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Gippsland Lakes
Shore Erosion & Revegetation Strategy

Final Report; June 2002

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Gippsland Coastal Board

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EXECUTIVE SUMMARY

The Gippsland Lakes are one of Victoria's best known environmental and tourism resources. Covering approximately 340 square kilometres with 350 kilometres of shoreline, the Lakes are a biologically diverse ecosystem recognised under the international Ramsar Convention on Wetlands (Ramsar, Iran, 1971) and are an important destination for many migratory bird species protected by international agreements.

This Shore Erosion and Revegetation Strategy describes shoreline variability around the Gippsland Lakes, presents results of photographic comparisons and discusses a range of possible actions in response to shoreline change. This study builds on early analysis of shoreline change around the Gippsland Lakes undertaken by Dr. Eric Bird for the period 1957-83 (Bird, 1978 & 1983).

Ecological conditions within the Gippsland Lakes have changed considerably since creation of a permanent opening at Lakes Entrance in 1889 (Bird, 1983; CSIRO, 1998 & 2002). Increased water salinity (often in places reaching that of sea water) has resulted in extensive die-back of fringing reedbed vegetation, primarily *Phragmites australis*, around much of the shoreline. The loss of energy-absorbing fringing reedbed has exposed adjacent shoreline vegetation, most commonly *Melaleuca ericifolia* dominated Swamp Scrub thickets, to greater wave energy, causing undermining of the highly erodable, unconsolidated, silty and sandy substrate, subsequent collapse of standing vegetation, and ultimately resulting in erosion around much of the Gippsland Lakes.

Global warming due to an enhanced "Greenhouse Effect" is predicted to cause sea level rise (depending on various scenarios) in the order of 3cm to 14cm for the period 1990 to 2025; 5cm to 32cm for the 50 year period to 2050; and between 9cm and 88cm for the hundred year period up to 2100 (IPCC, 2001). Any consideration of shore erosion around the Gippsland Lakes must clearly take into account the implications of rising sea levels, where the effect will be most dramatic in the many low-lying areas surrounding the Lakes.

From field investigation and comparison of aerial and historic photography, the vast majority of the Gippsland Lakes shoreline continues to change as *Phragmites australis* reedbeds retreat further and erosion persists. Deltas on the Latrobe, Avon, Mitchell and Tambo Rivers and on McLennan Strait all show evidence of continuing erosion. Other areas of substantial erosion include, Roseneath Point, Swell Point, Storm Point, west of Avon River / Clydebank Morass, Marlay Point, west of Loch Sport, east of Loch Sport, Luff Point, Harrington Point, northern Raymond Island, Point Fullarton, Tambo Bluff and the northern shores of Jones Bay. Spits and sandy cuspate forelands along the northern and southern shores of Lake Victoria continue to migrate eastward. Annotated aerial photograph comparisons in Photographic Set #1 indicate the amount of erosion for each site.

The erosion and breaching of banks separating isolated freshwater wetland ecosystems from the balance of the Lakes (e.g. Wild Dog Shore, Lake Wellington) may result in intrusion of saline water into such wetlands, potentially causing altered water regimes, altered water quality, possible loss of fringing reedbeds and modified wildlife habitat.

Evidence of shoreline accretion is rare, the largest being several metres along the sandy eastern shores of Lake Wellington, north of McLennan Strait.

Selected sites around the Gippsland Lakes have already been protected using a range of structures of varying types including sea walls, rock rubble, rock, timber and brushwood groynes, and tyre barriers. Extensive armouring of the Mitchell River Silt Jetties has been successful in preserving this geomorphic feature of international significance (Rosengren, 1984). In other locations (e.g. Broadlands, Jones Bay), tyre barriers and ad hoc dumping of rock have been less successful.

It is apparent from field investigations that very few public infrastructure assets are threatened by erosion. Beach Road at Metung is one site that remains vulnerable. Degraded sea walls at Marlay Point boat ramp are in a state of disrepair resulting in minor erosion. The majority of foreshore infrastructure assets are located at townships where shoreline protection works have already been successfully implemented.

Shoreline erosion generally occurs along Crown land. Private land is threatened or being eroded at relatively few locations.

Response to shoreline change around the Gippsland Lakes should be based on an evaluation of the erosion risk, the value of the shoreline being eroded, cost effectiveness of protection measures, and the long term environmental implications of the response.

Response options include:

- Do nothing;
- Retreat / define minimum setback buffer;
- Revegetation (terrestrial and aquatic); and
- Engineering solutions.

A Response Matrix is presented (Table 3) as a means of determining the most appropriate response to shoreline change based on a variety of circumstances and should act as a decision framework for management agencies. Consistent with State Government policy outlined in the Victorian Coastal Strategy (NRE, 2002), the response matrix adopts a “retreat rather than protect” philosophy in most cases other than for key public assets. The onus for protection of private land generally lies with the landowner.

The Do Nothing option is recommended for the majority of the Gippsland Lakes shoreline. This recognises that much of the shoreline is public land forming part of extensive National/Coastal Parks or Reserves where erosion is an on going process which does not threaten key infrastructure assets or sites of biological significance.

Retreating, re-locating and defining setback buffers acknowledges the need to cater for ongoing erosion processes at sites where sufficient land exists to relocate assets or where development may occur at some future time. A range of setback buffer categories are listed in Table 5 and shown on Maps 1 – 3. Designation of a setback buffer along an eroding shoreline does not imply a prohibition on development within the buffer zone. Instead, any development proposed within the buffer must take account of the longevity of the development in relation to the expected rate of erosion and demonstrate what measures will be put in place to cater for any anticipated loss of land. To be effective as a management tool, setback buffers must be integrated into local planning policy.

Shoreline erosion around the Gippsland Lakes will continue to occur in the absence of protective fringing reedbeds. Hence an obvious aim would be to recreate the wave-baffling effect of fringing vegetation to halt and possibly reverse erosion, however a key issue centres on the type of macrophytes suitable for revegetation. *Phragmites australis* is clearly unsuitable given its die-back in the increased saline conditions of the Gippsland Lakes. To provide similar protection, alternative species must be tolerant to estuarine salinity regimes, robust against the effects of waves, strongly rooted to the lakebed, exhibit a growth form dense enough to baffle wave energy, and grow along the interface between land and water. The Strategy assesses various species, both native and introduced, but concludes that all have significant limitations. In particular, the potential adverse impacts of introducing non-indigenous species to the Gippsland Lakes, including genetically modified varieties of *Phragmites*, will need detailed investigation and agreement by all management agencies and stakeholders.

Terrestrial revegetation of eroding shorelines is recommended as a tool to slow the rate of erosion rather than halting it all together. Erosion will still occur in the absence of protective fringing macrophytes, particularly while plants are young with limited root zone development, thereby offering little resistance. Species selection for terrestrial revegetation should be based on the composition of the ecological vegetation class (EVC) representative of the area being revegetated. Common shoreline EVC’s for the Gippsland Lakes and suggested species for revegetation are listed in Table 6.

A variety of engineered shoreline protection works are recommended to arrest erosion at specific sites as detailed in Table 8. Options include construction of seawalls, groynes, rock rubble, shingle beaches and ongoing beach renourishment. Of critical importance in implementing engineered shoreline protection works is a clear understanding of the potential impact on coastal processes, particularly sediment transport patterns. Establishment of a sea wall or groyne may halt erosion or capture sand at one location but may also interrupt longshore sediment transport, thereby starving downdrift areas of sand supply and effectively relocating the problem.

Recommendations in the Strategy for ongoing investigation focus on repeating shoreline erosion assessments at 15 to 20 year intervals, establishment of permanent shoreline survey benchmarks, determining the suitability of introducing genetically modified macrophytes, detailed investigation into the likely impacts of enhanced Greenhouse Effect-induced sea level rise, and the consequence of large sand-rich bedloads migrating down many of the rivers entering the Gippsland Lakes.

In summary, shorelines around the Gippsland Lakes continue to change as a result of both natural and man-induced processes. Erosion rates will vary depending on site-specific characteristics with low lying silty river deltas, wetlands and salt marshes most at risk. Sandy points, spits and headlands will continue to migrate eastward under the influence of prevailing wind and waves. Wetlands separated from the main lakes by narrow sandy barriers are potentially threatened by further erosion. Wild Dog Shore is particularly vulnerable as very little additional erosion will result in Lake Wellington "expanding" into extensive adjacent wetlands. Much of the Gippsland Lakes will ultimately exhibit a narrow sandy fringing beach as sand is liberated by erosion of sandy shorelines.

Engineering solutions are recommended only where erosion threatens high-value infrastructure assets, or the ecological character of a site, or where erosion will result in large scale changes to estuarine/fluvial processes. Further detailed site-specific design will be required in many instances prior to implementing engineered shoreline protection works.

In the longer term, the extent of shore erosion will increase dramatically as the anticipated sea level rise due to enhanced Greenhouse Effect begins to take effect by the middle of this century.

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1 INTRODUCTION

1.1 Background

The Gippsland Lakes are one of Victoria's best known environmental and tourism resources. The Lakes are a biologically diverse ecosystem recognised under the international Ramsar Convention on Wetlands (Ramsar, Iran, 1971) and are an important destination for many migratory bird species protected by international agreements. The Lakes offer boating, fishing, camping and swimming experiences as well as important port and commercial fishing opportunities.

