed on organisms in the shallows while the plover prefers to feed on the exposed bed of the lake.

Most waterbirds using the area feed in or on the edges of the water, although some species such as the Black Swan and Australian Shelduck also graze pastures and crops. Black Ducks, Grey Teal and Shovelers secure most of their food by stripping seed from emergent plants but also dabble in shallow water and mud for animals. The Pink-eared Duck, entirely a surface feeder, filters the surface water for small items. The Blue-billed Duck and the Musk Duck dive for their food (Frith 1977). Shallow water is particularly important for wading species such as the Long-toed Stint which inhabits the drying margins of shallow freshwater lakes, characteristically on mud margins, where it probes for insects.

Foods for waterbirds include: aquatic and dry-land plants; aquatic animals, such as frogs; snails; insects and their larvae (Frith 1977; Blakers et al. 1984).

The reeds, paperbarks and hollow trees provide shelter and nesting places for many of the waterbirds including: the Australian Shelduck; the Pink-eared Duck, one of the rarer birds of the south-west until 1952 (Serventy and Whittell 1976); and Baillon's Crake. In Western Australia, this latter species had only been recorded breeding on the south coast in The Atlas of Australian Birds (Blakers et al. 1984), but has now been recorded breeding at Forrestdale Lake.

As a breeding site, the RAOU has rated the Reserve as the most important (in terms of numbers) in the south-west, for the Purple Swamphen, Dusky Moorhen and Clamorous Reed-warbler. The Reserve also rates equal first with two other breeding sites for Hardheads.

Breeding of waterfowl is closely linked with rainfall (Frith 1977). In the study area, where rain fall predominantly in winter, breeding occurs mainly late in winter and spring. Baillon's Crake, Hardheads, Pink-eared Ducks and Swans, however, have been observed with eggs or young in summer, and the Red-capped Plover in autumn. Breeding generally occurs one to two months before the lake dries (RAOU 1985).

The breeding grounds of migratory birds extend through northern Europe, Siberia, Mongolia and north-west Asia, and as far north as the Palearctic (Blakers et al. 1984; Serventy and Whittell 1976). Birds such as the Long-toed Stint, first noted in 1886, remained a rare vagrant until the 1960s. Numbers increased after that time but more recently have begun to decline. Similarly, the little stint was not recorded in Australia until 1977. Increased recordings of these rare birds since 1960 may be largely a function of an increase in the number of observers.

Other vagrants at the Reserve include the freckled duck, observed in July 1982, and three summer visitors: the Grey Plover, the Lesser Golden Plover and the Broad-billed Sandpiper (species which usually inhabit tidal environments).

7.2 Terrestrial birds

The Reserve supports diverse and abundant terrestrial bird life. Surveys of these birds have been carried out by the RAOU as part of the Metropolitan Bird Project and by officers of the Wildlife Research Branch. All species recorded are listed in Appendix 4.

Based on a report provided by consulting biologist Dr. R.P. Hart and his paper 'Birds and mammals in the management of small bush reserves' (1983), the species composition largely reflects the poor state of vegetation and the proximity to urban areas.

Of the species present, most are well adapted to surburban areas and 'unnatural' sites. Species such as the Singing Honey-eater, Magpie, Port Lincoln Ringneck and the Red Wattlebird are common to suburban areas and are generally associated with suburban bushland or open spaces.

A small proportion of the species present do not normally enter the suburbs and are likely to be reduced or lost under pressure from fires, settlement extension or damage to vegetation. These include the Grey Shrike-thrush, Scarlet Robin and Golden Whistler.

On a broader scale the importance of small bush areas within a region should not be overlooked:

> 'Many species ... make regular north-south movements and small reserves may be important to these species as they pass through the urban area.'
> (Hart 1983).
> 'The presence of many bird species in the Perth metropolitan region is dependent on the continued availability of sufficient suitable habitats. Both nomadic and sedentary birds rely on the presence of good habitat for feeding, breeding and refuge. When sites are disturbed, either by man's activities or by natural events, birds utilizing the area are forced to find alternative habitats or perish.'
> (Briggs 1983).

7.3 Amphibians

Only two of the five families of Australian frogs are represented in Western Australia. Of the fourteen genera that occur in the state, six genera have been recorded at the Reserve. In all, seven species have been noted (Appendix 4). All were active at night.

The western bull frog (Litoria moorei) was the largest species recorded during the survey. This species was found mainly in the Typha and grasses along the edge of the lake, although two individuals were caught in banksia woodland and one in the Regelia swamp. The moaning frog (Heleioporus eyrei) and the tiny froglet Ranidella insignifera were also found in the banksia woodland and Regelia swamp.

The banjo frog (Limnodynastes dorsalis), a widespread species, was only found in the Regelia swamp but is expected to occur elsewhere on the Reserve.

Only one slender tree frog (Litoria adclaidensis) was seen during the survey. An adult was found on floating vegetation in a Typha stand.

All indigenous Western Australian frogs are protected under the Wildlife Conservation Regulations (1950).

7.4 Reptiles

Reptiles collected on the Reserve include: one species of tortoise, gecko, and goanna; two species of legless-lizards; five species of skinks and four species of snakes (Appendix 4).

One species, the lined skink (Lerista lineata), was placed on Western Australia's, 'rare, or otherwise in need of special protection' fauna list in 1978 but has since been found in reasonable numbers between the Swan and Serpentine River systems. The skink is confined to areas of banksia woodland on the coastal plain and is one of a group of burrowing skinks (A. Williams, pers. comm., 1985).

In contrast, Cryptoblepharus plagiocephalus is a common and widespread skink. During the survey, this species was found inhabiting the banksia and paperbark woodlands. It is a largely tree-dwelling skink active during the day, particularly during warm weather.

Menitia greyii is also a common and widespread skink active during the day. This species, although found only in the banksia woodland, is likely to occur throughout the Reserve. Another skink found in the banksia woodland was the common bobtail (Tiliqua rugosa).

Less common were the legless-lizards - Burton's snake-lizard (Lialis burtonis) and Delma greyii. The latter species, was collected in the dense Regelia association, although east of the Reserve it is often found under blackboy litter (B. Maryan, pers. comm., 1985).

Gould's goanna or sand monitor (Varanus gouldii) is reasonably common on the Reserve it appears to flourish at the interface between urban and bush areas. From local reports the tiger snake (Notechis scutatus) and dugite (Pseudonaja affinis) are also common on the Reserve although few were sighted during the survey.

7.5 Mammals

In 1961 a Fauna Protection Officer observed two western grey kangaroos and two western brush wallabies and reported that moderate numbers of these marsupials inhabited the Reserve as indicated by their tracks and scats. None have been recorded since.

Only the house mouse was collected during the survey although evidence indicates the presence of the white-striped mastiff bat (Appendix 4). Local residents have also reported seeing the remains of a number of bandicoots, possibly the short-nosed bandicoot. This species is known to occur within the region.

7.6 Introduced animals

The mammal fauna of the Reserve is dominated by mice, foxes, cats, dogs and rabbits.

There is little chance of eradicating these introduced animals from the Reserve unless it is done as part of a regional control program.

7.7 Midges

Forrestdale Lake supports a variety of invertebrate animals which are an important food source for both waterfowl and amphibians. One of the most common invertebrates is a species of midge from the family chironomidae, Polypedilum nubifer a non-biting insect which occurs naturally in wetlands of the Perth region. Other species which have been recorded in the area.

Occurrence

During spring and summer, large numbers of non-biting midges emerge at dusk and congregate in swarms. The insects are attracted to lights and also collect in sheltered areas such as under verandahs and vegetation, creating a nuisance to residents in the area. The nuisance at Forrestdale township is compounded by the summer south-westerly breezes which blow these weak fliers into the residential area.

Description

P. nubifer are small to medium-sized, dark-brown in colour and closely resemble mosquitoes. Their wings are cloudy in appearance with numerous spots. The insects have no mouth parts and therefore cannot bite.

Life cycle

The life cycle of chironomids includes distinct egg, larva, pupa and adult states. Under ideal conditions (i.e. water temperature 14° to 30°C) the cycle takes three to four weeks. The cycle can take up to eleven weeks in adverse conditions. The major part of the midges' life cycle is spent in the larval stage (Blair 1979).

Chironomids do not feed in the adult stage and live only two to three days during which time they mate. In the evening after the midges emerge from the water, the males swarm. Females fly into the swarm, mating occurs, and shortly after, the eggs are laid (Blair 1979).

The egg mass is attached at the water surface, to aquatic plants or debris, or onto wet soil at the shoreline. Within hours of this happening, the adult dies. In the case of P. nubifer, the larvae hatch, swim to the bottom and form tunnels in the mud (West 1985).

Breeding areas

The larvae of P. nubifer inhabit the surface layer of sediments but also thrive in surface water. Extensive surveys of areas where water has receded or recently dried up, indicate that the larvae of this species require only a small depth of water over the habitat to survive (West 1985).

Recent preliminary investigations (funded by the Department of Conservation and Land Management) of the lake's chironomid population, indicate that many of the midge larvae are utilising the free floating beds of aquatic vegetation rather than the muddy bottom of the lake (J. Davis, pers. comm., 1985). During these investigations a total of eight midge species has been identified.

