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ESPLANADE RESERVE RECOMMENDATIONS

FOR

LAKES SERPENTINE, MANGAHIA,

ROTOMANUKA, RUATUNA AND CAMERON

(WAIPA DISTRICT)

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EXECUTIVE SUMMARY

After initial fieldwork, several extensions to the original brief were considered necessary, particularly regarding esplanades on peat substrates, locating 'lake edge' in systems which are progressively changing, and defining key terms such as 'wetland', 'peatland', 'lake' and 'functional esplanade'.

The five lakes in the present brief were ranked in terms of their natural values: Mangahia, Serpentine, Rotomanuka, Ruatuna, Cameron. However, it is acknowledged that perceptions of 'natural values' vary. Thus, including all values: recreation, aesthetic, landscape, scientific and educational, it would be difficult to separate Mangahia and Serpentine in the rankings. Ruatuna has high educational values by virtue of current usage, although Mangahia, Serpentine and Rotomanuka have inherently higher educational values. Although Lake Cameron ranks as fifth on natural (and other) values, its absolute (as opposed to comparative) rating inevitably rises when it is understood that failure to establish a functional esplanade could result in its complete disappearance within less than 50 years.

Botanical descriptions are given for all lake margins and brief comments are made on lakewater depth and quality (= condition). The DOSLI library was used to compare 1943 and 1992 aerial photographs in order to establish recent historical (= actual and presumably legal) lake boundaries. A peat corer was used to confirm locations of lake edges and to roughly assess peat depths in relation to current lake levels and esplanade viability.

It is suggested that esplanade reserves should nowhere be set at less than 20 metres. We have specified this width when it coincides with the extent of current natural/semi-natural wetland boundary, when it is considered an adequate width to protect the lake from

physical damage, and when a greater width would probably not greatly increase the retention of nutrient inflows for the catchment.

However, in most cases we believe that wider esplanades would better enhance landscape and wildlife values, provided that rehabilitation (planting schemes etc) is properly done to avoid reversion to bramble and gorse thickets on drier land and expansion of willow stands on wet.

Where the existing natural/semi-natural margin is wider than 20 metres, we have usually recommended retaining all of it, up to about 50 metres. Contrary to the view expressed by Buxton (1991) esplanades should generally be wider on flat land than on sloping terrain.

Four of the lakes have peat margins and these must be treated differently again. In general a 50 metre minimum esplanade is appropriate, with drainage restrictions over a further 50 metres. Additional studies are needed on a lake by lake basis to confirm esplanade widths on peat and to compile more detailed management guidelines for peatland and wetland margins. For example, all drains entering lakes should be 'teed-off' to parallel drains well before the lake; esplanades should comprise part herbaceous and part woody vegetation in order to maximise nutrient processing, but trees other than manuka should be avoided on deep peat.

Further development of drainage and scrub clearance at Mangahia and Serpentine should be halted until esplanades are confirmed.

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1. AIMS & OBJECTIVES OF INVESTIGATION

1.1 Original brief

To delimit esplanade reserves around lakes Mangahia, Rotomanuka, Serpentine, Ruatuna and Cameron. The following brief was prepared by the Waipa District Council:

"In order to map the proposed esplanade reserves, it is necessary to define the extent of proposed reserve around each lake, as well as the depth of reserve necessary to maintain the ecological values of the lakes.

Furthermore, Council need to be able to justify (to the Planning Tribunal if necessary) the extent of esplanade reserve to be taken upon subdivision. In this respect it is necessary to enlist your services in order to physically outline the extent and depth of any proposed esplanade reserve based upon the comprehensive field survey of the- lakes you have recently completed.

As can be seen in the attached draft planning maps, some of the peat lakes are already bound by reserve, therefore meaning this mapping exercise will be restricted to the remaining riparian margins of the significant lakes.

It is also recognised that the current ecological condition of each peat lake is different. It may therefore be necessary to provide for esplanade reserves of varying depths depending on the current condition of the peat lakes in relation to the adjoining landuses."

1.2 Extensions to brief

1.2.1 Delimiting esplanades would be a straightforward exercise if all lake margins were solid mineralised ground. We were aware that at least three of the five lakes had substantial peat margins, but the depth was unknown. Having inspected the sites, we concluded that for esplanades to be more than a mere planning exercise further detailed substrate studies would be needed in some cases. There is no point in establishing esplanades unless they have long-term viability. We conducted, therefore, preliminary substrate investigations beyond our original brief in order to be able to advise on the extent of further work required.

1.2.2 Studies of aerial photographs over a 50 years period showed that some lake margins had not been constant. Studies had to be directed towards establishing a justifiable definition of 'lake edge'.

1.2.3 It had been anticipated that detailed work on defining wetland/peatland margins for management purposes would come within a later brief. Problems of identity occurred during the present investigation which made it necessary to clarify terms and definitions right from the outset. We have attempted to do this as an extension to the present brief, although our Section 2 is subject to further scrutiny during later more comprehensive studies and deliberations.

1.2.4 We have offered rankings for the five lakes studies on the basis of natural ecological and landscape values.

1.2.5 During a visit to DOSLI (KT, Darby West and J.Z. Ratuszny) to enquire about the relationship between cadastral and ecological boundaries, we offered to assist with defining baseline lake levels by using botanical indicators. We have tested our ideas out in Rotomanuka, Serpentine and Mangahia and we are satisfied that we can give fairly accurate estimates of both summer minimum and winter mean maxima from our knowledge of plant species tolerances of flooding conditions.

1.2.6 Lake Cameron was added after the original brief was costed. We did not adjust the costing.

2. DEFINITIONS

2.1 Wetland

We believe the most appropriate definition is that recommended by the Environmental Council (1983):

> "'Wetlands' is a collective term,for permanently or temporarily wet areas, shallow water and land-water margins. Wetlands may be fresh, brackish or saline, and are characterised in their natural and functional state by plants and animals that are adapted to living in waterlogged conditions"

This definition sets the condition that an area can only be a wetland if rooted emergent wetland plants predominate and wetland-characteristic animals are present.