The Gippsland Lakes comprise Lake Wellington, linked by McLennan Strait to Lake Victoria, and Lake King. Together they form the largest inland navigable waterway in Australia covering approximately 340 square kilometres with a catchment of 20,600 square kilometres, about 9% of Victoria's total land area. There is approximately 350 kilometres of shoreline around the Lakes.

Ecological conditions within the Gippsland Lakes have changed considerably since creation of a permanent opening at Lakes Entrance in 1889 (Bird, 1983; CSIRO, 1998 & 2002). Increased salinity has resulted in extensive die-back of fringing reedbed vegetation (primarily *Phragmites australis*) around much of the shoreline. The loss of energy-absorbing fringing reedbed has exposed adjacent shoreline vegetation (primarily *Melaleuca ericifolia*) to greater wave energy, resulting in shoreline erosion. A range of structures including sea walls, rock rubble and timber groynes have been established to protect selected eroding areas, although the vast majority of the Gippsland Lakes shoreline remains in a natural state.

1.2 Scope and Objective of Investigation

The Gippsland Lakes Shore Erosion and Revegetation Strategy is an initiative of the Gippsland Coastal Board (GCB) resulting from the Gippsland Lakes Coastal Action Plan (GCB, 1999)

in association with the Department of Natural Resources and Environment, and Parks Victoria.

The Strategy examines the shores of Lake Wellington, McLennan Strait, Lake Victoria, Lake King, the Mitchell River silt jetties, Cunningham Arm and North Arm. The Strategy objective is to:

- Identify foreshore areas which are stable, eroding or accreting;
- Identify the extent of lakeshore erosion since 1935/40;
- Prioritise areas for protection;
- Identify and prioritise those areas in need of engineering protective works and recommend appropriate techniques; and
- Identify and prioritise those areas requiring revegetation protection works and recommend appropriate techniques.

Excluded from the study area are rivers, the township foreshore at Loch Sport and existing sea walls and structures adjacent to main township areas such as at Bancroft Bay - Metung, McMillan Strait - Paynesville and the north shore of Cunningham Arm – Lakes Entrance.

The Strategy outlines the study methodology, describes shoreline variability around the Gippsland Lakes, presents results of photographic comparisons and discusses a range of possible actions in response to shoreline change.

1.3 Previous Investigations

Shoreline change around the Gippsland Lakes has previously been analysed by Dr. Eric Bird for the period 1957-83 (Bird, 1978 & 1983). This current study builds on that early work.

Two recent investigations undertaken by CSIRO detail the environmental condition of the Gippsland Lakes (CSIRO, 1998) and assess options for improving water quality and ecological functioning of the Gippsland Lakes (CSIRO, 2001).

Ladd et. al. (1976) provide a comprehensive description of vegetation types surrounding the Gippsland Lakes and Lake Tyers. Historic changes in extent of fringing shoreline vegetation have been documented by Bird (1961). The Department of Natural Resources and Environment has in recent years completed detailed mapping and description of ecological vegetation classes surrounding the Gippsland Lakes (NRE, 2001). This and other land management data is presented on the Gippsland Coastal Board's coastal mapping series (GCB, 2001).

Detailed shoreline survey of Raymond Island over a ten year period has been documented by Grace (2000).

1.4 Methodology

1.4.1 Methodology

In preparing the Gippsland Lakes Erosion and Revegetation Strategy the study team undertook the following methodology:

- Reviewed existing literature including previous shoreline change reports and technical reports concerning revegetation and restoration of wetlands;
- Acquired (loan) available aerial photography;
- Liaised with key stakeholders (through steering committee representatives);
- Undertook detailed field inspections to –
    - determine erosional state of shoreline (ie eroding, stable, or accreting),
    - determine shoreline and vegetation type,
    - capture digital photos of shoreline,
    - assess condition of existing rock or timber sea walls;
- Determined shoreline change from –
    - comparison of available aerial photography covering the period 1935-40 to 1997,
    - comparison of historic photos with new land and boat-based digital photographs of the same location;
- Results are presented in tabular form and colour prints of photographic comparisons;
- Recommendations are presented as text, in tabular form and as maps.

The study team was guided in preparation of the Strategy by a steering committee comprising representatives from the Gippsland Coastal Board, the Department of Natural Resources and Environment, Parks Victoria and Gippsland Ports.

1.4.2 Limitations

Certain limitations impact on the completeness and accuracy of the Strategy.

Aerial photography sets held by NRE were often incomplete or absent, presenting a considerable limitation on data availability. Furthermore, not all aerial photography sets were flown to cover the entire Gippsland Lakes. Comparisons have therefore been made using the 1997 photographs against the most appropriate year to achieve, where possible, a regular time interval.

Earlier aerial and land-based photographs were sourced from Dr Eric Bird's private collection.

Low resolution aerial photography, particularly from older sets, does not allow minor shoreline change to be detected. The limit of accuracy is generally in the order of ± 5 metres.

Inability to identify fixed reference features also hampers accurate comparisons.

Assessment of shoreline change is further limited by short term and seasonal variability in shoreline position, particularly sandy shores, and by the difficulty in interpreting shoreline position during times of high water level and minor floods.

Data from earlier shoreline measurements and comparisons by Dr. Eric Bird could not be retrieved from departmental archives. Hence, re-survey of former shoreline transects was not possible.

2 GIPPSLAND LAKES: A CHANGING ENVIRONMENT

2.1 The Changing Gippsland Lakes Environment

The Gippsland Lakes is a highly dynamic and continually evolving ecosystem. Lakes Wellington, King and Victoria were, during Pleistocene times, a broad marine embayment with waves breaking against sea cliffs at, among other places, Strathfieldsaye, Paynesville, Metung, Nungurner and Kalimna. Sea level change, coupled with successive development of sandy barrier formations across the mouth of the embayment, led to the formation of Ninety Mile Beach and isolation of a complex coastal lagoon system - the Gippsland Lakes (Bird 1965, 1978).

Estuarine shorelines such as those around the Gippsland Lakes are continually modified by a combination of processes including: wave and current action; sediment transport; encroachment by fringing vegetation; sand washed in from the sea and blown in over dunes; and fluvial sedimentation from rivers entering the system.

These ‘natural’ processes are often influenced by man-induced changes to: catchment and land use changes (including “urbanisation” of foreshore areas and clearing for agricultural purposes), construction of dams which reduce sediment delivery to the lakes; hydrological regimes; and sediment transport patterns.

The Gippsland Lakes has experienced major man-induced changes, primarily due to the establishment in 1889 of a permanent opening at Lakes Entrance and the resultant change from a largely freshwater ecosystem to an estuarine one. Increased water salinity (often in places reaching that of sea water) has modified the distribution of shoreline and aquatic vegetation, which in turn has been the catalyst for shoreline erosion. Unconsolidated silty and sandy shorelines around the Gippsland Lakes are generally highly erodable once exposed to wave action.

Importantly, shoreline change in the Gippsland Lakes must also be seen in the context of larger scale influences such as enhanced greenhouse effect and accelerated sea level rise, and coastal subsidence along the Gippsland coast (refer to section 2.4).

2.2 Loss of Fringing Reedbeds and Shoreline Erosion

Phragmites australis (Common Reed) is an integral component of wetland ecosystems and, where present as fringing reedbeds in shallow water, serves to trap suspended sediment often resulting in gradual shallowing and encroachment into open water. Importantly, fringing reedbeds also act to attenuate (baffle) wave action by dissipating the energy of shoaling waves thereby protecting the shoreline and vegetation located immediately inland.

Phragmites australis once formed extensive fringing reedbeds around the Gippsland Lakes and was first noted to be in decline as early as 1922 by T. S. Hart (Hart, 1922, cited in Bird, 1961). By 1961 it became clear that die-back of *Phragmites* in Lake King, Lake Victoria and to a lesser extent in Lake Wellington was a response to the increased frequency and duration of higher salinity levels in the Lakes as a result of the permanent opening at Lakes Entrance (Bird, 1961).

The salinity tolerance of *Phragmites australis* is in the range 10ppt to 17ppt, compared to marine water which is 35ppt (Bird, 1961; Adams and Bate, 1999). *Phragmites australis* can sustain repeated inundation by saline water (eg. tides) only if the root zone has a permanent source of fresher water, such as a freshwater seep at the base of an escarpment (Adams and Bate, 1999; Lissner and Schierup, 1996).

Salinity levels of water in the Gippsland Lakes vary considerably with seasonal conditions and river inflows. Deeper waters are often vertically stratified. CSIRO (2001) found a gradient from Lakes Entrance to Lake Wellington typically to be 30ppt to 5ppt respectively, although noted that Lake Wellington is commonly approximately 10ppt over summer and has been known to be as high as 22ppt.

The ongoing wide-spread reduction in extent of fringing *Phragmites australis* reedbeds can clearly be attributed to the Gippsland Lakes now being far more of an estuarine ecosystem compared with the predominantly freshwater regime that prevailed 110 years ago. Figures 1 and 2 illustrate healthy and retreating *Phragmites australis* reedbed stands respectively.

Figure 1: Healthy *Phragmites australis* reedbed prograding into water

Figure 2: Retreating *Phragmites australis* reedbed

Loss of fringing *Phragmites australis* reedbeds is the principle cause of accelerated shoreline change in the Gippsland Lakes.