Control measures

Some control of the midges has been achieved on many occasions over the past ten years by the use of the chemical Temephos, marketed as 'Abate 5SG'. This is applied aerially two or three times during spring and summer when conditions are ideal for midge reproduction. This chemical kills the larval stage and past applications have generally reduced the level of nuisance. Section 10. Past Management, discusses this management practice in more detail.

7.8 Implications for Management

1. Continued monitoring of waterbird use of the Lake is essential if the success of the management strategies advocated in this plan are to be determined.

2. The lake currently supports thousands of birds, some of which migrated there and others which breed there. They all have specific habitat requirements and need protection. Some changes in surrounding land-use practices and groundwater use are essential if their requirements are to be met in the long term.

3. Further degeneration of the Reserve vegetation could result in the disappearance of terrestrial species. Management strategies should aim to reduce this degeneration.

4. Midges occur naturally in wetlands of the Perth region. They are an important source of food for waterbirds and frogs. Therefore eradication is not ecologically desirable, although some control of their 'nuisance properties' may be necessary.

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8.0 FIRE

8.1 Fire History

The incidence of fire on the Reserve has been well recorded since 1980 by the local Fire Control Officer (R. Murphy), and by a local resident (D. James) since 1978. Fires prior to this time are poorly documented. Information about fires between 1961 and 1978 was obtained from reports submitted by Fauna Wardens following their investigations of reported fires. It is likely however, that many fires were not reported and have therefore not been recorded. There is no information regarding fires prior to 1961. Areas affected by fire are only approximate and in some cases reports of the extent and date of the fires conflict (Fig. 23).

There has been 13 fires recorded on the Reserve between February 1961 and January 1986. All fires have occurred as wildfires during the hot, dry summer period. There is no record of prescribed burning.

8.2 Environmental effects

All fires that have occurred since 1978 are believed to have been deliberately lit (R. Murphy, pers. comm., 1985) and it is likely that most of the fires prior to 1978 were also lit deliberately.

Too frequent wildfires on the Reserve have contributed substantially to degradation of vegetation and the establishment of exotic species, particularly grasses (Wycherley 1983). Fire opens up bush and facilitates access, which may have associated problems (e.g. rubbish dumping). In areas frequented by people, damage can occur by trampling.

Too frequent burning can prevent adequate regeneration of species and a loss of species may result (Connell 1978, Westman 1975 and Baird 1958, in Muir 1985). Some plant species are killed by fire. Most flora need time to recover and set seed after fire. Also, some plant species are killed by fire. Seedlings that germinate after a fire may not flower for a few years, and for some species a further year or so may be necessary to allow the seeds to develop and mature. Few seeds may be produced after the first flowering and some species may need to flower

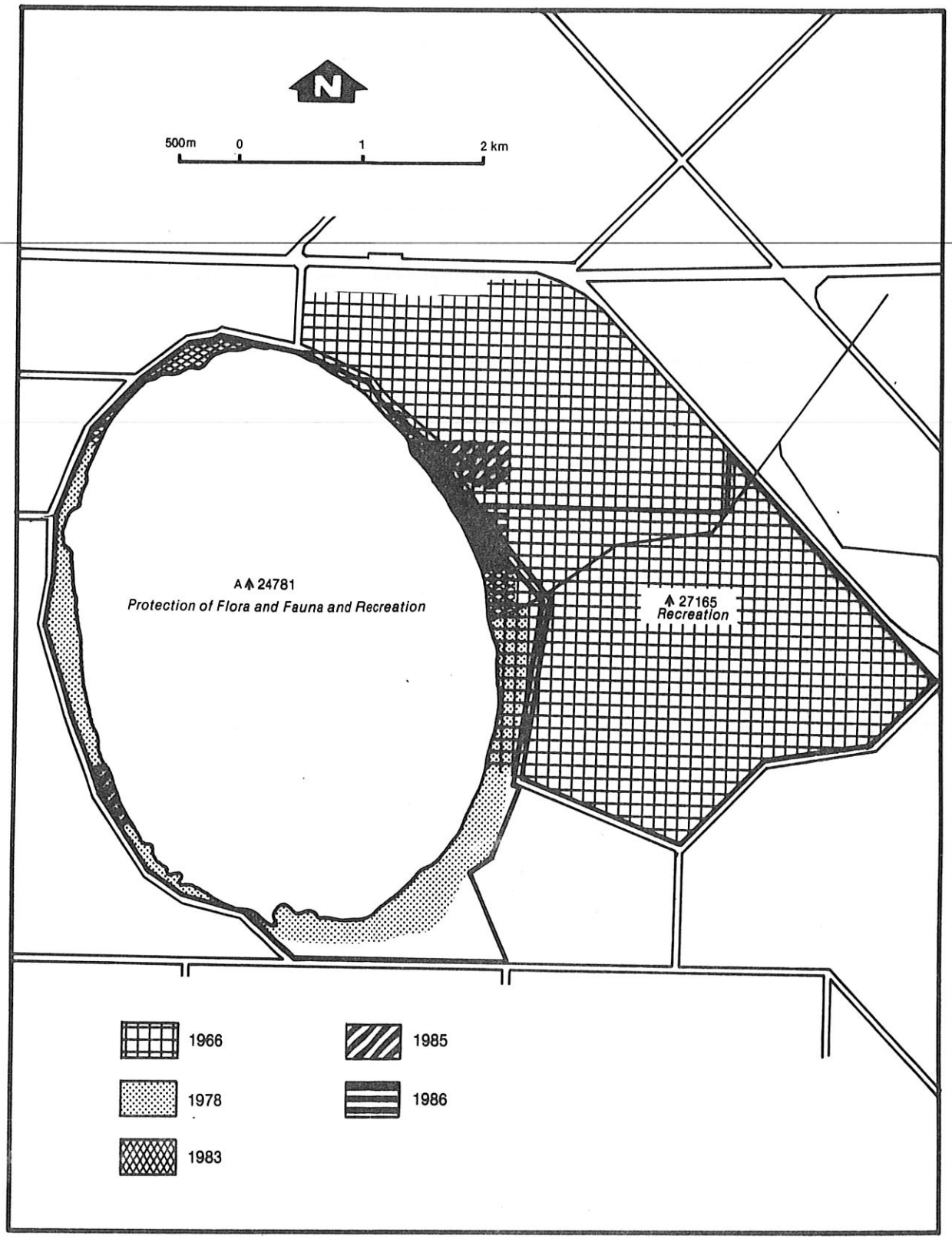

Figure 23. History of fires on and adjacent to the Reserve.
(Source: Department of Conservation and Land Management, 1985.)

over several years in order to set enough seed to guarantee future of the species survival (Muir 1985).

Muir (1985) has observed the time lapse between fire and the first flowering of a number of randomly selected species. For example, the golden wreath wattle, and slender and firewood banksias, common species on the Reserve, take between three and six years to flower after fire.

Plant species that survive fire (by having thick protective bark or rootstocks) are in less immediate danger of being eliminated by frequent fires. However, since the individual plants do not live forever, they need to be able to reproduce successfully for the species to survive in the long term. Frequent fires can kill their seedlings, which are less resistant to fire than the parent plants.

Frequent fires also favour weeds, which compete with the native plants. In the absence of fire for several years, the native plants, which continue to grow, increase their cover and drop litter, providing increased competition for the weeds. The degree to which they suppress the weeds varies according to the condition of the vegetation and the soil/vegetation type.

Research is currently in progress studying the effects of fire on small vertebrates such as reptiles, amphibians, small mammals and birds (Bamford 1985). While the research is centred on an area of banksia woodland around Gingin, where fires have been relatively infrequent, general conclusions may be relevant to the Forrestdale situation. Bamford found that generally, reptile species were not unduly affected by fire, and repopulated within a few years. The effect of fire upon bird numbers, however, was found to be more abrupt, possibly due to their greater mobility, with total numbers remaining low for some years following fire.

Small mammals seem to be most affected. Results of surveys at a site at Jandakot subject to frequent burning have indicated that the site had lost its native rodents and carnivorous marsupials, while numbers of the introduced house mouse had greatly increased. This area had been burnt at least every six years and while a fire-free period had allowed some

revegetation, Bamford and Dunlop (1983) suggest that fires had been too frequent for mammal recovery.

In the case of Forrestdale Lake Nature Reserve, it is likely that recurrent fires have contributed to the absence of native small mammals.

8.3 Implications for Managment

1. Too frequent fires on the Reserve are likely to have contributed to:

   a) the success of exotic floral species;
   b) stress on native flora;
   c) loss of native rodents and carnivorous marsupials and an increase in house mouse numbers; and
   d) destruction of some faunal habitat.

   A considerable reduction in fire frequency is advocated.

2. Frequent fires highlight the need for adequate fire protection measures.

3. Uncontrolled fire poses a threat to adjacent landholders. Precautions are essential.

4. Arsonists have been responsible for most, if not all, fires on the Reserve. They may be deterred through restricted access and vigilant neighbours.

5. It is likely that the spread of bulrushes (Typha) into the fringing vegetation is encouraged by fire. Precautions are necessary to reduce this risk.