An area can still be classified as wetland even if the substrate is not waterlogged for over half the year. Winter/early Spring flooding is still a sufficient stress to eliminate most mesophytic (non-waterlogging-tolerant) plants. Seasonally flooded land may still be a wetland within the above definition.

As a forest ceases to be a forest when it is felled, a wetland ceases to be a wetland when it is drained and its characteristic species are replaced with non-wetland-adapted ones. Thus it is important to identify significant and valuable wetlands quickly, since 'development' through drainage and pasture establishment convert it into non-wetland.

However, all (former) wetlands can be re-created by raising water levels and re-establishing appropriate species (eg. the Sinclair Wetlands in Otago; Kimihia Wetland near Huntly).

2.2 Peatland

It is conventional to consider substrates with an organic content exceeding 50% as 'peat'. 20-50% carbon is often called an 'organic soil'. In America these are called 'muck' soils and they are usually associated with lake margins and groundwater wetlands. They are also subject to shrinkage when drained but the degree of shrinkage is less than for peats. All peats (but particularly acid ones) need massive fertiliser additions to sustain good pasture. This inevitably accelerates peat deomposition rates and leaks into groundwater and, ultimately, peat lakes. All unmodified peatlands are wetlands; acid peatlands have highly specialised plant species (see Thompson, NWASCO 1987). All peat substrates remain 'potential wetlands', since the removal of drainage alone will initiate ecological succession towards adapted species.

2.3 Esplanade Reserve

In the present study this is considered to have both structural and functional aspects. It is not only a strip reserved for public access, and a zone surrounding a lake which improves the aesthetic value of the water body by placing it in a more natural setting. An esplanade is also interpreted as being a buffer zone to mitigate/filter the influence of outside activities such as drainage (stormwater runoff, point-source nutrient input) and stock rearing (grazing, diffuse-source nutrient input): a protective interface between land and water mediating between the intensive commercial development on land and the pre-eminence of natural ecological values in water.

We consider that since all lakes have annual seasonal maxima and minima, as well as extreme flood and drought levels, no esplanade in the Waipa District can be less than 20 m (cf. the old 'Queen's Chain') in width. This must be extended to at least 50 m on peat substrates (in most cases much more than this, but minimal commendations must be site-specific). Thus the width of a functional and effective esplanade is at least partly determined by the nature of the substrate.

All esplanade zones are largely, or at least partly, wetland for a significant part of the year. This wetland may be characterised by native plant species (such as manuka, Coprosma, tussock sedge, raupo) or indigenous exotics (such as willows, Glyceria, mercer grass).

However, esplanade design should also preserve and enhance wildlife, botanical, scientific and educational values. In this respect, we note that not a single lake in the Waipa District has a full natural, succession: from 'dry' (= mesophytic) forest to 'wet' (manuka/cabbage tree/coprosma/willow). We have not in this report specifically recommended re-establishment of native dryland forest, but some of our esplanades do extend to dry land where the minimal 20 m width exceeds the width of the wetland margin. Esplanades on dry land would need deliberately revegetating or they would quickly revert to unsightly gorse and bramble. If revegetation is considered to be feasible financially we would strongly support a dryland extension of the esplanade at least at Lake Serpentine. In any case, there would be good reason for trying to ensure that all drains terminate on dry land rather than in wetland fringe.

Where necessary, monitoring of lake quality and vegetation performance, rehabilitation programmes, and other management activities, should be undertaken in order to maintain the integrity and effectiveness of esplanades. The need for such procedures will vary with substrate characteristics, vegetation type, lake and esplanade values, catchment area and slope and lake depth and water residence time. These needs will be addressed in greater detail at a later date, and after further field investigations.

2.4 Lake

The definition is not as obvious as it may at first seem. Firstly, lake depths vary seasonally; secondly, most lakes have marginal emergent plants which grade into wetlands; thirdly most Waipa lakes are dynamic in that areas of open water and marginal vegetation have in several cases changed significantly during the last 50 years, so that a historical perspective is also needed to define lake boundaries.

Accordingly, we have had to apply, once again, site-specific criteria. For instance, the reeds *Eleocharis* and *Typha* are both considered to be species characteristic of lake margins, whereas willows usually characterise 'solid' substrates above mean lake level. There are occasional exceptions, as at Mangahia where some willows are rooted on a recently developed floating vegetation mat.

Consequently, we have also applied substrate criteria in defining lake margins: using a peat borer we have been able to identify the recent history of a lake margin from the sediments and the plant remains preserved therein. Aerial photographs over a 50 years period, together with substrate cores, have enabled us to establish recent historical lake levels, which are much more meaningful than the current indications of often highly dynamic systems undergong rapid change through present and progressive catchment changes.

We therefore define 'lake edge' on the basis of both vegetation and substrate criteria. 'Plant indicators' are also used to locate maximum normal flood levels (eg. moss and lichen bands on tree-trunks, distribution of hydrophilic species such as the aquatic rush *Juncus bulbosus*, or hydrophobic species such as bracken and bramble.

2.5 The Functional Lake Margin

Most of the characteristics and specifications have already been covered. They are summarised here:

(a) Margin must embrace maximum lake level, up to (approx.) 10 year return periods.

(b) Margin must have a natural or semi-natural vegetation, ideally a succession from herbaceous species near the lake to woody species beyond. This will maximise wildlife/botanical/landscape values. A dryland component would be ideal.