The loss of energy-absorbing fringing *Phragmites australis* reedbeds exposes adjacent shoreline vegetation (primarily *Melaleuca ericifolia* dominated Swamp Scrub thickets, but also *Leptospermum laevigatum* and *Banksia integrifolia* Coastal Dune Scrub) to greater wave energy, causing undermining of the sandy and peaty substrate, collapse of standing vegetation and ultimately resulting in shoreline erosion. Figure 3 illustrates this schematically.

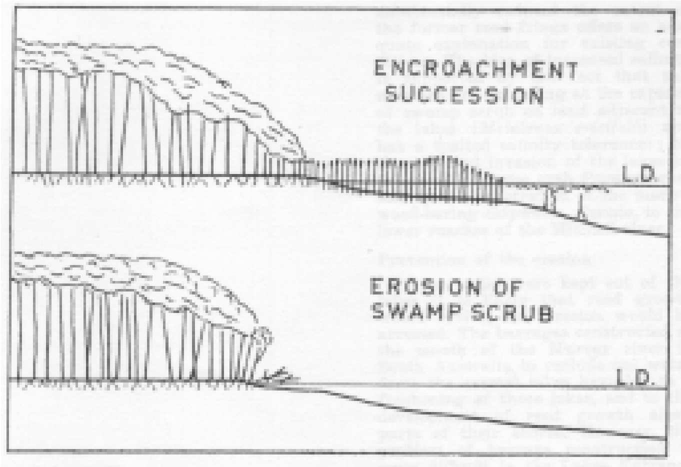

Figure 3: Schematic representation of healthy fringing *Phragmites australis* reedbeds encroaching into lake waters (top) and erosion caused by loss of reedbeds (bottom) (From: Bird, 1961).

Melaleuca ericifolia dominated Swamp Scrub thickets have also suffered die-back from increased water salinity.

The loss of fringing reedbeds also reduces wildlife habitat and impacts on overall biodiversity of the Gippsland Lakes system.

Aesthetically, loss of shoreline vegetation has impacted on landscape values by reducing (and often removing) large fringing vegetative margins so that open water now often laps directly against stands of taller trees and shrubs rather then reeds.

Concurrent with increased salinity of the Gippsland Lakes and the resultant loss of *Phragmites australis* reedbeds has been a considerable increase, since 1935-40, in the extent of seagrass *Zostera muelleri* in the shallow nearshore areas. Freshly vegetated seagrass areas act to trap nearshore mobile sediment and impede its movement along the shore. Sea Rush *Juncus krausii* has also increased in extent as fringing saltmarsh vegetation becomes more common.

It must also be recognised that catchment discharges of saline water, inappropriate land management practices and foreshore grazing have contributed to the loss of fringing reedbeds and shoreline erosion.

Soil compaction along well-worn shoreline paths at Hollands Landing results in water ponding and creation of fissures that ultimately cause large sections of bank to collapse (Schultz, A., pers. com.).

2.3 Implications Of Shoreline Change

2.3.1 Erosion

Eroding shorelines around the Gippsland Lakes have a range of impacts including:

- Loss of Crown (public) foreshore land;
- Loss of private land where the Crown foreshore has completely eroded away;
- Loss of private land where no Crown foreshore existed;
- Threat to physical assets such as jetties, roads/tracks, boat ramps, car parks, drainage infrastructure, recreational facilities (picnic tables etc);
- Loss of native vegetation and reduction in habitat;
- Threat to natural assets of biological significance (ie occurrences of rare flora and fauna species); and
- Threat and possible loss of Aboriginal sites of significance.

Erosion and breaching of banks, levees or barrier shorelines separating isolated freshwater wetland ecosystems from the balance of the Lakes may result in intrusion of saline water into such wetlands causing altered water regimes, altered water quality, possible loss of fringing reedbeds and modified wildlife habitat. Artificial breaches in banks and shoreline barriers also occur where unauthorised persons dig channels to gain boat access to otherwise isolated wetlands (for recreational hunting and fishing).

Breaches in banks and levees present a potential threat by allowing major hydrological changes to flow paths of rivers (including McLennan Strait), particularly during flood events.

Parks Victoria's management objective is to retain the natural values of freshwater wetland systems wherever possible, in keeping with their classification under the Ramsar Convention on Wetlands, and also to reduce the impact on the integrity the resource by those who utilise it for recreational purposes (Kambouris, P. pers. com.). Additional concerns exist regarding the unauthorised manipulation of artificial breaches into smaller wetlands. In such instances management actions seek to restrict public access, particularly to larger vessels, and avoid further erosion and the potential large scale re-routing of water flow paths.

Shoreline erosion around the Gippsland Lakes has to date been addressed using a range of structures of varying types including sea walls, rock rubble, rock, timber and brushwood groynes, and tyre barriers. Extensive armouring of the Mitchell River Silt Jetties has been successful in preserving this geomorphic feature of international significance (Rosengren, 1984). In other locations, tyre barriers (ie Broadlands, Jones Bay) and ad hoc dumping of rock have often not been successful.

Previous erosion mitigation works undertaken by government agencies and private landowners has created an expectation by landowners and the broader community that erosion mitigation works will be implemented to protect public assets and private land.

2.3.2 Accretion

Accreting shorelines result in:

- Increased sandy shoreline due to liberation of sandy substrates;
- Increased shoaling of navigable channels;
- Inundation by sand of boat ramps
- Increased terrestrial habitat as land encroaches into water; and
- Reduced estuarine habitat through smothering of seagrass (*Zostera muelleri*).

2.4 Effects of Rising Sea Level

Global warming due to an enhanced “Greenhouse Effect” is predicted to cause sea level rise resulting from thermal expansion of the oceans and melting of ice sheets. Forecasts in 1995 by the Intergovernmental Panel on Climatic Change (IPCC, 1995) suggested sea level rise (depending on various scenarios) in the order of 10cm to 15cm by 2030, increasing to between 30cm and 80cm by the end of the 21st century, and reaching one metre at some time during the following century. Refined predictions based on an increasing understanding of the sea level rise phenomenon (IPCC, 2001) suggest marginally lower estimates of 3cm to 14cm for the period 1990 to 2025; 5cm to 32cm for the 50 year period to 2050; and between 9cm and 88cm for the hundred year period up to 2100.

Sea level rise of such magnitude will initiate or accelerate coastal changes worldwide; an obvious outcome being that low-lying coastal areas will become permanently submerged, and that the sea will penetrate further into inlets, estuaries and coastal lagoons, including the Gippsland Lakes.

Implications for the Gippsland Lakes are detailed by Dr. Eric Bird in Appendix 1. In summary, likely impacts include:

- Increased intrusion of marine water and accompanying increased tidal range;
- Increased water levels and submergence of low-lying areas;
- Ongoing reduction of shoreline vegetation from increased salinity;
- Increased extent of seagrass and other estuarine flora;
- Increased estuarine fauna, particularly fish species
- Increased storminess producing larger waves resulting in greater erosion;
- Submergence of existing shore protection works rendering them less effective;
- Increased threat to infrastructure assets;
- Potential breaching of the outer sand barrier along Ninety Mile Beach producing additional entrances to the Gippsland Lakes;

Clearly, any consideration of shore erosion on the Gippsland Lakes must take into account the implications of rising sea levels.

The effect will be most dramatic in low-lying areas along the western and southern shores of Lakes Wellington, Tambo and Latrobe River deltas, McLennan Strait area, western end of Lake Victoria/ Blond Bay, sandy spits associated with the outer and inner barriers, northern end of Raymond Island, Point Fullarton, northern shore of Jones Bay, Mitchell River silt jetties, Tambo Bay, Point Jones, Shaving Point, Purran Corner, Baines swamp, islands in Reeve and Hopetoun Channels, parts of Boole Poole Peninsula, and Lakes Entrance foreshore (refer to figure in Appendix 1).

Elsewhere, along areas of higher land, increased sea level will result in accelerated erosion, although the width of land lost will be less dramatic, generally expected to be up to 10 metres over the next 100 years.

The effects of rising sea level will be further exacerbated by possible subsidence along the Gippsland coast resulting from oil and gas extraction in Bass Strait (Sinclair Knight Merz, 1995).

3 PHOTOGRAPHIC COMPARISONS

3.1 Aerial Photograph Comparisons

Comparison of vertical aerial photography has been completed using photographs from 1935, 1940, 1966, 1967, 1969, 1976, 1984, 1986, 1991 and 1997.

Limitations in comparing the photography are discussed in section 1.4.2.

The result of aerial photograph comparisons is presented in Photographic Set #1 at the rear of the Strategy and discussed in Section 4. Annotations on each photograph describe discernable shoreline changes.

Selection of sites for comparison was based on the extent of shoreline change evident from the photographs and available photo coverage. The location and description of all sites for which a comparison has been completed are cross-referenced to Table 1.

Flight diagrams locating all aerial photography used in the comparisons have been prepared and are included at the rear of the Strategy.

3.2 Other Photograph Comparisons

Locations of historic land-based and oblique aerial photos (mostly taken by Dr. Eric Bird) have been re-photographed for comparative purposes.

Only sites where the original location could confidently be determined are included.

Results are presented in Photographic Set #2 at the rear of the Strategy and discussed in Section 4. Notes on each pair of photographs describe discernable shoreline changes.

3.3 New Photographs for Future Comparisons

A comprehensive photographic record of the Gippsland Lakes' current shoreline condition has been established as part of the study.

Digital photographs taken from a light aircraft are presented as Photographic Set #3.