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9.0 PAST USE

9.1 Public use

Public use of the Reserve has varied. The lake has been used for sailing, water-skiing and swimming while the surrounding land has been used for picnicking, walking, bird-watching, photography and camping. The Reserve was leased to the Jandakot Sailing and Aquatic Club following the declaration of the Reserve, but few events were held because of low water levels during the 1958 to 1962 dry seasons. An event was held in 1960 despite low water and problems with weed, but in 1964 the club was forced to close despite good rains in 1963 (The West Australian South Suburban Section 24 July 1964; Popham 1980). In 1967, permission for recreational use on a day-to-day basis was granted to the Playboy Water Ski Club. However continual objection by concerned parties eventually led to the withdrawal of this right by the Reserves Committee in 1975. The Reserve has also been used as a practice area for emergency helicopter landing.

Many activities that are not permitted on Nature Reserves have occurred over the years. Some of these are continuing. These include: removal of management signs, blackboys, zamias, wildflowers and trees; stripping of paperbark; dumping of vehicles and other rubbish; horse-riding; motor-bike riding; driving of 4WD vehicles and sandbuggies through the Reserve; grazing and herding of stock; bird trapping; kangaroo hunting; camping; and pumping of water from the lake for private use.

9.2 Implications for managmeent

1. There are no longer demands for water-based activities such as sailing and swimming as the lake is too shallow and sediments have accumulated on the floor of the lake. Recreation provisions in the purpose of the Reserve are no longer necessary.

2. Many activities reflect ignorance of the purpose and conservation value of the Reserve. An information program would alleviate this problem.

3. Some detrimental and 'illegal' activities are continuing. Steps are necessary to deter offenders.

4. Some activities which conflict with the purpose of the Reserve may have occurred as a result of the lack of boundary definition.

10.0 PAST MANAGEMENT

10.1 Firebreaks

Firebreaks on the western and southern boundaries of the Reserve have not been maintained. On the eastern boundary, vehicle access to the Reserve is possible via a track originating on private property to the north, which extends from Broome Street south to Oxley Road, through the Recreation Reserve. The clearing along the transmission line is regularly maintained. Within the Reserve, vehicle access along existing tracks is limited and where tracks exist as bridle trails, access is not possible.

10.2 Weeds

Some work has been undertaken to control pampas grass (abundant along the south-western and southern edges of the Lake), and arum lilies (prolific along the western boundary). Further trials are underway, using a non-residual, non-specific herbicide, and employing techniques which will not adversely affect the conservation values of the area.

No work to remove other exotic species, such as veldt grass, has been carried out.

10.3 Midges

Midges, or the flying adult stage of the chironomid, Polypedilum nubifer, have been the subject of local resident complaints for many years at Forrestdale. On 19 November 1975, the Armadale Town Council (now the City of Armadale) began aerial spraying of the lake to control the number of midge larvae. Since that time, the lake has been sprayed two or three times a year during spring and summer.

In all cases, Abate 5SG was used. This is a granulated organo-phosphate chemical which is also marketed as Temephos. The chemical contains phosphorus, an essential plant nutrient.

Laboratory studies indicate that, when used as recommended, Abate is a relatively specific toxicant showing low toxicity towards mammals, birds and fish. However, the laboratory studies had obvious shortcomings as no assessment was made of either the residual effects of the chemical, or the subtle affects on wildlife that might occur in field conditions.

Application of Abate has, until recently, been carried out in response to of residents' complaints. Spraying has occurred as early as September and in most cases, has been successful in reducing midge numbers, however, in February 1984, 240 wading birds (including Long-toed Stints) died as a result of spraying when water levels were very low, and during the summer of 1984/85, spraying of the larvae proved ineffective.

These problems indicate an obvious need for detailed information on the effect of the chemical on the wetland and on possible alternative forms of midge-control. As a result, in 1985, a specialist consultant was engaged to undertake studies of the invertebrate fauna of the lake, the midge fauna in particular.

The lake was sampled fortnightly, until the lake dried in January 1986. Results of each fortnight's results were passed on to the City of Armadale to assist Council Officers in planning treatments.

Since the 1984 incident, the Council has been required to obtain specific approval from the Department of Conservation and Land Management for each proposed treatment. Various safeguards have been adopted to minimise the risk of further injury to birdlife which include: no spraying at low water levels (below 0.3m); before-and-after checks of waterbird populations by Department of Conservation and Land Management staff; and, monitoring of weather conditions on the day of the spraying.

10.4 Bulrushes (Typha)

In 1984 a consultant was employed by the Department of Fisheries and Wildlife to evaluate the existing bulrush situation and undertake experimental control of the Typha, after concern was expressed about changes that could occur if Typha continued to expand.

A number of mechanical and chemical controls were considered and several mechanical control measures tested.

The first involved the use of a drag to uproot seedlings from the dry lake bed. Some difficulty was experienced because of water just below the surface when the lake was dry, although this method was reasonably successful. The work was carried out just prior to the wet season and seedlings that did establish were quickly inundated and killed. This method, however, is only useful for the removal of seedlings. Removal of mature plants was found to be more difficult.

The second measure involved cutting the mature Typha, above and below the water, both by hand and with a 'brush-cutter'. Vigorous growth occurred after cutting above the water, however, cutting underwater proved very successful. The latter technique starved the Typha of oxygen, leading to anaerobic respiration and consequent death of the plants. This method is extremely labour intensive and time consuming, and for any large scale operations, removal of the cut Typha will require additional time and resources. (Leaving the cut Typha in the water is not a desirable option as it may to contribute to nutrient enrichment).

Investigation of control methods is continuing in order to establish appropriate management strategies.

10.5 Moore Street 'Clearing'

The cleared area at the end of Moore Street was the original site of the yacht club. Playground equipment still exists but is currently in a state of neglect. The area is mown from time to time by local residents and by officers of the City of Armadale.

10.6 Signs

'Forrestdale Lake Nature Reserve' signs conforming to the standard for nature reserves for the Department of Conservation and Land Management, are located at the end of Moore Street, Weld Street and Swamp Road, and are maintained by the Department of Conservation and Land Management. The signs standard prescribes wooden routed signs, with primrose yellow lettering on a pine-log green background.

10.7 Rubbish

Rubbish dumped on the Reserve has been removed by management staff and volunteers.

10.8 Regulation enforcement

Wildlife Officers have made investigations following reports of illegal activities on the Reserve, however, there have been few apprehensions. The Reserve has also been regularly inspected by Wildlife Officers as part of routine checks of nature reserves.

PART B

PLAN FOR MANAGMEENT

1.0 WATER QUALITY

1.1 Objective

To ensure that water quality remains consistent with the maintanance of a healthy aquatic ecosystem, which provides a feeding ground and a refuge for the suite of waterbirds that it currently supports.

1.2 Rationale

Attainment of this objective will require establishment of the nutrient status of the lake, identification of nutrient sources, and preparation of a nutrient budget.

Escalation of nutrient levels in the lake could lead to toxic algal blooms and botulism outbreaks resulting in death of birds, and death of invertebrates through reduction in oxygen levels. Death of invertebrate fauna would mean loss of food for other fauna, particularly waterbirds. Research is therefore essential.

Data collected by the Water Authority strongly suggest that there are excessively high levels of phosphorus in the lake. These levels are unacceptable by world standards. Excessive nutrient levels are also indicated by the extensive spread of Typha, and the abundance of algal and chironomid species.

Typha contains significant amounts of phosphorus in its tissue. According to the Water Authoritys data, levels of this nutrient in the lake appear to have declined with the increase in Typha, particularly since 1978. Although other factors may be involved, present evidence suggests that the Typha may be acting as a nutrient reservoir and a conservative approach to its control or removal should be adopted until more is known about this inter-relationship.

1.3 Management Strategies

1. In co-operation with the Water Authority of Western Australia, a water sampling program will be carried out to monitor nutrient levels. A nutrient budget will be prepared. This will involve

determination of the nutrient status of the lake and identification of the sources of nutrients. During the course of the work, public involvement will be encouraged.

2. Negotiate with local and Government Authorities over management to achieve the level of water quality required.

3. As the effects of large scale removal of Typha on the lake system are unknown, the amount removed will be limited to only that necessary for containment, fire protection purposes and experimental control works until results of investigations of the plant's role in lake dynamics are known.

2.0 WATER LEVELS

2.1 Objectives

To maintain an annual pattern of water levels suitable to the needs of the full range of waterbirds currently using the lake.

2.2 Rationale

If the Nature Reserve is to continue as a refuge for waterfowl, it is essential that the lake receives a regular and reliable supply of water that will satisfy the requirements of all species that have been identified there. These requirements vary from deeper water for diving ducks to the shallow mud flats utilised by waders. Continued lowering of water levels may have far-reaching implications for waterbirds seeking refuge during summer.

Low water levels encourage the spread and growth of Typha, making control difficult. Therefore continued low water levels have direct and quantifiable costs (associated with Typha control).

Deepening the lake by as little as 0.5 m by dredging, would not only be expensive, but may have serious adverse effects. While dredging may serve to maintain water in the lake as well as act to remove any nutrients stored in the sediments, it would also increase turbidity. This may have detrimental effects on the aquatic flora and fauna as

light penetration would be reduced. Also, benthic communities that dwell in the mud and are an important part of the food chain, would be removed from the system. As a consequence of deepening the lake, the wader feeding habitat would be reduced or lost.