(c) Drains should carry stormwater only. Dairyshed, and other concentrated wastewaters, should not be discharged to drains directed towards lakes. Drains should terminate in a 'T' well before the lake, so that point-source discharges are eliminated and water is 'filtered' to lakes through surface and sub-surface diffuse flow. Even stormwater discharges will have relatively high nitrogen levels after passing through intensive pasture.

(d) For margins to function as effectively as possible as 'nutrient processors and filters', they should ideally include at least some herbaceous wetland vegetation with a reasonably organic substrate, and all drains should be modified to provide diffused flow.

(e) Peat subsidence (by drainage and oxidation) must be halted adjacent to peat lakes, otherwise, in the medium to longer term, lake levels would have to be lowered to prevent flooding. This is especially the case at Serpentine (although this has no outlet) and Mangahia. We can provide examples from Waikato and Hawkes Bay Regions where this is a serious land-use problem.

(f) All margins must be effectively fenced and recreational use of the margins must be monitored so that damage does not occur to the functional system.

3 METHODOLOGY

Baseline resource material has included:

3.1 Vegetation maps prepared for the FORST-supported study. "Vegetation of the Waikato Lakes" (Champion, de Winton, de Lange, 1993).

3.2 1943 and 1992 series aerial photographs of the Waipa Lakes. Since some lake margins are not stable, recommendations in the present report have been based partly upon a historical perspective established by overlaying the two series of photographs. Earlier photographs have also enabled us to assess changes in lake quality from albedo and trends in vegetation community, as well as progressive erosion of marginal buffers through clearance and drainage.

3.3 Since the above FORST project had no management output, field visits were necessary to interpret the maps in terms of designing functional esplanades.

3.4 A problem arose because the original survey lines for the lakes appeared to be fairly arbitrary. This was confirmed after discussion with Mr Ratuszny, Land Transfer Surveyor at DOSLI. The lakes do not have agreed baselines. It was agreed that we would use plants as indicators of mean low and high water lake levels to establish lake margins botanically. All plants have specific environmental tolerances, and with respect to water levels they also integrate their experiences over several seasons. We agreed to determine lake levels botanically so that esplanades could be located precisely.

3.5 In addition, we have been able to substantiate historical perspectives obtained with aerial photograph overlays, with evidence gained from peat cores taken with a Girktorf peat borer. By identifying plant fragments in the cores, and using the clear distinction between mineral substrates (usually water-borne), organic sediments deposited under water, eutrophic (high nutrient) peats and oligotrophic (bog) peats, we are able to confirm lake history and assess the future stability and survivability of lake margins. This technique was particularly valuable at Mangahia in confirming the historical (and presumably cadastral) lake margin.

We are aware that the NZ peatlands survey in 1987 (Davoren, McCraw & Thompson) reported on both Rukuhia and Moanatuatua Bogs, but the detail of this study was insufficient to be of value in the present evaluation.

3.6 Some simple assessments of the lakes have been made. "Secchi disc reading" refers to the visibility of a black and white quartered disc progressively lowered in the water until it disappears from view. It is therefore a measure of transparency or (conversely) turbidity. Among other terminology, "bog peats" are more acid (pH 3-5) and low in nutrients ('oligotrophic' - supplied only with rainwater); "lake peats" are less acid (pH 5.5 - 7) and higher in nutrients ('mesotrophic' or 'eutrophic' - supplied also by groundwater flow). (See Thompson, 1987.)

4. LAKE STUDIES

4.1 Lake Cameron

4.1.1 Description

This lake has very few remaining natural values and would rank bottom of the five lakes in the present study on the basis of natural and wildlife/botanical values. The only remaining native dominated vegetation is a marginal sward of *Carex secta* occupying the north western shore of this lake. Pussy willow (*Salix cinerea*) formed the dominant marginal vegetation and due to a prolonged period of fencing a diverse understory, including the native kahikatea (*Dacrycarpus dacrydioides*), cabbage tree (*Cordyline australis*) saplings and seedlings, *Coprosma tenuicaulis*, *Baumea tenax*, *Carex secta*, *Blechnum minus* and *Hydrocotyle novae -zelandiae.* Marginal plantings of swamp cypress (*Taxodium distichum*), tortured willow (*Salix matsudana*),