Land-based photographs are presented in Photographic Set #4 at the rear of the Strategy.

These new photographs will serve as a valuable record for future comparisons in addition to any new vertical aerial photography that is flown. To facilitate ongoing comparisons of shoreline change around the Gippsland Lakes, each photograph is labeled by location and AMG co-ordinates.

4 SHORELINE CONDITION

4.1 Current State in 2002 – An Overview

A comprehensive description of shoreline conditions surrounding the Gippsland Lakes, based on the photographic comparisons described above and from detailed field inspections undertaken as part of this study, is provided in Table 1.

Generally, shorelines around the Gippsland Lakes continue to change. However, as was the case in 1983 when Bird compared results with 1957-59 data (Bird, 1983), the rate of change appears to be less than was originally expected to have occurred by now (see Section 5).

Most marked is the continuing eastward migration of spits and sandy cuspate forelands along the northern and southern shores of Lake Victoria (eg Storm Point, Waddy Point, Wattle Point, Point Turner, Point Scott, Trouser Point, Green Hill Point, Sperm Whale Head), and along the southern shores of Cunningham Arm and Bunga Arm. Erosion west of these points liberates material transported around the point and deposited on the eastern flank where successive deposition leads to an accreting shoreline. Short term episodes of westward migration also occurs. This pattern of migrating cuspate forelands is well documented (Woodburn, 1978; Bird, 1983) and is a natural process largely unaffected by recent changes in lake salinity levels and associated loss of fringing *Phragmites australis* reedbeds.

The extent of fringing *Phragmites australis* reedbeds continues to reduce, as evidenced along the southern shore of Lake Wellington, Sheepwash Point, Tucker Point, Tucker Bay, Wild Dog Shore, Bull Point, Bull Bay and on deltas of Latrobe and Avon Rivers. Aerial photography confirms that much of the *Phragmites australis* reedbed fringe had already been lost by 1935/40. Only at one site, the western shore of Lake Wellington between the Latrobe River delta and Marlay Point, were young shoots of *Phragmites australis* observed to be actively prograding out into open water. Healthy stands of *Phragmites australis* also remain on the Lake Wellington end of McLennan Strait and at the Mitchell River Cut in Jones Bay. Elsewhere throughout the Lakes, roots of *Phragmites australis* are often exposed indicating active erosion.

The most common shore type is *Melaleuca ericifolia* Swamp Scrub thicket along the waters edge with either evidence of active erosion or fringed by a narrow sandy beach. The sand appears to be material liberated by erosion of the *Melaleuca* substrate rather than shoreline accretion. A similar situation occurs along the Outer Barrier (Bunga Arm, Hopetoun Channel) and sections of the Inner Barrier, where *Leptospermum laevigatum* and *Banksia integrifolia* dominate the vegetation type. Increasing amounts of sand will be liberated as erosion of the *Melaleuca ericifolia* Swamp Scrub continues. This sand is being actively redistributed along shorelines in response to wave and current patterns, generally in an easterly direction.

Juncus kraussii is common towards the eastern end of the Lakes where it often forms a rushy fringe to a coastal saltmarsh complex or *Melaleuca ericifolia* thickets. However, *Juncus kraussii* does not offer the same level wave attenuation as *Phragmites australis* due to its tussock growth form and occurrence in the inter tidal zone rather than out in open water.

Deltas on the Latrobe, Avon, Mitchell and Tambo Rivers and on McLennan Strait all show evidence of continuing erosion. Two small islands not protected by rock on the end of Mitchell River Silt Jetties have eroded to below the water line during the past decade.

Other areas of more substantial erosion include, Roseneath Point, Swell Point, Storm Point, west of Avon River / Clydebank Morass, Marlay Point, west of Loch Sport, east of Loch Sport, Luff Point, Harrington Point, northern Raymond Island, Point Fullarton, Tambo Bluff and the northern shores of Jones Bay. Annotated aerial photograph comparisons in Photographic Set #1 indicate the amount of erosion for each site.

The breach between Lake Wellington and Clydebank Morass is allowing intrusion of lake water into the Morass to the extent that it now experiences minor tidal and wind driven water level variations.

Channels linking isolated wetlands with the rest of the Lakes occur as a result of human interference and erosion of banks, levees or barrier shorelines. Such channels are located at Tucker Swamp, Wild Dog Shore, Betsy Lagoon, Little Morley Swamp and an unnamed wetland adjacent to Morely Swamp. Intrusion of estuarine water into these essentially fresh water wetlands may have a detrimental impact on *Phragmites australis*.

It is possible, though unlikely in the short term, that the combination of artificial breaches into wetlands south of McLennan Strait and ongoing erosion could allow McLennan Strait to re-route into Spoon Bay, thereby potentially reducing the navigability of McLennan Strait.

Evidence of shoreline accretion is rare, the largest being several metres along the sandy eastern shores of Lake Wellington, north of McLennan Strait. Other sites of shoreline accretion include north of Point Turner, Elbow Point and Boole Poole near Baines Swamp. Rigby Island has undergone substantial change resulting from dredging and spoil disposal practices associated with maintenance of the entrance at Lakes Entrance.

A small deltaic area is continuing to form in the Mitchell River Cut in Jones Bay as deposited sediments accumulate and the island becomes vegetated. This areas will continue to grow at the expense of the Silt Jetties.

Large sand-rich bedloads have been recorded migrating down rivers and will eventually enter the Gippsland Lakes (E. Bird, pers. com.). Sand deposits have already reached Sale in the Latrobe River, below Clydebank Bridge on the Avon River, below Iguana Creek on the Mitchell River and below Tambo Upper on the Tambo River. Upon reaching the Lakes, this sand will provide a local sediment source for areas close to river deltas.

It is apparent from field investigations that very few public infrastructure assets are threatened by erosion. Beach Road at Metung remains vulnerable. Degraded sea walls at Marlay Point boat ramp are in a state of disrepair resulting in minor erosion. The majority of foreshore infrastructure assets are located at townships where shoreline protection works have already been successfully implemented.

4.2 Foreshore Classification

From shoreline inspections and interpretation of aerial photographs, the Gippsland Lakes foreshore has been classified into eight categories as shown in Table 2.

Table 2. Gippsland Lakes Foreshore Classification

Category	Example
1	**Low lying land which is rarely greater than 1 metre above lake level, and which supports mainly salt marsh and swamp vegetation. There is little sand in the soil and the foreshore erodes rapidly once wave absorbing fringing vegetation is removed or dies.**
Lake Wellington	
	Bull Point to Tucker Point
	Tucker Point to Sheepwash Point
	Sheepwash Point to Crash Boat Landing
	Frawley Drain to Marlay Point
	Marlay Pt Yacht Club to Strathfieldsaye
	Much of McLennan Strait
Lake Victoria	
	Spoon Bay and Bandin Bay
	McLennan Strait to Jones Bay (west)
	Blond Bay
	Gorcrow Point

Table 2. continued

Category	Example
1	**Low lying land which is rarely greater than 1 metre above lake level, and which supports mainly salt marsh and swamp vegetation. There is little sand in the soil and the foreshore erodes rapidly once wave absorbing fringing vegetation is removed or dies.**
	Lake King to Lakes Entrance
	Point Fullarton and adjacent shoreline
	Jones Bay northern shore
	Old Nicholson River entrance
	Baines Swamp and Salt Lake foreshore
	Point Jones
	Swamp area adjacent to Hopetoun Channel
	Salt marsh and swamp areas on Fraser and Rigby Islands
	Eastern Creek
2	**Low lying vegetated land adjacent to the foreshore with sand soils that form beaches when the foreshore is eroded**
	Lake Wellington
	Bull Point
	Tucker Point
	Sheepwash Point
	Storm Point to Roseneath Point
	Point Plover to Bull Bay
	Lake Victoria
	Hybla Point to about 2 km east of Thalia Pt
	Mid-way between Trouser Pt and Green Hill Point
	On the western side of Green Hill Point
	Shoreline backed by swamp between Green Hill Point and Point Wilson
	Rotamah, Rotten and Barton Islands
	Waddy Point and 1 km west and north of Waddy Point
	Luff Point
	Lake King to Lakes Entrance
	Mitchell River Silt Jetties
	Raymond Island north and east shores
	Balance of south shore from Point Best to and through Hopetoun Channel to Lakes Entrance
3	**Low lying farm land or recently revegetated farmland adjacent to the foreshore, marginally greater that 1 metre above lake level**
	Lake Wellington
	Crash Boat Landing to Frawley Drain
	Marlay Point to Marlay Point Yacht Club
	Lake Victoria
	Between Jones Bay (west) and Blond Bay
	Lake King to Lakes Entrance
	Mitchell River Silt Jetties
	New Mitchell River entrance, clockwise to Point Bolodun
	Broadlands
	Jones Island
	Tambo Bay and Swan Reach Bay adjacent to the Avon River entrance
	Flannagan Island
	Point Tyers and Mosquito Point
4	**Raised farm land with slowly eroding foreshore**
	Lake Wellington
	Strathfieldsaye to Storm Point
	Lake Victoria
	Tannin, Terrace and Toms Point
	Bluff Head to Duck Arm