As knowledge of the system is extremely limited, many other effects could not be predicted and any such proposal would first require extensive research. Benefits associated with such a proposal appear to be limited.

Lake water levels have been monitored by the Department of Conservation and land Management at two-monthly intervals since September 1979. During this period, recorded water levels have been highest in September (5 years) or November (2 years). The average maximum water depth for the seven years was 0.72 m with a range of 0.33-0.93 m.

The Lake has been observed dry each year as early as January (1 year) in March (4 years) and as late as May (5 years).

Given that the problem of Typha invasion has worsened considerably over this period, and in order to reverse the trend of Typha encroachment, it is recommended that the responsible management agencies endeavour to achieve a maximum depth of at least 1 m each year. A natural cycle of filling and drying should also be maintained.

Maximum water levels of approximately this magnitude, if achievable, should assist in limiting the spread of Typha while providing adequate feeding opportunities during spring and summer for the suite of waterbirds that currently use the lake.

The Water Authority is responsible for groundwater management in the Jandakot Water Supply Area. In this area, groundwater from uncontrolled and unmonitored private sources such as domestic bores, constitutes the major proportion of water drawn from the unconfined aquifer. Accounting and control of private bores is required.

2.3 Management Strategies

1. To ensure that the requirements of all waterbird species currently utilising the lake, are met, the responsible Authority should attempt to achieve a peak of at least 1 m in late spring of each year. The present cycle of filling and drying should be maintained. This should ensure that the feeding and habitat requirements for the suite of waterbirds currently using the lake, are met.

2. Groundwater inputs need to be monitored. If these are not adequate to maintain the required levels in Forrestdale Lake, CALM will be responsible for co-ordinating action, to rectify the situation.

3. The Department of Conservation and Land Management will maintain close liason with the Water Authority of Western Australia regarding aspects of lake management involving groundwater quality and quantity.

3.0 BULRUSHES (*TYPHA*)

3.1 Objectives

1. To manage *Typha* for the maximum benefit of the waterbird population and the lake ecosystem.

3.2 Rationale

If nutrient levels in Forrestdale Lake continue to increase it is highly likely that, if left to grow unchecked, the bulrush (*Typha*) will continue to spread over the entire lake. This will destroy a valuable waterbird refuge (as many species require open water for feeding). Control of the bulrush with minimal disturbance to the environment, is therefore advocated. A consultant will investigate appropriate controls.

Complete removal of bulrushes is not practical considering the extent of their growth and the existence of seed sources outside the Reserve; nor is it desirable as bulrushes provide shelter and a nesting place for some waterbirds. As the role of bulrushes in maintaining water quality is not well understood, the effect of its removal on nutrient levels, should be determined.

In mid to late summer the lake is often dry and vehicle access to the lake relatively easy. Vehicles driven on the lake bed contribute significantly to the spread of bulrushes because seeds colonise the moister environment created in the wheel ruts.

During summer, dry bulrushes pose a severe fire risk, and fire protection is required.

3.3 Management Strategies

1. Typha stands will be isolated by cutting into 'blocks' for fire protection purposes (see 5.0 Fire). Further expansion of Typha will be controlled, as far as is possible, to prevent takeover of the lake by the bulrush. Typha cut during control works, will be removed from the lake.

2. Methods of Typha control will be based on the results of experimental control works currently being investigated by a consultant funded by the Department of Conservation and Land Management.

3. Vehicle access onto the Reserve and subsequently onto the lake will be restricted by erection of a fence along the Reserve boundary (Section 12.0. Boundary Delineation).

4.0 MIDGES

4.1 Objectives

1. To establish guidelines for control of midges by the Local Authority.

2. To minimise the impact of midge control measures on other fauna and flora.

4.2 Rationale

Emergence of adult midges in large numbers during spring and summer causes a substantial nuisance to neighbouring residents. While control of the insects is the responsibility of the Local Authority, permission to implement any controls must be obtained from the Department of Conservation and Land Management. In addition, the procedure requires close monitoring to ensure protection of the Reserve environment.

In the past, use of Abate has varied in its effectiveness in reducing midge numbers and in its impact on waterbirds. The study of the distribution and abundance of larval midges at the lake during the summer of 1985-1986 which placed particular emphasis on the effects of pesticide application and possible 'sheltering' role of the fringing vegetation (Typha), should lead to a better understanding of the effectiveness of this control measure. Further research, however, is likely to be required.

4.3 Management Strategies

1. The City of Armadale will be permitted to continue spraying of lake to control midge numbers until an appropriate, alternative method of control is determined.

2. Specific approval from the Department of Conservation and Land Management is required for each treatment.

3. The following conditions were communicated to the City of Armadale and were applicable for the summer of 1985/86.

   i) Spraying is not be be undertaken without prior approval being obtained from this Department. Specific approval will be required for each treatment.

ii) Requests for approval will need to specify the proposed date of treatment (a period of 1-4 days may be nominated), the chemical formulation, method of application and application rate.

iii) Requests for approval will need to be received at least three working days prior to the proposed treatment. This is to ensure sufficient time is available for pre-treatment checks on water depths and bird populations.

iv) Approval for treatment will be given in each instance unless conditions are such that wader-poisoning appears likely. As a guide, it is unlikely that approval to spray will be given if the late water level (as measured by the Fisheries and Wildlife Department gauge installed in 1977) is less than 0.3 metres. The water level at the time waders died in February 1984 was approximately 0.05 metres.

v) Approval to spray on more than one occasion during each summer, will be given provided that the above conditions i-iv are met.

These conditions will be reviewed each year.

4. Guidelines for future midge control will be based on the findings of the chironomid study, although further studies may need to be conducted to determine alternative methods of control.

5. During the course of investigations into the midge situation, larvae numbers will be monitored and sampling results will be passed on to the Local Authority to assist Council Officers in planning treatments.

6. Lake levels, weather conditions and waterbird populations will continue to be monitored by officers from the Department of Conservation and Land Management before, during and after treatments.

5.0 FIRE PROTECTION

5.1 Objectives

1. To protect the conservation values of the Reserve.
2. To limit the area affected by uncontrolled wildfire.
3. To protect human life.
4. To protect the assets of reserve neighbours.

5.2 Rationale

Frequent fire on the Reserve has been a major contributor to degradation of vegetation and the success of exotic floral species, in particular annual grasses which are favoured by regimes of recurrent burning. Frequent fires also assist the invasion of the lake's fringing vegetation by bulrushes (Typha). Fire in dry Typha stands tends to spread into fringing vegetation, sometimes killing trees and opening up areas for further Typha expansion.

To ensure adequate fire protection both for the Reserve and for adjacent landholders, establishment and maintenance of firebreaks, procedures for local residents to contact the Department of Conservation and Land Management in the case of fire, and the breaking up of Typha stands to restrict the spread of fire, are necessary. In addition, the fire hazard could be reduced if fire is excluded from the Reserve allowing the native understorey to recover and dominate the more flammable exotic grasses. This may not be possible, however, as arsonists are believed to have been responsible for most if not all fires on the Reserve.

5.3 Management Strategies

1. Firebreaks

Maintenance of a peripheral firebreak (not necessarily on land vested in the NPNCA) will be carried out in co-operation with the Local Authority. The break will be approximately 10 m wide and will have a dual purpose as a firebreak and bridle-trail (see Section 10.0 Public Use).

Construction and maintenance of radial firebreaks from the peripheral firebreak to the edge of the lake into the stands of Typha will be carried out. Radials will be 3-4 m clear earth firebreaks associated with 6-8 m of slashed vegetation either side.

2. Fuel reduction burning

As further burning will only encourage growth of exotic grasses no fuel reduction burning is programmed. Provision will be maintained, however, for burning parts of the Reserve as necessary to safeguard life and surrounding property, and to protect the nature conservation values of the Reserve.

3. Notifiable Authority

The Department of Conservation and Land Management has taken the necessary steps to become a Notifiable Authority with respect to the Reserve. Responsibilities concerning Notifiable Authorities are described in the Bush Fires Regulations (1954).

4. Fire Suppression

Fire-fighting units from the Department of Conservation and Land Management will attend wildfires on or threatening the Reserve. Fire crews will also attend prescribed burns adjoining the Reserve provided crews are not already committed elsewhere. All Reserve neighbours will be advised of procedures for contacting the Department of Conservation and Land Management in the event of fire.

5. Adequacy of control measures

Special attention will be given to the views of reserve neighbours and the Local Authority in the matter of maintaining measures for fire protection. Through this plan, formal provision is made for individuals or groups affected, to draw the attention of the Executive Director of the Department of Conservation and Land Management to inadequacies they may perceive in the fire protection arrangements for the Reserve.

6. Typha control

To restrict the spread of fire, Typha stands will be isolated by cutting into 'blocks'.

6.0 DIEBACK PROTECTION

6.1 Objectives

1. To exclude the fungus Phytopthora cinnamomi from uninfected areas.

6.2 Rationale

While the destructive effects of dieback on jarrah are well publicised, the broader effects are not as well known. Dieback destroys many species of native flora and it is expected that the disease will indirectly affect many animals through its impact on their habitat. Because dieback is so destructive, it is necessary to prevent the transport of the disease within or from the Reserve.