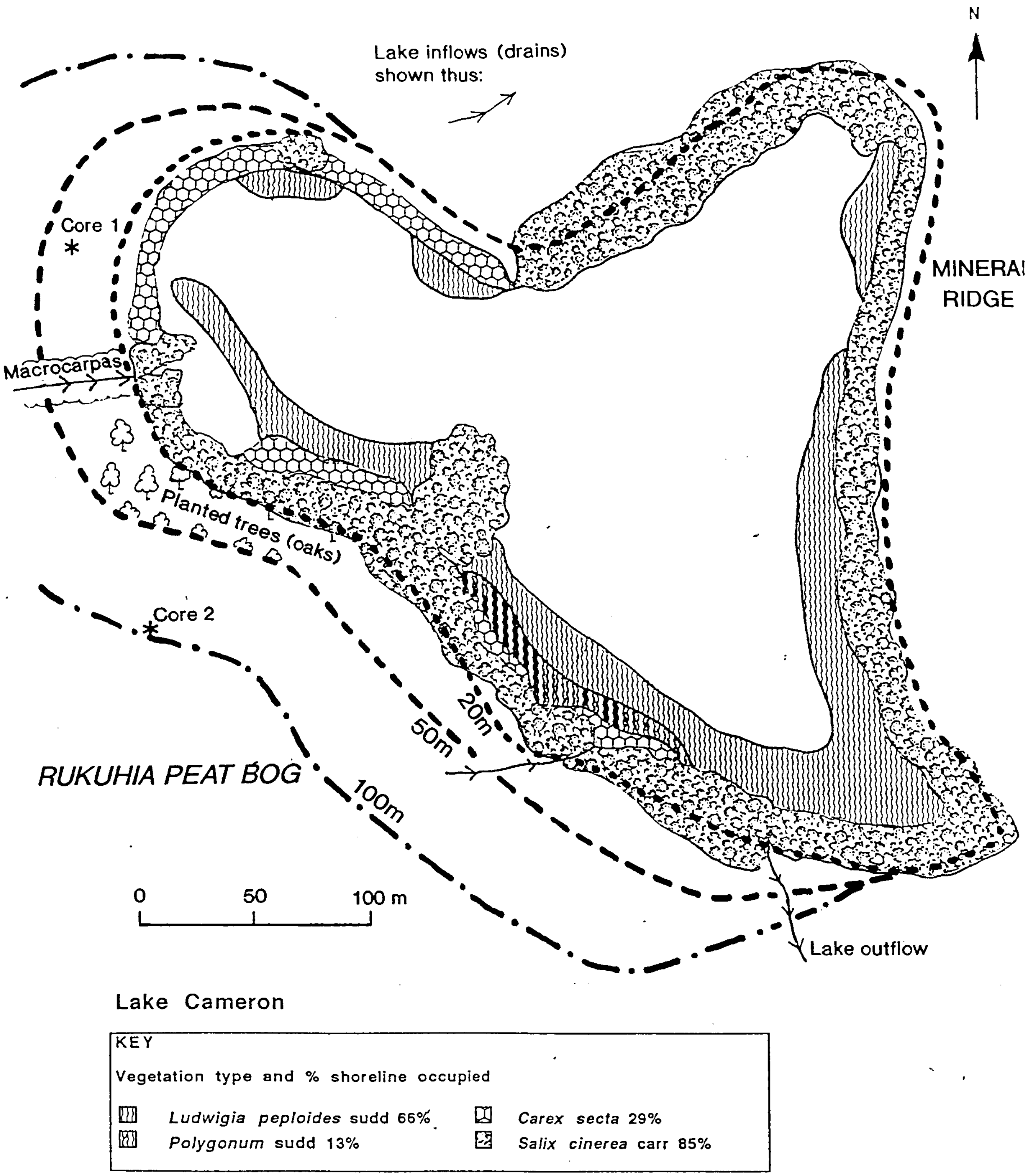

N
Lake inflows (drains)
shown thus:
Core 1
MINERA
RIDGE
Macrocarpas
Planted trees (oaks)
Core 2
20m
50m
100m
RUKUHIA PEAT BOG
0
50
100 m
Lake outflow
Lake Cameron
KEY
Vegetation type and % shoreline occupied
Ludwigia peploides sudd 66%
Polygonum sudd 13%
Carex secta 29%
Salix cinerea carr 85%

Figure 1

swamp oak (*Quercus* sp.) and other species were noted in, and adjacent to, this willow zone. Outside much of this marginal vegetation, a floating mat (sudd) of the introduced primrose willow (*Ludwigia peploides*) has developed. At the time of this investigation (May/June) this sudd had mostly decomposed, reflecting the seasonal nature of this plant.

Aerial photographs of Lake Cameron taken in 1943 show the lake to be dark coloured, indicating low levels of suspended solids and a predominant peat influence (dystrophic character). The 1992 aerial photograph shows high levels of suspended solids (brown, turbid character) also indicated by low transparency (Secchi disc of 0.38 m) and the absence of submerged vegetation. The early photograph (1943) shows remnant patches of manuka (*Leptospermum scoparium*) around the western edge of the lake but the remaining area was even then already converted to pasture. The complete absence of emergent vegetation in this lake is unusual. It could well suggest a rapid lowering of lake level in recent years, with obvious implications for future management.

Two sediment cores were tkane along the western side of the lake to ascertain the peat influence on the margin of Lake Cameron which faces the Rukuhia Peat Bog. The northern and western margins are bounded by mineralised soils. The first core was taken in a poorly drained pasture with the watertable at 30-40 cm; vegetation was dominated by the grass *Axonopus affinis* and the rush *Juncus effusus,* with occasional patches of the peat moss *Sphagnum cristatum*. The first 2 m of core comprised a eutrophic peat possibly formed by *Eleocharis* or *Baumea* grading at 3 m into mineralised lake sediments representing the historical lake bed (possibly 2500 yr BP). The second site was situated in good ryegrass/clover pasture approximately 1.0 m above the present water table and 1.5 m above lake level. The first 2 m comprised unconsolidated peat, probably of Rukuhia (bog) origin rather than from lake marginal vegetation. At 2 m solid wood was struck possibly relating to the swamp forest vegetation prior to peat encroachment. The depths of peat in Core 2 were interesting, because although the paddock surface was well above lake level, peat base was still well below it. We assumed that the slope towards the lake occurred too far from the lake edge, and must therefore have been caused by planted trees and self-seeded willows accelerating peat breakdown through oxidation.

4.1.2 Esplanade recommendations

The present willow and *Carex* boundaries should be retained to a minimum width around the visible lake edge of 20 metres. This does, of course, include some pasture. Assuming a conservative estimate for peat breakdown (shrinkage and oxidation) rates of about 10 mm per year under good pasture, in theory, much of the western margin would subside below present lake levels within less than 10 years if drainage were effective and continued.