Table 2. continued

4	**Raised farm land with slowly eroding foreshore**	
	Lake King to Lakes Entrance	
		Point Bolodun to Point Norgate
		Nicholson River to Slaughterhouse Creek
		Tambo Bay to Tambo Bluff
5	**Sandy accreting foreshore**	
	Lake Wellington	
		Eastern Beach
	Lake Victoria	
		Eastern side of Point Turner, Elbow Point, Terrace Pt, Wattle Point, Waddy Point, Storm Point, Red Bluff, Pelican Pt and Trouser Pt
	Lake King to Lakes Entrance	
		Eastern side of Point Scott and Jones Point
		West Metung between seawall and the northern end of the Shaving Point reach
		Southern end of Beach in front of Baines Swamp
6	**Sandy eroding foreshore backed by high land**	
	Lake Victoria	
		2 Km east of Thalia Point to start of Loch Sport
		Pelican Point to Pt Wilson and the SE towards Rotamah Channel, except for low areas identified under Category 2.
		Banksia Peninsula – eastern end
		South shore of Raymond Island
		Wattle Point to 2 Km west of Wattle Point
		Between Storm Point and Waddy Point
	Lake King to Lakes Entrance	
		Eagle Point Bay at settlement
		West side of Shaving Point
		Southern shore of Hopetoun Channel up to the start of Bunga Arm
7	**Steeply sloping shoreline backed by high land**	
	Lake King to Lakes Entrance	
		Tambo Bluff to Metung
		Bancroft Bay
		Bell Point through to Mount Barkly (Jemmy's Point)
		North Arm foreshore except for those areas previously identified as belonging to other categories
8	**Shorelines modified by the placement of dredged sand**	
	Lake King to Lakes Entrance	
		Point Scott
		Eastern end of Flannagan Island
		Rigby Island at various locations
		Bullock Island
		Southern shore of North Arm
		Cunningham Arm – various locations

4.3 Erosion and Private Land Boundaries

Much of the Gippsland Lakes is surrounded by Crown land forming the Lakes National Park, Gippsland Lakes Coastal Park, Wildlife or other conservation reserves, or unreserved Crown land.

Private land surrounding the Gippsland Lakes is fronted in nearly all instances by a Crown land foreshore of varying width. Crown land foreshores are either reserved as part of the Gippsland Lakes Reserve, as Wildlife Reserves or other conservation reserves, or are unreserved Crown land. The private land - Crown land boundary is surveyed and fixed.

Crown land foreshores are absent only in rare instances, usually where titles were created prior to 1881 and where the title boundary may be shown as the waters edge (D. Scott, pers. com.). All subsequent titles made allowance for the provision of a Crown reserve at least 20 metres wide. Private land with titles that extend to the waters edge are located at Broadlands between Jones Bay and Jones Island (Nicholson River Mouth), and at Shaving Point.

The actual definition of a property boundary is in these circumstances may be a matter of complex property law, but generally such titles are dynamic in the sense that if the water line moves, the title boundary moves. Hence if such private land is eroded, the title is reduced in area. It is this situation that stimulates private land owners into protecting their shoreline from further erosion. Conversely, if natural accretion occurs the title is enlarged.

Private land may also extend to the waters edge, or beyond, where land is defined by a surveyed boundary and where the surveyed Crown foreshore reserve has been completely eroded away. In such instances the reserve still exists, but out in the water. The private land status applies only to the bed of the lake, not the water. This situation often results in management agencies having difficulty in controlling private structures (ie jetties, ramps, minor buildings etc) that they would otherwise not allow on a Crown land foreshore. Areas where private land extends into lake waters are located at Wellington Park, Harrington Point, northern end of Raymond Island, Jones Island, Tambo River mouth, Point Tyers, and North Arm.

Anecdotal evidence suggests that numerous other sites exist, however, the lack of fixed features and uncertainty in locating title boundaries on aerial photographs prohibits accurate positioning. Only through detailed land-based surveys can title boundaries be accurately located with respect to Crown foreshores and the waters edge.

There are many circumstances around the Gippsland Lakes where erosion of the Crown foreshore reserve has left only a narrow strip of Crown land fronting private land. Further erosion may eventually result in loss of private land. Examples include Disher Bay, Andrew Bay, Jones Bay (west) to Blond Bay, Raymond Island, Mosquito Point, Chinamans Creek to Boxes Creek, Bell Point, and North Arm. Ongoing foreshore erosion will place further pressure on private land.

Negotiations between the Department of Natural Resources and Environment and private landowners seeking subdivision approval has on occasion resulted in relinquishment of private land for addition to narrow Crown foreshore reserves. Such an outcome creates an expectation that NRE will manage the foreshore so as to prevent further erosion and future risk to the private land.

Eroding shorelines and the relationship between private land and Crown land presents a significant management problem for managers of Crown land (ie DNRE and Parks Victoria). Whilst the Crown land manager may not regard protection of the Crown foreshore a priority, the adjoining landowner would most likely see any reduction in width as a serious threat to their private land. The Crown land manager is only able to respond in terms of the prevailing Government policy, which currently espouses a “retreat rather than protect” philosophy (refer to section 6.1). Private land owners should therefore not expect Government assistance in mitigating against erosion of private land.

4.4 Sites of Biological Significance

The biological significance of the Gippsland Lakes is demonstrated by their listing under the Ramsar Convention on Wetlands (Ramsar, Iran, 1971) as internationally significant for waterfowl habitat. The Lakes are also an important destination for many migratory bird species protected under the Japan-Australia Migratory Bird Agreement (JAMBA, 1974), the China-Australia Migratory Bird Agreement (CAMBA, 1987) and the Convention of the Conservation of Migratory Species of Wild Animals commonly referred to as the Bonn Convention (Bonn, Germany, 1983).

At a local scale, the Lakes and immediate hinterland contain a vast array of important biological sites. The Department of Natural Resources and Environment's BioSites database records the location of rare or threatened vascular plants (NRE, 2000a), threatened vertebrate fauna (NRE, 2000b), and "local" Sites of Biological Significance that include the occurrence of significant species, important habitat, nesting or roosting areas and wildlife corridors (biolinks).

Many such sites are found on or near shoreline locations around the Gippsland Lakes and are affected to varying degrees by shoreline changes.

From discussions with DNRE staff, it appears the ongoing viability of significant plant and animal species is not immediately threatened by shoreline erosion (M. Bramwell, pers. comm.). For instance, nowhere is erosion causing an immediate threat to a White-bellied Sea-eagle nest tree. However, ongoing reduction in the extent of *Phragmites australis* reedbeds and *Melaleuca ericifolia* habitat associated with freshwater wetlands will reduce the available habitat for waterfowl and significant breeding colonies of Ibis, Pied Cormorants, Great Egrets (such as at Tucker Swamp).

Shore erosion also causes a more diffuse, low-level impact on species that utilise nearshore, intertidal and sandy shoreline habitats. These habitats are most at risk from shore erosion, although whilst erosion may reduce the extent of available habitat, coastal processes will also result in the transformation and creation of suitable habitat at other sites.

Erosion of sandy beaches may reduce available nesting sites for Little Terns and Fairy Terns, but the sand is likely to be deposited elsewhere to provide similar habitat, (ie at migrating sandy spits).

Sand banks along the entrance channels into Bunga Arm offer important Pelican breading habitat that is threatened to a limited extent by erosion.

Erosion of shallow nearshore and saltmarsh areas providing habitat for wader birds such as Eastern Curlew and Hooded Plover poses a potentially greater impact if, in the long term, these areas are lost. The threat at this point in time does not justify an engineered form of protection.

In summary, shoreline erosion in itself is unlikely to cause immediate loss of significant species. However, the combination of likely sea level rise and ongoing erosion will dramatically alter the extent and distribution of different ecological vegetation classes, possibly resulting in certain habitat areas no longer being represented in the Gippsland Lakes, and hence influencing the distribution and occurrence of fauna species.

4.5 Existing Foreshore Erosion Control Structures and Works

A range of erosion control structures and works have been implemented with varying degrees of success around the Gippsland Lakes.

Most structures are on Crown land and managed by the public land manager.

Seawalls have been constructed at:

- Newlands Arm, north shore - little adverse impact because of the natural wave protection that occurs.
- North of Bull Point (adjacent to McLennan Strait in Lake Victoria) - successful because not exposed to waves generated from the south west. However, there appears to be some scour at both ends of the seawall, particularly the northern end adjacent to the vertical timber walling.

  Existing degraded sections of seawalls at Newland Arm, Paynesville and Raymond Island have been addressed in the East Gippsland Shire Seawall Audit 2000 (TiBaR Services, 2000).
- Mitchell River Silt Jetties. Several gaps in the existing rock walls pose only a limited threat to Crown foreshore and private land due to their narrow aperture.
- Jones Bay where rubber tyres have been place along extensive sections of private shoreline with very ineffective results.
- Tambo River delta – new work on Crown and private land.
- Metung and Bancroft Bay, The Narrows, Bullock Island, North Arm and Cunningham Arm - little adverse impact because these seawalls and the adjacent foreshore are quite well protected from waves.

The condition of all seawalls except on the Mitchell River Silt Jetties and at the Tambo River delta have been assessed in the East Gippsland Shire Seawall Audit 2000 (TiBaR Services, 2000).

Seawalls protecting the Mitchell River Silt Jetties are generally in good condition. Degraded sections are restricted to where the silt jetties are wide and backed by very low-lying land. Erosion behind these degraded sections is unlikely to threaten the integrity of the silt jetties over the next 20 years, but in the longer term sea level rise may ultimately submerge much of the silt jetties.