A survey of the Reserve by an officer of the Department of Conservation and Land Management has indicated the presence of dieback. Exclusion of horses and restriction of vehicles using the Reserve is therefore necessary to prevent the spread of the fungus.

6.3 Management Strategies

A detailed survey will be carried out to map boundaries of the affected areas which will be quarantined. Access by vehicle into infected areas will only be permitted in an emergency (e.g. wildfire suppression) and full hygiene measures according to Departmental guidelines, will be observed. All measures possible will be taken to prevent further spread of the fungus. The spread and impact of the disease will be monitored.

7.0 EXOTIC SPECIES

7.1 Objectives

To minimise the spread of exotic plants and animals and where possible, eradicate them.

7.2 Rationale

Approximately 30% of the flora of Forrestdale Lake Nature Reserve is exotic. Although it will be impossible to return the vegetation to a pristine state, it is essential that the more aggressive, competetive weed species are controlled.

Two species, pampas grass and arum lilies, are cause for immediate concern and their control will be a priority. Pampas grass has the potential to take over the wetland fringe and arum lilies dominate native plant growth, particularly along the western boundary.

Rabbits, foxes and cats are a continuing problem on the Reserve, however, efforts to eradicate these pests are of little use unless a regional approach is taken.

Control of other exotic plants and animals may be necessary from time to time to protect flora and fauna on the Reserve, adjacent properties or in the general area.

7.3 Management Strategies

1. Works to eradicate or control further growth of exotic floral species such as pampas grass, arum lilies and figs, will continue.

2. The necessary arrangements for organised control of exotic species in the area will be made by an officer of the Perth Metropolitan Region of the Department of Conservation and Land Management.

3. As with the provisions for fire protection in this plan, reserve neighbours and the local authority are invited to draw the attention of the Executive Director of Conservation and Land Management to what they consider to be inadequacies in the control of exotic plants and animals which may develop during the currency of this plan. On receipt of such comments, the Executive Director will organise a joint inspection, or take other action as may be needed, to remedy the situation.

4. Techniques to eradicate exotic species compatible with protection of nature conservation values, will be developed.

8.0 REHABILITATION

8.1 Objectives

1. To encourage regrowth of natural vegetation.
2. To encourage revegetation of access tracks and firebreaks no longer necessary for fire protection or other purposes.
3. To re-establish natural vegetation along the lake fringe.

8.2 Rationale

Degradation of the Reserve has occurred as a result of frequent burning, introduction of pest species, rubbish dumping, ad hoc access, trampling by horses and encroachment by private properties onto the Reserve. Removal or reduction of these pressures over time should allow natural regeneration of degraded areas, however, some planting may be necessary.

In the long term, natural replacement of exotic grasses by less flammable natural vegetation can lead to a reduction in fire hazard in an area. This can be assisted by excluding fire or, at the very least, by reducing fire frequency (B. Muir, pers. comm., 1985).

8.3 Management strategies

1. All firebreaks and access tracks not needed under the provisions of this plan for fire protection or general management purposes will be closed and allowed to regenerate.

2. Provisions will be made under this management plan for the collection and propagation of seeds and cuttings from trees and shrubs on the Reserve. These will be used to accelerate the re-vegetation of tracks and degraded areas, and to act as a buffer between emerging midges and the residential area.

9.0 RESEARCH AND MONITORING

9.1 Objectives

1. To gather data required to further develop appropriate management strategies for the protection of utilising the area.
2. To monitor the effects of the management strategies advocated in the plan.

9.2 Rationale

To maintain the lake as suitable habitat for the existing diversity and abundance of waterbirds, on-going monitoring of waterbird numbers and breeding status is essential in order to assess the level of success of management strategies employed and to modify strategies where necessary. However, changes observed may be a reflection of regional or broader trends e.g. changes in climate. Monitoring of the status of waterbird populations of the regional, state and national levels, as well as determination of migratory patterns, would contribute greatly to the understanding of waterbird requirements. This information could then be used to implement appropriate protection heavily utilised by the birds.

On a local scale, changes may reflect changes in the immediate environment. It is important, therefore, to have a detailed understanding of the processes affecting the integrity of the Reserve and of the effects any changes can have on waterbird populations so that optimum management strategies are employed.

Little research has been undertaken at Forrestdale Lake Nature Reserve and consequently much needed data have not been available. This plan has identified a number of areas that require further research and monitoring. These are listed in the following section.

9.3 Management Strategies

1. The Royal Australasian Ornithologists Union has been funded by the Department of Conservation and Land Management for three years beginning January 1986, to continue monitoring waterbird use of

selected nature reserves in the south-west. Forrestdale Lake will be included in this program.

2. Water quality research is essential. This should be carried out, and jointly funded, by the Department of Conservation and Land Management and the Water Authority of Western Australia. Information requirements have been addressed in Section 1.0. Water Quality.

3. Any bird deaths on Forrestdale Lake will be investigated by officers from the Department of Conservation and Land Management. The cause of death will be determined where possible and steps taken to prevent a recurrence.

4. Investigations of alternative methods of midge control and the effect of Abate spraying on the aquatic system (e.g. water quality) are required. On-going monitoring of invertebrate populations is also necessary. Other areas in need of further research may also come to light upon completion of current projects.

5. Development of Typha control techniques by a consultant, funded by the Department of Conservation and Land Management, is continuing. The need for further research will be assessed at the end of spring 1986.

6. A further survey is required to map dieback affected areas (see 6.0 Dieback Protection).

7. Control techniques for exotic species, that have minimal impact on non-target species, need to be developed (see 7.0 Exotic Species).

8. The banding and colour-marking of waterbirds is necessary to determine their migratory paths so that protection measures for these birds can be determined where necessary. If funding is made available this project would be the joint responsibility of the Department of Conservation and Land Management and the RAOU.

9. Monitoring of visitor impact and visitor requirements is necessary.

10.0 PUBLIC USE

10.1 Objectives

1. To ensure that public use of the Reserve does not detract from conservation values.
2. To minimise conflict between uses.

10.2 Rationale

The Nature Reserve has been subjected to considerable inappropriate and often 'illegal' public use which has contributed substantially to its degradation. Environmental education is considered to be a desirable and positive approach to the resolution of many conflicts, particularly in the long term, however, necessary provisions for resolution of immediate problems are made in this plan.

Portions of the Nature Reserve are suited to limited forms of public use such as nature study, bird watching and photography. Activities such as horse-riding and off-road driving need to be excluded as experience has shown that the ground-cover vegetation of this Reserve is readily damaged by both activities.

A cleared area at the end of Moore Street has been used in the past for recreation, however it is now in a state of neglect. The Forrestdale Progress Association has formulated proposals for the development of the Skeet Memorial Park, west of Moore Street, as a picnic and play area in association with the Moore Street area. The memorial park is vested in the City of Armadale and abuts the Reserve.

Provision is made in this plan for limited public use of the Reserve for environmental education.

10.3 Management Strategies

1. The existing cleared area at the end of Moore Street will, subject to City of Armadale agreement, be maintained by that Authority. Approval for any modifications to the area (e.g. erection of structures) must be obtained from the Executive Director of Conservation and Land Management. Given that the primary purpose of nature reserves is for the conservation of flora and fauna and maintenance of a 'natural' environment, structures will be kept to a minimum.

2. A bridle-trail following the perimeter firebreak will be established (see Section 5.0. Fire Protection). Signposts indicating the trail will be erected subject to approval from the Local Authority.

3. An information brochure will be prepared and made available for the general public and/or local schools. Distribution will be via interest groups, the Local Authority and the Department of Conservation and Land Management.

11.0 CLASSIFICATION

11.1 Objectives

1. To ensure that the classification of the lake and its surrounds reflects its importance as a conservation area for flora and fauna.

2. To identify adjacent land that may enhance the conservation values of the Reserve.

11.2 Rationale

Both the 'A' and 'C' Class Reserves have been set aside for the 'Conservation of Flora and Fauna and Recreation'. Recreation was included in the classification to cater for the activities of a sailing club in 1957 when the Reserve was set aside. Now, falling water levels, apparent changes in lake conditions, realisation of the importance of

the Reserve as a waterbird refuge and the sensitivity of flora and fauna to disturbance, make this provision no longer appropriate.

The status of the 'C' Class Reserve also needs alteration in order to reflect the importance of the neighbouring 'A' Class Reserve.

A gazetted rare orchid Diuris purdiei has been identified on the adjacent Recreation Reserve No. 27165 currently vested in the City of Armadale. Inclusion of part of the Recreation Reserve in Forrestdale Lake Nature Reserve would ensure the protection of this rare plant.

11.3 Management strategies

1. The secondary purpose of recreation will be deleted from the classification of Forrestdale Lake Nature Reserve as it is no longer appropriate.

2. 'C' class Reserve No. 37016 will be cancelled and its area added to the 'A' Class Reserve No. 24781.

3. Negotiations will be held with the City of Armadale regarding the inclusion of part of Recreation Reserve No. 21765 (vested in that authority) within the 'A' Class Reserve.