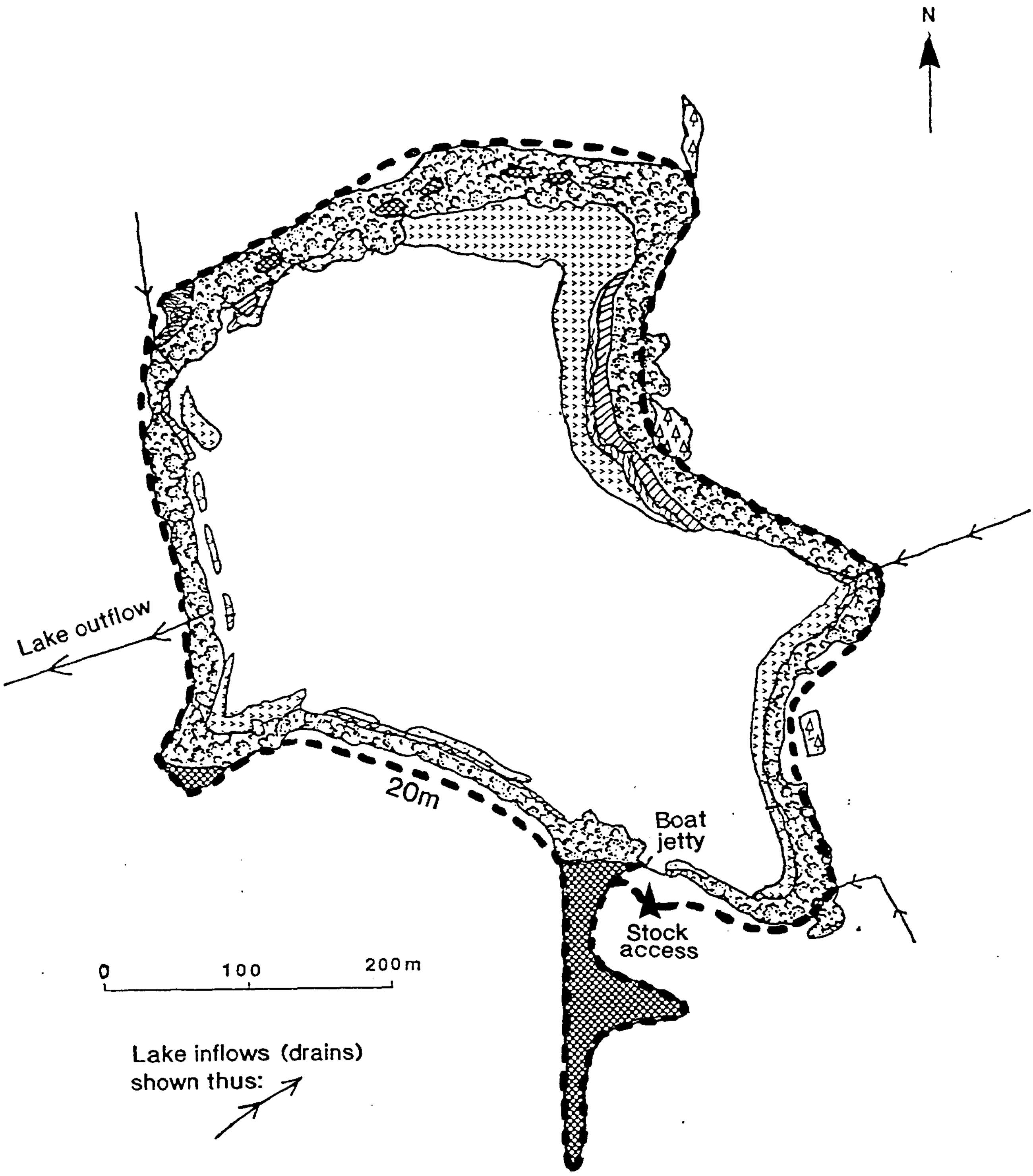
Even though the natural values of Lake Cameron rank lowest of any of the five water bodies studied, the lake is worth retaining for its landscape and (some) wildlife values. Since it is only 1.5 m deep its future is critically dependent upon land-use decisions taken now. Full rehabilitation would be more expensive than for any of the other lakes, and yet failure to enact some controls will result in complete loss of the lake within a relatively short time. All of the Rukuhia peat bog is subsiding at the 10 mm minimal rate (average more likely 20 - 25 mm). Ultimately, survival of Lake Cameron will depend upon retaining a sufficient actively-growing peat barrier to prevent drainage. At this stage, we could recommend reducing tree dominance along the lake margin and replacement with a manuka and herbaceous fringe, plus an immediate esplanade of 50 metres, with drainage restrictions extending to 100 m. Lowering of the lake level should not be permitted.

In other words, the decision with Lake Cameron is not so much whether or not to enhance it - this is certainly possible, but not easy - but whether to retain it at all. To retain it is in the longer term is likely to involve an immediate esplanade of 50 - 100 m, with extension of this well within 25 - 30 years. These are conservative estimates. We would be able to report in more detail after further investigations.

4.2 Lake Ruatuna

4.2.1 Description

This lake would rank 4th of the five lake systems investigated regarding natural values. It is almost completely encircled by a marginal vegetation dominated by pussy willow, but with pockets of native flax



Lake Ruatuna

KEY

Vegetation type and % shoreline occupied

Typha 16%	swamp meadow 34%
Typha-Lycopus 3%	*Phormium* 15%
Eleocharis sphacelata 75%	*Salix cinerea* carr 88%
Bolboschoenus fluviatilis 2%	*Leptospermum-Cordyline* forest 3%
Ludwigia peploides sudd 16%	plantation 2%

Figure 2

(*Phormium tenax*), raupo (*Typha orientalis*), and a manuka/cabbage tree community on the northern side of the lake. Emergent species were common around the lake growing to depths of 1 m. The commonest major emergent was *Eleocharis sphacelata,* with raupo and purua grass (*Bolboschoenus fluviatilis*) also forming swards above the water. Few submerged plants have ever been found in this lake, although a very localised community of *Nitella hookeri* was recorded in 1991. The secchi depth is only about 45 cm, so it is not surprising that underwater vegetation is limited.

From observations of the Ruatuna catchment, it would appear that there has been no direct connection with the Rukuhia Peat Bog. 1943/1992 aerial photograph comparisons indicate that the lake marginal areas have remained constant over this period, suggesting that mineralised soils or local eutrophic peats influence the waters of this lake rather than acid peat deposits.