Beach nourishment has been used quite extensively from Lake King to Lakes Entrance, particularly on high use recreational beaches. Sites include:

- Pt Scott
- Montague Pt
- Paynesville Beach (Progress Jetty)
- Eagle Point Bay
- Round Head
- Shaving Point
- Beach Road, Metung
- Eastern end of Flannagan Island
- Rigby Island
- Bullock Island
- North Arm, southern shore

- Cunningham Arm, - various

Numerous groynes have recently been established at Loch Sport and are successfully trapping sand and building beaches. Beach nourishment also occurred at Loch Sport prior to establishment of the groynes.

Additional minor "private" structures are located at Mosquito Point where small, low timber groynes are effective in capturing small amounts of sand. It is possible that a number of these structure are located on Crown land.

Small "private" groynes on Bell Point near Bancroft Bay are largely ineffective in capturing significant quantities of sand, essentially due to the limited local supply.

Groynes that intercept sand drifting alongshore often result in the onset or acceleration of erosion downdrift. When the compartments between the groynes are full of sand it can drift past and renourish eroded sectors downdrift.

5 EROSION RATE

From field observations and photographic comparisons, shoreline change generally appears to be relatively slow. As was the case in 1983 when Bird compared results with 1957-59 data (Bird, 1983), the rate of change appears to be less than was originally expected to have occurred by now.

Aerial photography confirms that much of the *Phragmites australis* reedbed fringe had already been lost by 1935/40. The initial loss of fringing *Phragmites* reedbeds was a marked large event giving the impression of a high erosion rate, but having receded to the backing *Melaleuca ericifolia* thickets, shoreline recession now appears less rapid, probably due to the sand/peat substrate being more robust.

Comparison of aerial photographs spanning 1935/40 to 1997 demonstrate that the vast majority of shorelines are eroding at an average of less than 0.1 m/yr. Locations for which the average erosion rate is greater than 0.1 m/yr are listed in Table 1, and range between 0.2 to 0.5 m/yr. These rates of change are averages over many years and do not reflect short term events where erosion may be more rapid with a subsequent period of stability or even accretion.

Data for Raymond Island (Grace, 2000; reproduced as Appendix 2) illustrates short term fluctuations based on beach surveys over a ten year period from 1990 to 2000. Erosion rates up to 4.6 metres over the ten years (0.46m/yr) are consistent with longer term average rates up to 0.5m/yr based on aerial photograph comparisons.

6 RESPONDING TO SHORELINE CHANGE

Response to shoreline change around the Gippsland Lakes should be based on an evaluation of the erosion risk, the value of the shoreline being eroded, cost effectiveness, and the long term environmental implications of the response.

Response options include:

- Do nothing;
- Retreat / define minimum setback buffer;
- Revegetation (terrestrial and aquatic); and
- Engineering solutions.

6.1 Response Matrix and Priorities

Table 3 outlines a Response Matrix based on the response options described above. Table 4 outlines response priorities.

The Response Matrix provides a means of determining the most appropriate response to shoreline change based on a variety of circumstances and should act as a decision framework for management agencies.

The response initiated by management agencies must be consistent with State Government policy as outlined in the Victorian Coastal Strategy, section 3.3, page 32 (NRE, 2002), which states:

i) Establish risk based priorities for works, with emphasis on protection of critical or key public assets and maintenance of coastal infrastructure;

ii) Retreat to setback lines based on coastal buffer zone widths required to maintain biological and physical processes, and to accommodate public infrastructure, use and access for a 100 year planning period; and

iii) Revegetate very narrow coastal reserves threatened by erosion.

Implicit in this policy is a "retreat rather than protect" philosophy in most cases other than for key public assets.

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Table 3. Shoreline Erosion Response Matrix

Response / Circumstance	Do Nothing	Retreat / Define Minimum Setback Buffer	Revegetation		Implement Engineering Solution	Comments
			Terrestrial	Aquatic		
Key public infrastructure asset on public land (ie road, amenities building, drainage infrastructure)					YES	Should not result in shifting erosion problem
Secondary public asset on public land (ie car park, paths, recreational facilities picnic tables		YES	YES		YES	Where available room exists. Generally relocate rather than protect.
Public foreshore or other Crown land (including National/Coastal Parks and Reserves) with significant biological, geomorphic or cultural value			YES		Only if Nationally Significant	
Public foreshore or other Crown land (including National/Coastal Parks and Reserves) where erosion threatens ecological character or large scale estuarine/fluvial processes			YES		YES	Includes inundation of freshwater wetlands with saline water, and re-routing of river flow paths
Public foreshore of high recreational value	YES	YES		Trial sites		Relocate recreational asset or activity
Extensive public land lacking significant biological or recreational value	YES			Trial sites		
Narrow public foreshore reserve fronting private land		YES	YES			With contribution/ support by landowner
Private land		YES	YES		YES	At private landowner’s expense

Table 4. Response Priority

Shoreline Erosion Scenario	Priority for Action
Key public infrastructure asset on public land (ie road, amenities building, drainage infrastructure)	High
Secondary public asset on public land (ie car park, paths, recreational facilities picnic tables	Moderate
Public foreshore or other Crown land (including National/Coastal Parks and Reserves) with significant biological, geomorphic or cultural value	Moderate
Public foreshore or other Crown land (including National/Coastal Parks and Reserves) where erosion threatens ecological character or large scale estuarine/fluvial processes	High
Public foreshore of high recreational value	Low
Extensive public land lacking significant biological or recreational value	Low
Narrow public foreshore reserve fronting private land	Moderate
Private land	Low

6.2 Do Nothing

Recommendation: Do Nothing Option

- The DO Nothing option is recommended for the majority of the Gippsland Lakes shoreline.

A Do Nothing option recognises that much of the Gippsland Lakes shoreline is public land forming part of extensive National/Coastal Parks or Reserves where erosion is an on going process that does not threaten key infrastructure assets or sites of biological significance.

Erosion will continue and be most rapid in low-lying areas. Areas of silt will erode more rapidly than sand rich shorelines. Eroded material will tend to have a net eastward migration.

Shorelines exposed to prevailing wind and waves will ultimately realign towards an equilibrium position perpendicular to prevailing wind and waves, such as sections of the eastern shore of Lake Wellington, where both erosion and accretion is evident.

6.3 Retreat / Define Minimum Setback Buffer

Retreating, re-locating and defining setback buffers recognises the need to cater for ongoing erosion processes at sites where sufficient land exists to relocate assets or where development may occur at some future time. Implementation of large scale revegetation and/or engineering solutions at such sites is often not justifiable, unless incorporated into private development at the developers expense.

A range of setback buffer categories are listed in Table 5 and shown on Maps 1 – 3. The different categories are based on the various shoreline classifications in Table 2 and cross-referenced in Table 1. Buffer distances assume a 100 year planning timeframe, with and without a Greenhouse sea level rise component.

To be effective as a management tool, setback buffers must be integrated into local planning policy, principally the East Gippsland and Wellington planning schemes. This could be achieved through introduction of a Local Policy and inclusion into or introduction of a Coastal Overlay.

Designation of a setback buffer along an eroding shoreline does not imply a prohibition on development within the buffer zone. Instead, any development proposed within the buffer must, at the planning approvals stage, take account of the longevity of the development in relation to the expected rate of erosion and demonstrate what measures will be put in place to cater for any anticipated loss of land. Mobile structures that can be moved (including caravan parks for example) or developments with a short life expectancy may not be at risk, depending on the rate of erosion.

Recommendation: Setback Buffers

- Assign development setback buffers along eroding shorelines of the Gippsland Lakes in accordance with Tables 1 and 4.
- Development within buffers should only be permitted where the development caters for anticipated erosion or is of a short-term nature in relation to the expected rate of land loss. Responsibility for dealing with any erosion should lie with the proponent/developer.
- Integrate development setback buffers into local planning policies of the East Gippsland and Wellington planning schemes through use of local Policies and Coastal Overlay(s).

Table 5. Setback Buffer Categories shown on Maps 1 –3 (Based on foreshore classifications in Table 2)

Buffer Category	**Buffer Width** (Without Greenhouse) 100 year planning	**Buffer Width** (with Greenhouse) 100 year planning	**Description**	**Current Erosion Rate** (m/yr)	**Comment**
B1	10 metres	20 metres	Dune scrub, land rapidly slopes to >1 m	very low	
B2	20 metres	30 metres		<= 0.2 m	
B3	50 metres	60 metres		<= 0.5 m	
B6	10 metres	> 100 metres	Dune scrub or Swamp Paperbark with low land behind	low	
C1	10 metres	20 metres	Eroding cleared land > 1 metre level	very low	Buffer is from top of cliff, lower terrace excluded>> sacrificial
C2	20 metres	30 metres		<= 0.2 m	
C3	50 metres	60 metres		<= 0.5 m	
D1	10 metres	30 metres	Eroding Swamp Paperbark	very low	
D2	20 metres	50 metres		<= 0.2 m	
D3	50 metres	> 100m		<= 0.5 m	
E1	10 metres	20 metres	Eroding Swamp Paperbark with higher land backing	very low	
E2	20 metres	30 metres		<= 0.2 m	Steady erosion=20m; Typically about 30m of swamp paperbark which would all go with sea level rise
E3	50 metres	60 metres		<= 0.5 m	
F1	10 metres	20 metres	High cliffs	low	
F2	20 metres	30 metres		<= 0.2 m	
F3	50 metres	60 metres		<= 0.5 m	

Continued over …..