4. Because of the sensitivity of the area's soils and vegetation to horses and off-road vehicles, all of the Nature Reserve will be declared a Limited Access Area under Section 48 of the Wildlife Conservation Regulations (1950). This means that all the Nature Reserve within the proposed boundary fence will be accessible to the public on foot but not to people on horseback or in vehicles of any kind other than for management purposes.

12.0 BOUNDARY DELINEATION

12.1 Objectives

1. To define the boundary for management purposes.

12.2 Rationale

Lack of boundary definition has contributed to conflicts of land-use such as encroachment of neighbouring properties and roads. Delineation is also necessary for management purposes and enforcement of regulations. A survey of the boundary will therefore be necessary.

12.3 Management strategies

1. To delineate the boundary, a fence of wooden posts and wire, the whole structure being approximately 1.5 m high, will be erected around the Reserve over the first 3 years of the management plan.

   Locked gates in the fence will be provided for access by management and fire-fighting personnel, and pedestrian gates will be provided at strategic points for entry by the public.

13.0 GENERAL MANAGEMENT

13.1 Objectives

1. To manage the Reserve as a community resource.

13.2 Rationale

The Reserve is important in both the local regional and international context as an area for the conservation of flora and fauna and as an educational resource. It is therefore important to ensure that the general public have a sense of responsibility for the Reserve.

Volunteers can play an important role in the general management of the Reserve by acting as guardians and by participating in rehabilitation works and weed control. Support from the public for management outside of day-to-day requirements, is essential for long-term protection of the wetland system.

13.3 Management Strategies

1. Interested persons will be encouraged to become involved in the ongoing management of the Reserve including rehabilitation and weed control works.

2. An honorary warden will be appointed.

3. To protect the conservation values of the Reserve, the Local Authority should consult with the Department of Conservation and Land Management regarding any proposed developments adjacent to the Reserve.

APPENDIX 1. STRUCTURAL VEGETATION CATEGORIES (MUIR 1977)

LIFE FORM/HEIGHT CLASS	CANOPY COVER			
	DENSE 70–100%	MID-DENSE 30–70%	SPARSE 10–30%	VERY SPARSE 2–10%
Trees 30m	Dense Tall Forest	Tall Forest	Tall Woodland	Open Tall Woodland
Trees 15–30m	Dense Forest	Forest	Woodland	Open Woodland
Trees 5–15m	Dense Low Forest A	Low Forest A	Low Woodland A	Open Low Woodland A
Trees 5m	Dense Low Forest B	Low Forest B	Low Woodland B	Open Low Woodland B
Mallee Tree Form	Dense Tree Mallee	Tree Mallee	Open Tree Mallee	Very Open Tree Mallee
Mallee Shrub Form	Dense Shrub Mallee	Shrub Mallee	Open Shrub Mallee	Very Open Shrub Mallee
Shrubs 2m	Dense Thicket	Thicket	Scrub	Open Scrub
Shrubs 1.5–2.0m	Dense Heath A	Heath A	Low Scrub A	Open Low Scrub A
Shrubs 1.o–1.5m	Dense Heath B	Heath B	Low Scrub B	Open Low Scrub B
Shrubs 0.5–1.0m	Dense Low Heath C	Low Heath C	Dwarf Scrub C	Open Dwarf Scrub C
Shrubs 0.5m	Dense Low Heath D	Low Heath D	Dwarf Scrub D	Open Dwarf Scrub D
Mat Plants	Dense Mat Plants	Mat Plants	Open Mat Plants	Very Open Mat Plants
Hummock Grass	Dense Hummock Grass	Mid-Dense Hummock Grass	Hummock Grass	Open Hummock Grass
Bunch Grass 0.5m	Dense Tall Grass	Tall Grass	Open Tall Grass	Very Open Tall Grass
Bunch Grass 0.5m	Dense Low Grass	Low Grass	Open Low Grass	Very Open Low Grass
Herbaceous spp.	Dense Herbs	Herba	Open Herbs	Very Open Herbs
Sedges 0.5m	Dense Tall Sedges	Tall Sedges	Open Tall Sedges	Very Open Tall Sedges
Sedges 0.5m	Dense Low Sedges	Low Sedges	Open Low Sedges	Very Open Low Sedges
Ferns	Dense Ferns	Ferns	Open Ferns	Very Open Ferns
Mosses, Liverwort	Dense Mosses	Mosses	Open Mosses	Very Open Mosses

APPENDIX 2. PLANT SPECIES RECORDED ON FORRESTDALE LAKE NATURE RESERVE

Source: Jeni Alford, Wildlife Research Branch, Department of Conservation and Land Management (1985).

ZAMIACEAE	
Macrozamia riedlei	Zamia
TYPHACEAE (Rushes)	
* Typha orientalis	Bulrush
PINACEAE	
* Pinus pinaster	Pinaster
POACEAE	
* Avena barbata	Bearded Oat
* Briza maxima	Blowfly Grass
* B. minor	Quivery Grass
* Cortaderia selloana	Pampas Grass
* Cynodon dactylon	Couch Grass
* Ehrharta longiflora	Veldt Grass
* Lagurus ovatus	Pussy Tails
* Lolium perenne	Perennial Rye Grass
Neurachne minor	
Paspalum dilatatum	Paspalum
* Stenotaphrum secundatum	Buffalo Grass
* Stipa elegantissima	
CYPERACEAE	
Bolboschoenus caldwellii	Marsh Club Rush
Chorizandra enodis	Black Bristle Rush
Cyperus alterniflorus	
Gahnia trifida	Coast Saw Sedge
Isolepis marginata	
Lepidosperma longitudinale	Common Sword Sedge
Mesomelaena stygia	
Schoenus curvifolius	
S. grandiflorus	Large-flowered Bog Rush

Tricostularia neesii	
ARACEAE	
* Zantedeschia aethiopica	Arum lily
RESTIONACEAE	
Leptocarpus canus	
Loxocarya fasciculata	
L. flexuosa	
L. pubescens	
Lyginia barbata	
CENTROLEPIDACEAE	
Centrolepis polygyna	Wiry Centrolepis
JUNCACEAE	
Juncus bufonius	Toad Rush
J. holoschoenus	Joint Leaf Rush
Luzula meridionalis	Woodrush
ASPARAGACEAE	
* Asparagus asparagoides	Bridal Creeper
DASYPOGONACEAE	
Acanthocarpus preissii	
Calectasia cyanea	Blue Tinsel Lily
Dasypogon bromeliifolius	Pineapple-leaved Dasypogon (Pineapple Bush)
XANTHORRHOEACEAE	
Xanthorrhoea preissii	Blackboy
PHORMIACEAE	
Dianella revoluta	Spreading Flax Lily
Stypandra grandiflora	Candyup Poison
S. imbricata	Cluster Leaved Blind Grass

ANTHERICACEAE	
Arnocrinum preissii	
Corynotheca micrantha	
Laxmannia squarrosa	
Sowerbaea laxiflora	Vanilla Lily (Purple Tassels)
Thysanotus banksii	
T. multiflorus	(Many-flowered) Fringe Lily
T. patersonii	
T. sparteus	
T. tuberosus	Common Fringe Lily
COLCHICACEAE	
Burchardia umbellata	Milkmaids
HAEMODORACEAE	
Anigozanthos humilis	Cat's Paw
A. manglesii	Red and Green Kangaroo Paw
Conostylis aurea	Golden Conostylis
C. involucrata	
Haemodorum spicatum	
Phlebocarya ciliata	
Tribonanthes australis	
T. violacea	
IRIDACEAE	
Patersonia occidentalis	Purple Flags
* Romulea rosea	Onion Grass
ORCHIDACEAE	
Acianthus reniformis var. huegelii	Midge Orchid
Caladenia deformis	Blue Beard
C. discoidea	Bee Orchid
C. flava	Cowslip Orchid
C. huegelii	King Spider Orchid
C. latifolia	Pink Fairies
C. marginata	White Fairy Orchid
C. patersonii	White Spider Orchid
Diuris laxiflora	Cat's Face Orchid
D. longifolia	Common Donkey Orchid

Elythranthera brunonis	Purple Enamel Orchid
Leporella fimbriata	Hare Orchid
Lyperanthus nigricans	Red Beaks
Microtis orbicularis	Dark Mignonette
M. unifolia	Common Mignonette
*Monadenia bracteata	South African Orchid
Prasophyllum parvifolium	Autumn Leek Orchid
Pterostylis nana	Snail Orchid
P. vittata var. vittata	Banded Greenhood
Thelymitra antennifera	Vanilla Orchid
T. crinita	Blue Lady Orchid
T. flexuosa	Twisted Sun Orchid
T. nuda	Scented Sun Orchid
T. pauciflora	Slender Sun Orchid
CASUARINACEAE	
Allocasuarina fraseriana	Sheoak
MORACEAE	
* Ficus carica	Fig
PROTEACEAE	
Adenanthos cygnorum	Woolly Bush
A. obovatus	Basket Flower
Banksia attenuata	Slender (Candlestick) Banksia
B. ilicifolia	Holly-leaf Banksia
B. littoralis	Swamp Banksia
B. menziesii	Firewood (Flame) Banskia
B. telmatiaea	Swamp Fox Banksia
Dryandra nivea	Couch Honeypot
Hakea varia	Variable-leaved Hakea
Petrophile linearis	Narrow-leaved Cone Bush (Pixie Mops)
Stirlingia latifolia	Blueboy
Synaphea polymorpha	Showy (Albany) Synaphea
LORANTHACEAE	
Nuytsia floribunda	Christmas Tree