4.2.2 Esplanade recommendations

The margins of this lake are almost entirely mineralised and the shores are stable. Marginal vegetation is generally poorly developed, and the transition to dryland communities is abrupt. Its natural values at present are not high. However, it is used extensively by educational groups and this alone could justify effort towards enhancement of its natural values, character and quality.

Whilst we recommend a minimum esplanade of 20 m, with inclusion of the indigenous vegetation outside 20 m along the northern margin, we think that greater efforts should be made to protect and rehabilitate this lake. We understand that the Council controls the outlet weir level, and it is imperative that this arrangement should continue (with no lowering). We recommend further studies on the catchment to locate and assess drainage inputs and to evaluate potential for further enhancement of the marginal zone. This could involve restricting stock access and initiating planting programmes through, perhaps, the educational groups using the lake.

4.3 Rotomanuka lakes

4.3.1 Description

This area comprises two lakes (Rotomanuka and Gin), separated by a shallow, seasonally flooded wetland area with peripheral manuka and pussy willow (*Salix cinerea*) vegetation. Lake Rotomanuka is incompletely fringed by a narrow zone of pussy willow, with planted weeping willow (*Salix babylonica*) and, on the southern shore, a significant manuka dominated scrub. Inside the woody vegetation, the aquatic emergent reed raupo forms an almost complete fringe in shallow water around the lake, to depths of 1.8 m. *Eleocharis sphacelata* is more restricted in distribution forming a deeper water fringe outside the raupo. *Baumea articulata* occurs in small pockets between the raupo and manuka zones.

Lake Rotomanuka is the clearest (Secchi 3.50 m) and deepest of the Waipa Lakes and is the last remaining lake with dense submerged vegetation. Clearly, depth is a significant protection against eutrophication and loss of water clarity. As a general principle, lake management must aim at maintaining depth, volume and throughput, in order to retain water quality. Throughput is not possible with Rotomanuka or Serpentine (no outputs) so depth becomes critical as a safeguard.

This lake is the only Waipa Lake to have a dense submerged sward of the exotic oxygen weed *Egeria densa,* but native submerged species still persist too (eg. *Potamogeton cheesemanii, Nitella hookeri, Utricularia australis*). The submerged vegetation is one of the greatest values of Rotomanuka (the bladderwort *Utricularia,* for instance, is no longer found in any other Waipa lake) and this is therefore a good argument for making a significant effort to protect the lake from further deterioration.

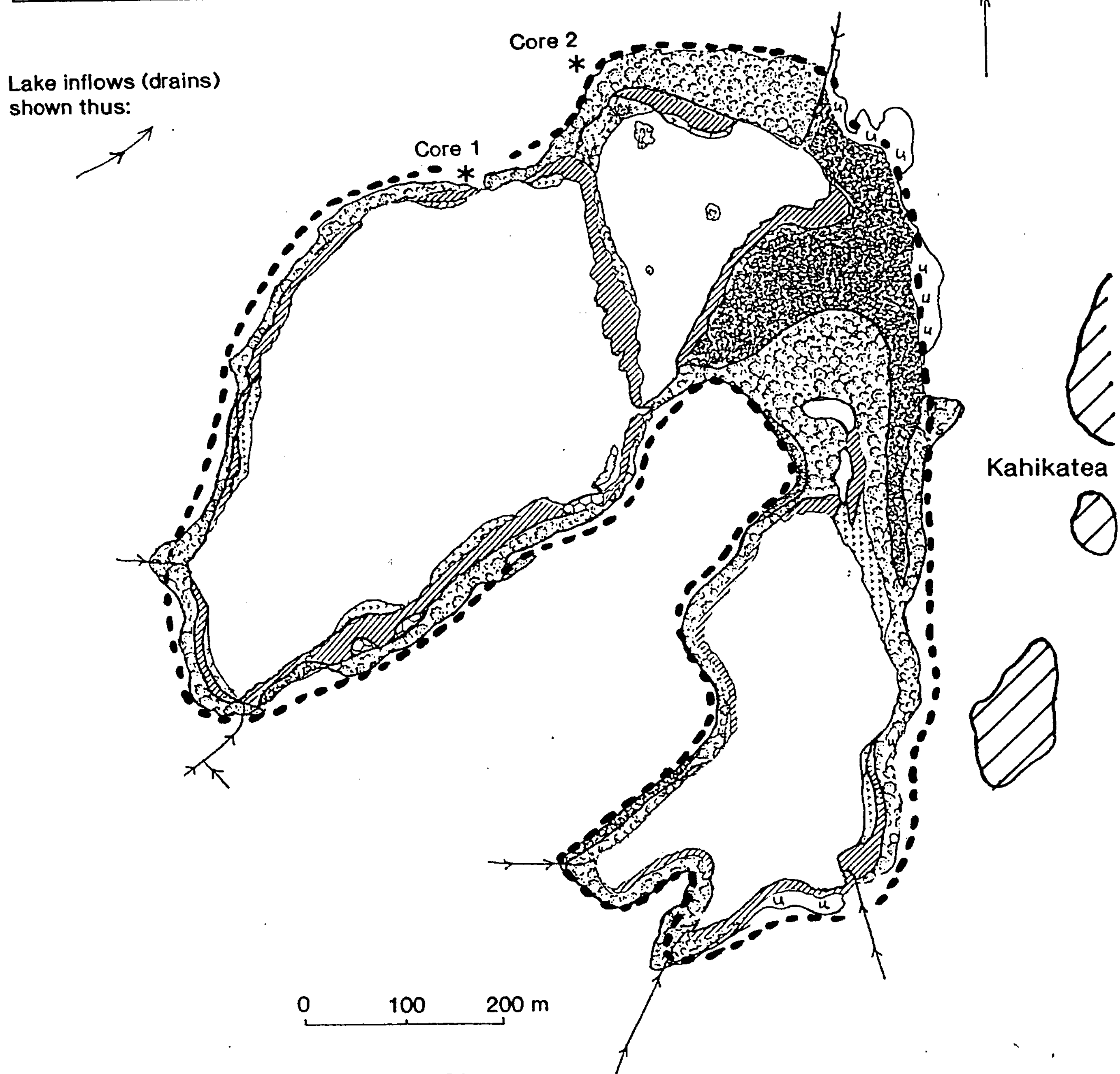
The closely associated Lake Gin, on the other hand, appears from sequential aerial photographs to have suffered considerable deterioration. Gin Secchi reading is only 60 cm, but Rotomanuka is still 3.5 metres.