Table 5. *continued …..*

Buffer Category	**Buffer Width** (Without Greenhouse) 100 year planning	**Buffer Width** (with Greenhouse) 100 year planning	**Description**	**Current Erosion Rate** (m/yr)	**Comment**
G	Keep clear of low lying spit land	Keep clear of low lying spit land	Sandy spits and cusps (low by their nature)	Generally mobile	Low lying, would grow in height with Greenhouse Effect because are generally wave formed
H1	50 metres	> 100 metres	Juncus or Phragmites backed by Swamp Paperbark		Rate of erosion has little impact on buffer width
H2	50 metres	60 metres	Juncus or Phragmites backed by rising dune scrub or land		
H3	50 metres	> 100 metres	Juncus or Phragmites backed by low dune scrub or land		
H4	20 metres	30 metres	Juncus or Phragmites backed by high dunes or cliffs		
H5	20 metres	> 100 metres	Low lying land and swamp <1 m above lake level	very low	
R			Rock or vertical walled		
S	10 metres	20 metres	Sandy beach - protected waterway area	stable, minor losses	
T	Behind ridge line	Behind ridge line	Potentially unstable cliffs-groundwater & slipping		
U	No development on seaward side of road	No development on seaward side of road	Road between cliff/dune and shore		

6.4 Revegetation

Revegetation of eroding shorelines is a common management response, often designed to slow the rate of erosion by increasing root material, thereby reducing the erodibility of soils.

Two distinct revegetation scenarios exist for the Gippsland Lakes:

i) Terrestrial revegetation involving establishment of native species on eroding beaches and foreshores; and

ii) Aquatic / macrophyte revegetation involving re-establishment of macrophytes (reedbeds) in shallow areas along shorelines where the wave-baffling effect of fringing vegetation is required to halt and possibly reverse erosion.

6.4.1 Terrestrial Revegetation

Terrestrial revegetation of eroding shorelines must be seen as a tool to slow the rate of erosion rather than halting it all together. Erosion will still occur in the absence of protective fringing macrophytes, particularly while plants are young with limited root zone development and hence offer little resistance. In the early years after planting, trees/shrubs close to the waters edge should be regarded as sacrificial, particularly on rapidly eroding shorelines. The benefit of foreshore revegetation, from an erosion management perspective, will not be realised for perhaps 5 years until plantings have attained a degree of maturity.

Species selection for terrestrial revegetation should be based on the composition of the ecological vegetation class (EVC) representative of the area being revegetated. Common shoreline EVC's for the Gippsland Lakes and suggested species for revegetation are listed in Table 6.

Terrestrial revegetation also serves to enhance the biodiversity value of shoreline areas around the Gippsland Lakes. Site selection for revegetation should therefore aim to address both minimising erosion and maximising larger scale biodiversity gains. Supplementing existing revegetation areas can often achieve greater benefit than commencing revegetation of a new site.

Suitable sites for terrestrial revegetation have been established with input from DNRE (M. Bramwell, M. Keogh) and Parks Victoria (A. Schultz). Each site encompasses an extensive length of shoreline and implementation will therefore need to be staged. Priorites are listed in Table 7.

Recommendation: Terrestrial Revegetation

- Implement terrestrial revegetation priorities as outlined in Tables 6 and 7.

Table 6: Species Selection for Terrestrial Revegetation (Trees and shrubs only)

Ecological Vegetation Class	**Dominant Plant Species**
Coastal Dune Scrub Mosaic	Hairy Spinifex *Spinifex sericeus* and Marram grass *Ammophila arenaria* (non-native) for Sand areas Shrubs should include Coast Tea-tree *Leptospermum laevigatum*, Coast Wattle *Acacia longifolia* var. *sophorae*, Drooping Sheoke *Allocasuarina verticillata*, Sweet Bursaria *Bursaria spinosa*, Common Beard-heath *Leucopogon parviflorus*, Sea Box *Alyxia buxifolia* and Coast Everlasting *Ozothamnus turbinatus*
Coast Banksia Woodland	Tree/shrub species should include Coast Banksia *Banksia integrifolia,* Sallow Wattle *Acacia longifolia* var. *sophorae*, Swamp Paperbark *Melaleuca ericifolia*, Common Boobialla *Myoporum insulare* and Coast Tea-tree *Leptospermum laevigatum*.
Gippsland Lakes Damp Sands Herb-rich Woodland	Trees and shrubs: Coast Manna Gum *Eucalyptus viminalis* ssp. *pryoriana*, Shining Peppermint *E. willisii*, Bangalay *E. botryoides,* Black Wattle *Acacia mearnsii,* Coast Banksia *Banksia integrifolia*, Saw Banksia *Banksia serrata,* Prickly Tea-tree *Leptospermum continentale*, Coast Tea-tree *L. laevigatum,* Coast Wattle *Acacia longifolia* var. *sophorae,* Common Heath *Epacris impressa*, Honey-pots *Acrotriche serrulata* and Spike Wattle *Acacia oxycedrus*
Coastal Saltmarsh	Sea Rush *Juncus krausii,* Chaffy Saw-sedge *Gahnia filum*, Beaded Glasswort *Sarcocornia quinqueflora,* Salt-grass *Distichlis distichophylla,* Creeping Brookweed *Samolus repens,* Shiny Swamp-mat *Selliera radicans,* Rounded Noon-flower *Disphyma crassifolium,* Creeping Monkey Flower *Mimulus repens*, Sea Celery *Apium prostratum* and Streaked Arrow-grass *Triglochin striata*
Estuarine Wetland	Trees:Swamp Paperbark *Melaleuca ericifolia* and Common Boobialla *Myoporum insulare,* Forest Red Gum *Eucalyptus tereticornis* *Reeds/Rushes:* Common Reed *Phragmites australis* Cumbungi *Typha* spp Also diverse ground cover

Source: Descriptions of Ecological Vegetation Classes (EVCs) occurring in the Victorian Gippsland RFA Region (NRE, 2001)

Table 7: Priorities for Terrestrial Revegetation of Gippsland Lakes Shoreline

Priority	Objective	Specific Location	Comment
1	Minimise shoreline erosion and link existing conservation reserves / large areas of remnant vegetation		
		• Wattle Point to Waddy Point / Blond Bay Reserve	Supplements existing vegetation
		• Wattle Point to Banksia Peninsula	Supplements existing vegetation
		• Nicholson River mouth to Jones Bay Wildlife Reserve	Mostly private land
2	Minimise shoreline erosion and link existing wildlife corridors or Biolinks		
		• Nicholson River mouth to Tambo River mouth (mostly private land)	Links existing corridors down both rivers. Mostly private land
		• Nicholson River mouth to Jones Bay Wildlife Reserve (private land)	Mostly private land
3	Minimise shoreline erosion and supplementary planting of existing remnants or revegetation areas		
		• Bunga Arm camp sites	Supplements existing (re)vegetation
		• Chinamans Creek to Boxes Creek	Supplements existing vegetation and stabilises slope
		• Raymond Island	Southern, eastern and northern shores
		• Boxes Creek to Nungurner	Supplements existing vegetation
		• North Arm, eastern shore	Supplements existing vegetation
		• Hollands Landing foreshore area	Also improve/restrict pedestrian access
		• Marlay Point yacht club to Marlay Point	Mixture of cleared and remnant vegetated areas
4	Minimise shoreline erosion and generally enhance shoreline biodiversity values		
		• On sandy barrier between Dolomite Swamp and Lake Victoria, East of Loch Sport	To support recommended beach nourishment
		• Tambo Bay	Private land and narrow Crown foreshore reserve
		• North Arm, western shore	Partly private land, otherwise narrow Crown foreshore reserve
5	Supplementary planting of existing revegetation areas		
		• Mitchell River Silt Jetties	Fill in gaps and failed sites from previous revegetation
		• Tambo River delta	Supplements existing revegetation (partly private land)
		• Disher Bay	Extend and fill in existing revegetation

6.4.2 Aquatic / Macrophyte Revegetation

Shoreline erosion around the Gippsland Lakes will continue to occur in the absence of protective fringing reedbeds. Hence an obvious aim would be to recreate the wave-baffling effect of fringing vegetation to halt and possibly reverse erosion, however this will require artificial protection from the effects of waves, particularly on shorelines exposed to onshore winds.

Recent advances in use of geotextile tube structures as semi-permanent protective barriers have proven successful overseas (Davis & Landin, 1998). A breakwater is created by pumping sand into a geotextile tube such that it extends from the lake floor to the water surface. Planting of suitable macrophyte species is then undertaken in the lee of the breakwater and plants are protected during early growth stages.

Geotextile tube breakwaters require considerable maintenance and are prone to vandalism by people cutting the fabric.

Other issues requiring careful consideration include sourcing sand and disposal of sand once the breakwater is no longer required. The latter is often achieved by cutting open the tube and allowing the sand to disperse across the lakebed, with potential adverse impacts on benthic flora and fauna.

Alternate options for protecting nearshore revegetation include re-locatable wooden structures and floating tyre breakwaters.

All such engineering protective structures tend to be prohibitively expensive to construct and maintain for a full scale project.

Nevertheless, whilst establishment of protective breakwaters may be technically possible, an overriding issue centres on the type of macrophytes suitable for revegetation. There would be little use in establishing a nearshore breakwater if revegetation was not guaranteed of success.