POLYGONACEAE	
* Rumex crispus	Curled Dock
PHYTOLACCACEAE	
* Phytolacca octandra	Inkweed
AIZOACEAE	
* Carpobrotus edulis	Pigface
MOLLUGINACEAE	
Macarthuria australis	Mouse Ear Chickweed
PORTULACACEAE	
Calandrinia liniflora	
CARYOPHYLLACEAE	
* Cerastium glomeratum	
LAURACEAE	
Cassytha racemosa	Dodder-laurel
BRASSICACEAE	
* Rorippa nasturtium-aquaticum	Nasturtium
DROSERACEAE	
Drosera gigantea	Giant Sundew
D. glanduligera	Scarlet Sundew
D. menziesii	Menzie's Sundew
MIMOSACEAE	
Acacia pulchella	Prickly Moses
A. saligna	Golden Wreath Wattle
A. huegelii	
PAPILIONACEAE	
Bossiaea eriocarpa	
* Cytisus proliferus	Lucerne Tree
Gompholobium tomentosum	
Hardenbergia comptoniana	Wild Sarsparilla (Native Wisteria)

Hovea trisperma	Common Hovea
Jacksonia furcellata	
J. sternbergiana	
Kennedia prostrata	Scarlet Runner (Running Postman)
* Lotus uliginosus	Trefoil
* Medicago polymorpha	Burr Medic
* Melilotus indica	Common Melilot
* Trifolium angustifolium	Narrow-leaved Clover
* T. resupinatum	Reversed Trefoil
Vicia sativa	Common Vetch
GERANIACEAE	
* Erodium cygnorum	Blue Heron's-bill
* Geranium molle	Crane's-bill Geranium
Pelargonium australe	
* P. capitatum	
OXALIDACEAE	
* Oxalis pes-caprae	Soursop
RUTACEAE	
Eriostemon spicatus	Peter and Salt
POLYGALACEAE	
Comesperma volubile	Love Creeper
EUPHORBIACEAE	
* Euphorbia terracina	Petty Spurge
* Ricinus communis	Castor Oil Plant
DILLENIACEAE	
Hibbertia hypericoides	Yellow Buttercups
H. subvaginata	
LYTHRACEAE	
* Lythrum hyssopifolia	Lesser Loose Strife
MYRTACEAE	
Astartea fascicularis	

Calothamnus lateralis	
Calytrix angulata	
C. fraseri	Summer Fringe-Myrtle (Pink Summer Calytrix)
Eucalyptus marginata	Jarrah
E. rudis	Flooded (Swamp) Gum
Hypocalymma angustifolium	White Myrtle
Kunzea vestita	
Melaleuca cuticularis	Salt-water paperbark
M. incana	Grey (Silver-grey) Honey Myrtle
M. lateritia	Robin Red-breast Bush
M. preissiana	Paperbark
M. rhaphiophylla	Swamp Paperbark
M. viminea	
Regelia ciliata	
Scholtzia involucrata	Spiked Scholtzia
Verticordia densiflora	
ONAGRACEAE	
Epilobium billardierianum	Variable Willow Herb
APIACEAE	
Daucus glochidiatus	Australian Carrot
Trachymene pilosa	Native Parsnip
EPACRIDACEAE	
Brachyloma preissii	Globe Heath
Conostephium pendulum	Pearl Flower
Leucopogon oxycedrus	
L. propinquus	
PRIMULACEAE	
* Anagallis arvensis	Scarlet and Blue Pimpernel
* Centaurium erythraea	Common Centaury
* C. spicatum	Spike Centaury
MENYANTHACEAE	
Villarsia albiflora	

ASCLEPIADACEAE	
* Asclepias curassavica	Red-head Cotton Bush
LAMIACEAE	
Hemiandra pungens	Snake Bush
SOLANACEAE	
* Solanum nigrum	Blackberry Nightshade
* S. sodomaeum	Apple of Sodom
SCROPHULARIACEAE	
* Parentucellia latifolia	Common Bartsia
* P. viscosa	Sticky Bartsia
OROBANCHACEAE	
Orobanche australiana	Australian Broom-Rape
LENTIBULARIACEAE	
Polypompholyx multifida	Pink Petticoats
Utricularia menziesii	Redcoats
CAMPANULACEAE	
* Wahlenbergia capensis	Cape Bluebell
LOBELIACEAE	
Lobelia alata	Angled Lobelia
GOODENIACEAE	
Dampiera linearis	Common (Narrow-leaved) Dampiera
Scaevola aemula	Fairy Fan-flower
S. canescens	Grey Scaevola
STYLIDIACEAE	
Stylidium junceum	Reed Trigger Plant
S. piliferum	Common Butterfly Trigger Plant
S. repens	

ASTERACEAE	
Angianthus preissianus	
* Cirsium vulgare	Spear Thistle
* Conyza bonariensis	Fleabane
Cotula coronopifolia	Water-buttons
* Dittrichia graveolens	Stinkweed
* Hypochaeris glabra	Smooths Cat's Ear
Lagenifera huegelii	Coarse Lagenifera
*Pseudognaphalium luteo-album	Jersey Cudweed
Sonchus oleraceus	Sow Thistle
* Taraxacum officinale	Dandelion
* Ursinia anthemoides	Ursinia

* Introduced

APPENDIX 3.

ALGAL SPECIES RECORDED IN FORRESTDALE LAKE

Source: Van Alphen (1983)

ALGAE

CHLOROPHYTA	Ankistrodesmus
	Botryococcus
	Chara
	Cladophora
	Closterium
	Dictyosphaerium
	Mougeotia
	Oedogonium
	Scenedesmus
	Spirogyra
	Stigeoclonium
	Ulothrix
	Volvox
	Zygnema
CHRYSOPHYTA	
	Tribonema
	Vaucheria
CYANOPHYTA	
	Anabaena
	Anabaenopsis
	Lyngbya
	Merismopedium
	Microcystis
	Nostoc
	Oscillatoria
	Spirulina
EUGLENOPHYTA	
	Euglena
	Phacus

APPENDIX 4.

FAUNA RECORDED ON FORRESTDALE NATURE LAKE RESERVE

Sources:

A - Royal Australasian Ornithologists Union (RAOU) - South-west Waterbird Project (1986)

B - RAOU - Perth Metropolitan Bird Project (1986)

C - Andrew Williams, Wildlife Research Branch, Department of Conservation and Land Management (1985)

D - Western Australian Museum (1985)

BIRDS		Breeding	Source
PODICIPEDIDAE (GREBES)			
Poliocephalus poliocephalus	Hoary-headed Grebe		A B
Tachybaptus novaehollandiae	Australasian (Little) Grebe	*	A B C
PELECANOIDIDAE (PELICANS)			
Pelecanus conspicillatus	Australian Pelican		A B
ANHINGIDAE (DARTERS)			
Anhinga melanogaster	Darter		A
PHALACROCORACIDAE (CORMORANTS)			
Phalacrocorax carbo	Great (Black) Cormorant		A
P. sulcirostris	Little Black Cormorant		A B
P. melanoleucos	Little Pied Cormorant		A B C
ARDEIDAE (HERONS, EGRETS)			
Ardea pacifica	Pacific (White-necked) Heron		A B C
A. novaehollandiae	White-faced Heron	*	A B C
Egretta alba	Great (large) Egret		A B
Nycticorax caledonicus	Rufous (Nankeen) Night Heron		A B C
Ixobrychus minutus	Little Bittern	*	A
PLATALEIDAE (IBIS, SPOONBILLS)			
Plegadis falcinellus	Glossy Ibis		A
Threskiornis aethiopica	Sacred (White) Ibis		A B C

Threskiornis spinicollis	Straw-necked Ibis		A B C
Platalea flavipes	Yellow-billed Spoonbill		A B
ANATIDAE (DUCKS, SWANS)			
Cygnus atrutus	Black Swan	*	A B C
Stictonetta naevosa	Freckled Duck		A
Tadorna tadornoides	Australian Shelduck (Mountain Duck)	*	A B C
Anas superciliosa	Pacific Black Duck	*	A B C
A. gibberifrons	Grey Teal	*	A B C
A. castanea	Chestnut Teal		A
A. rynchotis	Australasian (Blue-winged) Shoveler	*	A B C
Malacorhynchus membranaceus	Pink-eared Duck	*	A B
Aythya australis	Hardhead (White-eyed Duck)	*	A B C
Chenonetta jubata	Maned (Wood) Duck		A
Oxyura australis	Blue-billed Duck	*	A B
Biziura lobata	Musk Duck	*	A B
	Unidentified Duck		A
	Domestic Hybrid Ducks		A
ACCIPITRIDAE (KITES, HAWKS, EAGLES, HARRIERS)			
Elanus notatus	Black-shouldered Kite		B C
Haliastur sphenurus	Whistling Kite (Eagle)		B
Accipiter fasciatus	Brown Goshawk		B C
A. cirrhocephalus	Collared Sparrowhawk		B
Aquila audax	Wedge-tailed Eagle		B
Hieraaetus morphnoides	Little Eagle		B
Circus aeruginosus	Marsh (Swamp) Harrier		A B C
FALCONIDAE (KESTRELS)			
Falco cenchroides	Australian Kestrel		B
PHASIANIDAE (QUAILS)			
	Quail sp.		B
RALLIDAE (RAILS, CRAKES, HENS, COOTS)			
Rallus philippensis	Buff-banded (Land) Rail		A B
Porzana pusilla	Baillon's (Marsh) Crake	*	A B