Lake Rotomanuka

KEY

Vegetation type and % shoreline occupied

- *Typha* 92%
- *Eleocharis sphacelata* 53%
- *Baumea* sedgeland 6%
- swamp meadow 5%
- *Salix cinerea* carr 62%
- *Leptospermum* scrub 6%



Lake Gin

KEY

Vegetation type and % shoreline occupied

- *Typha* 59%
- *Eleocharis sphacelata* 28%
- *Salix cinerea* carr 45%
- *Leptospermum* scrub 54%
- *Ulex-Rubus* scrub 22%

Figure 3

Lake Gin has a corresponding paucity of submerged plants, with only small, scattered beds of *Egeria, Potamogeton* and *Nitella*. There are three major drains feeding into Lake Gin and these are likely to be implicated in the greater deterioration. By contrast, the major inputs to Rotomanuka come from a drain entering the linking wetland, which consequently acts as a buffer. The marginal vegetation of Lake Gin is similar to Lake Rotomanuka.

The area between the two lakes has considerable botanical values and must also be a major wildlife habitat for waterfowl and other birds. It should certainly be included in the protected area and even enhanced if possible.

Sediment cores were taken on the northern side of Lake Rotomanuka and of the adjoining wetland (see map). Close to the lake, a shallow peat deposit representing a lake margin vegetation overtopped a mineral soil, but in the second core, further from the lake, 1.5 m of oligotrophic (acid) peat overtopped this underlying mineral layer. This bog peat represents the fringe of the Moanatuatua Bog, and confirms that Rotomanuka too is a lake closely associated with deep peat deposits which may be critical to the lake's survival.

4.3.2 Esplanade recommendations

Due to the rapid transition from lake to dry mineral soils and pasture over much of the lake margin, a 20 m esplanade would be recommended in the first instance for the Rotomanuka Lakes. The esplanade is measured from the mean winter water level, as assessed by indicator plant species.

Further investigations are needed to discern which drains would need attention to prevent further deterioration of Lake Gin in particular. The relatively pristine waters of Lake Rotomanuka would also be further protected by investigating the present inflows around the lake, and preventing further drainage within the catchment. We see this as a very high priority.

The extent of peat influence along the eastern margin needs further investigation before we can confirm esplanade width here. Any significant deposits will expand the protection zone to 50 - 100 m or more. Further enhancement would be provided if a dry land area were reserved around these lakes and native species re-established. As with Lake Serpentine, Rotomanuka is well worth the additional enhancement of native dryland forest around the wetland margin. This extra protection would provide a further buffer for a lake which is still in remarkably good condition. However, without such additional dryland protection, and strict drainage controls, we would expect deterioration to be progressive over the next two decades, as has occurred at Lake Maratoto.

4.4 Serpentine Lakes

4.4.1 Description

The Serpentine complex is made up of three lakes linked by a seasonal wetland predominantly vegetated by the emergent sedge *Eleocharis sphacelata.* The southern and eastern lakes appear to be surrounded by mineralised soils and have a marginal vegetation dominated by manuka and swamp meadow assemblages. Active willow clearing on the western wide of the southern lake has increased the swamp meadow area but evidence of regrowth suggests that reversion to pussy willow will occur in a relatively short time period. Flax plantings around the southern and eastern lakes comprise the remaining marginal vegetation except for a grazed margin of *Carex demissa* on the eastern shore of Lake Serpentine South. The northern lake has a complete woody marginal vegetation comprised of pussy willow, manuka and occasional kahikatea. *Eleocharis sphacelata* is the dominant emergent with raupo restricted to drain inlets on Lake Serpentine South. *Baumea articulata* forms a large sedgeland around the southern lake and the adjacent wetland.

Sparse submerged vegetation was noted in all three lakes including *Potamogeton ochreatus, P. cheesemanii, Nitella hookeri, Chara corallina,* one record of *C. fibrosa* from Serpentine North and *Myriophyllum propinquum*. Unlike Lake Rotomanuka, all the species from these lakes were native. All the lakes exhibited peat staining with secchi depths of around 1 m. Sediment cores near Lake Serpentine (see map) revealed peat of at least 3 m depth.