P. fluminea	Australian (Spotted) Crake		A B
P. tabuensis	Spotless Crake	*	A
Gallinula ventralis	Black-tailed Native-hen		A B
Gallinula tenebrosa	Dusky Moorhen	*	A B
Porphyrio porphyrio	Purple (Western) Swamphen	*	A B
Fulica atra	Eurasian Coot	*	A B C

CHARADRIIDAE (PLOVERS, DOTTERELS)

Vanellus tricolor	Banded Lapwing (Plover)		A B
Pluvialis squatarola	Grey Plover **		A
P. dominica	Lesser Golden Plover **		A
Erythrogonys cinctus	Red-kneed Dotterel		A
Charadrius dubius	Little Ringed Plover **		A
C. ruficapillus	Red-capped Plover (Dotterel)	*	A B
C. melanops	Black-fronted Plover (Dotterel)		A B

RECURVIROSTRIDAE (STILTS, AVOCETS)

Himantopus himantopus	Black-winged (Pied) Stilt	A B
Cladorhynchus leucocephalus	Banded Stilt	A B
Recurvirostra novaehollandiae	Red-necked Avocet	A B
	Unidentified Stilt-type	A

SCOLOPACIDAE (CURLEWS, SANDPIPERS, GODWITS)

Tringa glareola	Wood Sandpiper **	A B
T. hypoleucos	Common Sandpiper **	A
T. nebularia	Greenshank **	A B
T. stagnatilis	Marsh Sandpiper **	A B
Limosa limosa	Black-tailed Godwit **	A B
Calidris tenuirostris	Great Knot **	B
C. acuminata	Sharp-tailed Sandpiper **	A B
C. melanotos	Pectoral Sandpiper **	A B
C. ruficollis	Red-necked Stint **	A B
C. minuta	Little Stint **	A
C. subminuta	Long-toed Stint **	A B
C. ferruginea	Curlew Sandpiper **	A B
Limicola falcinellus	Broad-billed Sandpiper **	A

LARIDAE (GULLS, TERNS)		
Larus novaehollandiae	Silver Gull	A B
Chlidonias hybrida	Whiskered Tern	A
COLUMBIDAE (PIGEONS)		
Columbia livia	Feral Pigeon	B
Streptopelia chinensis	Spotted Turtle-Dove	C
S. senegalensis	Laughing Turtle-Dove	B C
Phaps chalcoptera	Common Bronzewing	B
Ocyphaps lophotes	Crested Pigeon	B C
CACATUIDAE (COCKATOOS, GALAHS)		
Calptorhynchus brandinii	White-tailed Black-Cockatoo	B
Cacatua roseicapilla	Galah	B C
LORIIDAE (LORIKEETS)		
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	B
PLATYCERCIDAE (PARROTS)		
Purpureicephaeus spurius	Red-capped Parrot	B C
Barnardius zonarius	Port Lincoln Ringneck	B C
Neophema elegans	Elegant Parrot	B
CUCULIDAE (CUCKOOS)		
Cuculus pallidus	Pallid Cuckoo	B
C. pyrrhophanus	Fan-tailed Cuckoo	B C
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	C
C. lucidus	Shining Bronze-Cuckoo	B
PODARGIDAE (FROGMOUTHS)		
Podargus strigoides	Tawny Frogmouth	B C
STRIGIDAE (OWLS)		
Ninox novaeseelandiae	Southern Boobook	C
ALCEDINIDAE (KOOKABURRAS, KINGFISHERS)		
Dacelo novaeguineae	Laughing Kookaburra	B C
Halcyon sancta	Sacred Kingfisher	B C

MEROPIDAE (BEE-EATERS)			
Merops ornatus	Rainbow Bee-eater		B
HIRUNDINIDAE (SWALLOWS)			
Hirundo neoxena	Welcome Swallow		B C
~~Cecropis nigricans~~	Tree Martin		B C
MOTACILLIDAE (PIPITS, WAGTAILS)			
Anthus novaeseelandiae	Richard's Pipit		B
CAMPEPHAGIDAE (CUCKOO-SHRIKES)			
Coracina novaehollandiae	Black-faced Cuckoo-shrike		B C
MUSCICAPIDAE (WAGTAILS, ROBINS, WHISTLERS)			
Petroica multicolor	Scarlet Robin		B
Pachycephala rufiventris	Rufous Whistler		B C
Colluricincla harmonica	Grey Shrike-thrush		B
Rhipidura fuliginosa	Grey Fantail		C
R. leucophrys	Willie Wagtail		B C
SYLVIIDAE (WARBLERS, GRASSBIRDS)			
Acrocephalus stentoreus	Clamorous Reed-Warbler	*	A B C
Megalurus gramineus	Little Grassbird		A B
MALURIDAE (FAIRYWRENS)			
Malurus splendens	Splendid Fairy-wren		B C
ACANTHIZIDAE (WRENS, THORNBILLS)			
Sericornis frontalis	White-browed Scrubwren		B
Smicrornis brevirostris	Weebill		B
Gerygone fusca	Western Gerygone (Warbler)		B C
Acanthiza apicalis	Inland Thornbill		B C
A. inornata	Western Thornbill		B
A. chrysorrhoa	Yellow-rumped Thornbill		B C
NEOSITTADAE (SILLELLAS)			
Daphoenositta chrysoptera	Varied Sittella		B

MELIPHAGIDAE (WATTLEBIRDS, HONEYEATERS)

Anrochaera carunculta	Red Wattlebird	B C
A. chrysoptera	Little Wattlebird	B
Manorina flaviqula	Yellow-throated Miner	B
Lichenostomus virescens	Singing Honeyeater	B
Lichmera indistincta	Brown Honeyeater	B C
Phylidonyris novaehollandiae	New Holland Honeyeater	B C
Acanthorhynchus superciliosus	Western Spinebill	B C

PARDALOTIDAE (PARDALOTES)

Pardalotus straitus Striated pardalote (White eye) B C

ZOSTEROPIDAE (WHITE-EYES)

Zosterops lateralis	Silvereye	B C

GALLINIDAE (MAGPIE-LARKS)

Grallina cyanoleuca	Australian Magpie-lark	B C

ARTAMIDAE (WOOD SWALLOWS)

Artamus cinereus	Black-faced Woodswallow	B

CRACTICIDAE (BUTCHERBIRDS, MAGPIES)

Cracticus torquatus	Grey Butcherbird	B C
Gymnorhina tibicen	Australian Magpie	B C

CORVIDAE (RAVENS)

Corvus coronoides	Australian Raven	B C

** migratory

AMPHIBIANS

LEPTODACTYLIDAE (SOUTHERN FROGS)

Crinia georgiana		C D
Heleioporus eyrei	Moaning Frog	C
Limnodynastes dorsalis	Bullfrog (Banjo Frog)	C D

Pseudophryne guentheri		D
Ranidella insignifera		C D
HYLIDAE (TREE FROGS)		
Litoria adelaidensis	Slender Tree Frog	C
Litoria moorei	Bullfrog	C D

REPTILES

TORTOISES

CHELIDAE (SIDE-NECKED TORTOISES)		
Chelondina oblonga	Long-necked Tortoise	C

LIZARDS

GEKKONIDAE (GECKOES)		
Phyllodactylus marmoratus	Marbled Gecko	D
PYGOPODIDAE (LEGLESS LIZARDS)		
Delma grayii		C D
Lialis burtonis	Burton's Snake-lizard	C
SCINCIDAE (SKINKS)		
Cryptoblepharus plagiocephalus		C D
Leiolopisma trilineatum		D
Lerista lineata	Lined Skink	C D
Menetia greyii		C D
Tiliqua rugosa	Bobtail	C
GOANNAS/MONITORS (VARANIDAE)		
Varanus gouldii	Gould's Goanna (Sand Monitor)	C

SNAKES

ELAPIDAE (ELAPID SNAKES)		
Demansia reticulata reticulata		D
Notechis scutatus occidentalis	Tiger Snake	C D
Pseudonaja affinis affinis	Dugite	C D

Rhinoplocephalus gouldii		D

MAMMALS

VESPERTILIONIDAE (BATS)		
Tadarida australis	White-striped mastiff-bat	C
MURIDAE (MICE)		
Mus musculus	House Mouse	C

INTRODUCED MAMMALS

Oryctolagus cuniculus	Rabbit (LEPORIDAE)	C
Vulpes vulpes	Fox (CANIDAE)	C
Felis catus	Cat (FELIDAE)	C