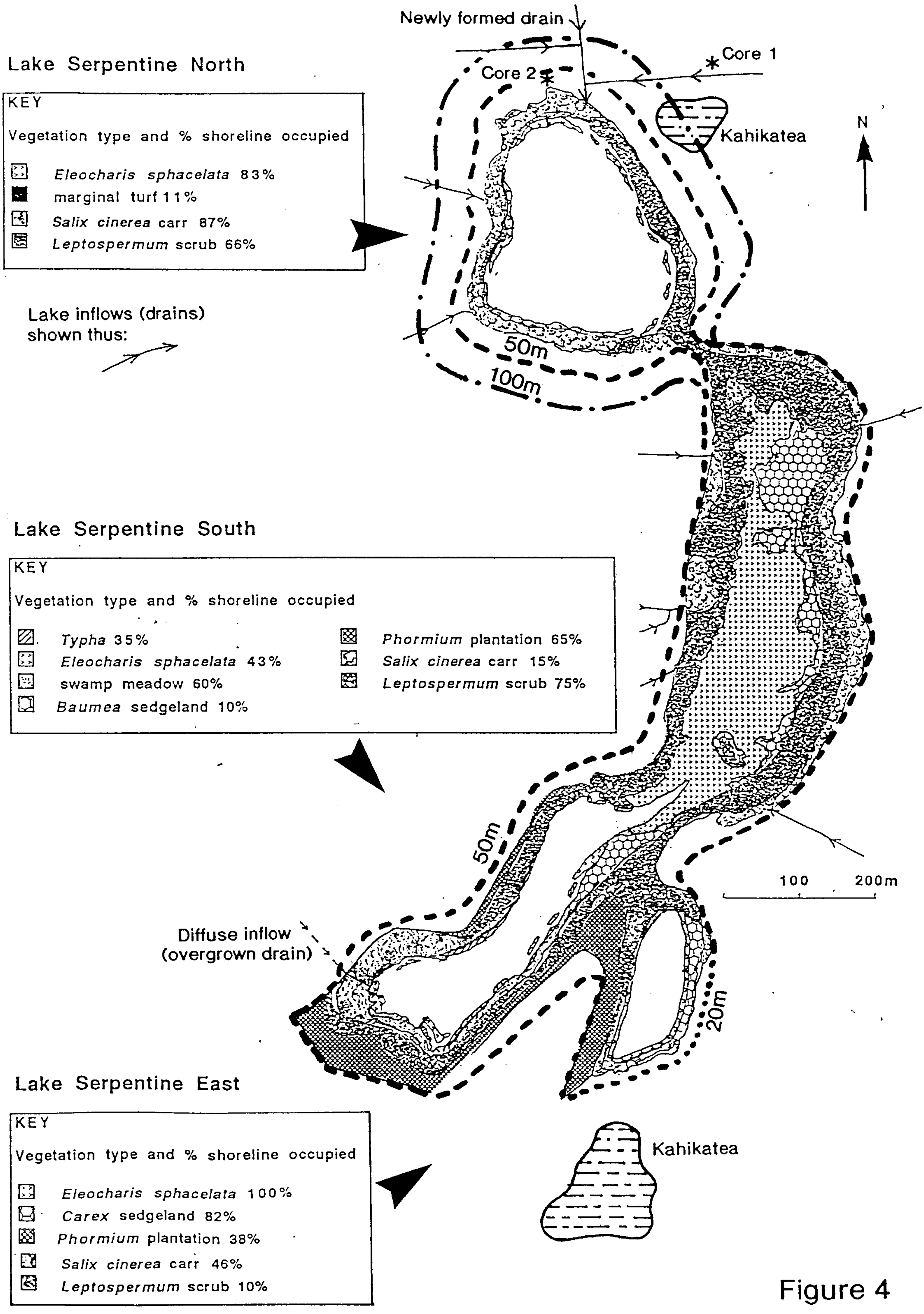

Newly formed drain
Core 1
Core 2
Kahikatea
N
Lake Serpentine North
KEY
Vegetation type and % shoreline occupied
Eleocharis sphacelata 83%
marginal turf 11%
Salix cinerea carr 87%
Leptospermum scrub 66%
Lake inflows (drains) shown thus:
50m
100m
Lake Serpentine South
KEY
Vegetation type and % shoreline occupied
Typha 35%
Eleocharis sphacelata 43%
swamp meadow 60%
Baumea sedgeland 10%
Phormium plantation 65%
Salix cinerea carr 15%
Leptospermum scrub 75%
50m
100 200m
Diffuse inflow (overgrown drain)
20m
Lake Serpentine East
KEY
Vegetation type and % shoreline occupied
Eleocharis sphacelata 100%
Carex sedgeland 82%
Phormium plantation 38%
Salix cinerea carr 46%
Leptospermum scrub 10%
Kahikatea

Figure 4

4.4.2 Recommendations

The existing vegetation margin surrounding Lake Serpentine South is adequate to filter diffuse nutrient enrichment from the surrounding pasture although provision of 'T' junctions to drains before the edge of this vegetation would also remove 'point source' additions to this lake. A 50 m esplanade would encompass this marginal vegetation around the Southern Lake and adjoining wetland. Lake Serpentine East still receives direct grazing on the eastern shore but a 20 m fenced esplanade, revegetated with manuka would suffice to renovate this lake. The northern lake provides major future problems due to the thickness of peat around its northern (and possibly other) margins.

Core 1 (Figure 4) is only 100 m from Serpentine North, but reveals peat to a depth of over 3 m. Core 2, on the Reserve boundary, is still in excess of 2 m, with a base well below the present lake level. The peat type is peculiar and needs further study beyond the scope of the present report; however it is not an acid peat at these points.

We are quite concerned about the recently completed drainage work in paddocks at the northern end. Some of this may have to be undone if our esplanade recommendations are accepted. However, apart from our general guideline of 50 m on peat and some drainage restrictions over a further 50 m, we cannot confirm the esplanade recommendation for Serpentine North (and possibly part of the eastern margin of the wetland too) until further coring has been done.

The Serpentine Lakes rank second in terms of natural values among the lakes studied in this report. We therefore consider a 50 metre esplanade to be appropriate around most of the lake margin. This would leave some scope for some revegetation to native dryland forest around the western margin of Serpentine South. On the Eastern margin of this lake we have placed the outer esplanade boundary outside the existing semi-natural vegetation and our inner boundary is placed at the outer fringe of the *Eleocharis* and *Baumea* communities (as explained under earlier definitions, these two communities are regarded as 'lake'). At some points our eastern esplanade is therefore in excess of 50 metres. We see it as a purely administrative matter to decide either upon an esplanade width equivalent to all remaining natural/semi-natural vegetation, or

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