Phragmites australis is clearly unsuitable given its die-back in the increased saline conditions of the Gippsland Lakes. To provide similar protection, alternative species must be tolerant to estuarine salinity regimes, robust against the effects of waves, strongly rooted to the lakebed, exhibit a growth form dense enough to baffle wave energy, and grow along the interface between land and water. A number of species found locally meet these requirements but all have limitations, as listed below:

Local species;

- *Juncus kraussii* (Sea Rush) - saline tolerant but tends to grow in tussocks in salt marshes above the water line, hence offering limited wave protection.
- *Zostera muelleri* & *Hetrozostera tasmanica* (Seagrass) - saline tolerant and grows in water depths up to 2.5 metres. Can form dense beds up to the water surface but which act to baffle waves only to a limited degree. Leaves shed annually and are often washed up on beaches to offer some protection from smaller waves. Will spread further throughout Gippsland Lakes but will not offer the same protection as *Phragmites australis*.
- *Typha orientalis / domingensis* (Bullrush) - excellent wave baffling properties similar to *Phragmites australis* but very low tolerance to elevated salinity.
- *Avicennia marina ssp. australasica* (White Mangrove) - saline tolerant and excellent wave baffling properties but requires significant tidal variation and near marine salinity levels.

(White Mangrove (*Avicennia marina ssp. australasica*) has recently been identified in wetland areas fringing eastern Cunningham Arm. Its occurrence in the Gippsland Lakes signifies the continuing evolution of the Lakes from an essentially fresh water environment to one dominated by estuarine tidal waters entering the now permanent entrance.)

A number of species currently not found in the Gippsland Lakes have been suggested as possible replacements for lost *Phragmites australis* fringing reedbeds. However the introduction of a non-indigenous saline tolerate plant species may cause unforeseen ramifications resulting in degradation of other estuarine flora and fauna values throughout the Gippsland Lakes.

Introduced species;

- *Spartina spp* - salt tolerant and will baffle wave energy to a limited degree but highly invasive in tidal areas where it is now regarded a major marine pest plant.

  Previously introduced to the Gippsland Lakes as a trial (E. Bird, pers. comm) and still present as a minor occurrence at Purran Creek in Purran Corner, Lake King (J. Stephens, pers. comm).

- *Phragmites karka* - A salt tolerant variety of *Phragmites* found in Asia and the middle east. Also recorded in northern Australia (Hardwick, 2001). Appears to withstand a considerable range of salinities but possibly not high enough to grow on shorelines in the western sections of the Gippsland Lakes. Requires further research.

Genetic modification to increase the saline tolerance of *Phragmites australis* or *Phragmites karka* is another potential solution.

The potential adverse impacts of introducing non-indigenous species to the Gippsland Lakes, including genetically modified varieties of *Phragmites*, will need detailed investigation and agreement by all management agencies and stakeholders.

It is concluded that no single macrophyte species replicates the role of *Phragmites australis* and implementation of aquatic revegetation using species indigenous to the Gippsland Lakes is unlikely to be successful.

The use of temporary nearshore breakwaters is not warranted until the lack of suitable aquatic plant species to undertake revegetation is overcome.

Recommendation: Aquatic Revegetation

- Establish cross-agency position on the broad scale introduction of non-indigenous plant species to the Gippsland Lakes for the purposes of erosion control.
- Undertake further research into the suitability of *Phragmites karka* as a saline tolerate alternative to *Phragmites australis* (if considered appropriate to introduce non-indigenous species)
- Encourage research into genetic modification of *Phragmites australis* to increase its suitability for estuarine environments.
- The use of temporary nearshore breakwaters is not warranted until the lack of suitable aquatic plant species to undertake revegetation is overcome

6.5 Engineering Solutions

A variety of engineered shoreline protection works can be employed to arrest erosion including construction of seawalls, groynes, rock rubble, shingle beaches and ongoing beach renourishment. The particular technique applied is dependent on site-specific shoreline conditions (ie foreshore categories from Table 2) and cost/benefit analysis.

Of critical importance in implementing engineered shoreline protection works is a clear understanding of the potential impact on coastal processes, particularly sediment transport patterns. Establishment of a sea wall or groyne may halt erosion or capture sand at one location but may also interrupt longshore sediment transport, thereby starving downdrift areas of sand supply and effectively relocating the problem. In certain situations such an outcome may be acceptable.

6.5.1 Seawalls

Seawalls can be of mortared rocks or bricks, loose rock, concrete, steel or timber. Loose rock seawalls are most common because they are robust and relatively easy to build. However, all seawalls are expensive, the minimum unit rate per lineal metre being $300. Depending on the height and type of wall, the cost can range up to $3,000 per metre for a structural vertical seawall.

Seawalls will be ineffective in the long term for low lying salt marsh and swamp areas of Category 1 because the land behind the seawall will become inundated by the expected Greenhouse sea level rise within the next 100 years.

Seawalls can be used to protect low lying sandy foreshores (Category 2) and low lying farm land > 1m above water (Category 3) areas. However, continuous seawalls would be required along each precinct to prevent terminal erosion at the seawall ends. This terminal erosion will usually be at the eastern end of the seawall. Note that land in Categories 2 and 3 is very likely to be inundated by sea level rise within 200 years.

Seawalls could be used for raised farm land with slowly eroding foreshore (Category 4), sandy eroding foreshores backed by high land (Category 6) and steeply sloping shorelines backed by high land (Category 7), but the issue of terminal scour at seawall applies. Rates of erosion for Category 4, 6 and 7 areas are usually low and any terminal scour is likely to be at a greater rate than the original natural erosion.

Seawalls should only be considered for the protection of fixed assets that are located close to shore and endangered by erosion. Downdrift erosion impacts need to be considered and avoided or mitigated against.

Waves reflected by seawalls prevent deposition of sand, often resulting in the absence of sandy beaches in front of seawalls.

6.5.2 Groynes, Headlands and Offshore Breakwaters

Short groynes, mostly constructed of timber and brushwood have been used for local shoreline protection at a number of sites from Lake King to Lakes Entrance. Most of these groynes have been constructed in relatively sheltered locations with respect to wave attack and have functioned quite well.

In more exposed locations, such as the west shore of Shaving Point, groynes are of a more robust construction, typically rock.

The natural rate of sand supply by littoral drift in the Gippsland Lakes is usually low, hence beach stabilisation by groynes should generally be accompanied by beach nourishment.

6.5.3 Sand Nourishment & Sand Dykes

Nourishment of shorelines is a common practice on high use recreational beaches around the Gippsland Lakes

The key factor for beach nourishment is the availability of suitable sand at a reasonable cost. Such sand sources have not been identified. It is possible that limited quantities of suitable sand exist in the Eastern Beach area of Lake Wellington and from dredging operations at Lakes Entrance.

Ongoing coastal processes will cause a general eastward mobilisation of any sand placed on eroding beaches and hence sand nourishment should only be regarded as a short term solution in the absence of other works to hold the sand in place.

Sand can also be used to plug narrow channels and breaches into wetlands adjoining Lake Wellington and McLennan Strait. Creation of a sand dyke will likely also require use of geotextile materials and minor rock armoring to prevent interference from boat users seeking access through the channels.

6.5.4 Shingle Beach Creation

Creation of a shingle beach offers a method of protecting foreshores where wave climate is relatively mild. Shingle comprises pebbles and cobbles. To be economically viable a source of pebbles and cobbles needs to be located in reasonably close proximity.

In essence this protection mode lies somewhere between a sandy beach and a rock seawall.

A source of shingle occurs in the upper reaches of rivers, as is evident in the Avon River at the Princes Highway.

A shingle beach would typically be built with a slope of about 1 : 5, or it may be placed as layer upon the sloping surface of an existing substrate.

A shingle beach acts more like a beach than a seawall:

- It tends to absorb rather than reflect wave energy;
- It traps sand during periods of low wave energy but allows sand movement along the shore as part of longshore drift when wave energy is sufficient to separate the sand.
- It has a gentle slope and is visually less obtrusive than a seawall; and
- The shingle can still move along the beach in response to wave action, but the rate of movement will be much slower than sand in low wave climate areas of Lakes Wellington, Victoria and King.

6.5.5 Engineered Revegetation Solutions

Engineered revegetation solutions involve the use of temporary nearshore breakwater to protect shoreline revegetation from waves during the establishment phase.

The applicability of temporary nearshore breakwater is discussed in section 6.4.2

6.6 Engineering Priorities

Priorities for engineered shoreline protection works are listed in Table 8.

Further detailed site-specific design will be required in many instances prior to implementing engineered shoreline protection works.

Recommendation: Engineered Shoreline Protection

- Engineered shoreline protection works should only be implemented when both the upstream and downstream impacts in sediment movement and shoreline change are fully understood.
- Implement shoreline protection works listed in Table 8 following further detailed site-specific design as required.

Table 8: Engineered Shoreline Protection Works

Shoreline Protection Technique	Location
Seawalls	• Marlay Point Yacht Club – repair existing damaged walls • Loose rock into breach at Clydebank Morass (currently being implemented independently by Parks Victoria) • Loose rock into breach at Tucker Swamp (currently being implemented independently by Parks Victoria) • Mitchell River Silt Jetties. Several gaps in the existing rock walls pose only a limited threat to Crown foreshore and private land due to their narrow aperture. Additional rock beaching is justified given the extent of existing rock beaching protecting this site of international geomorphological significance. Additional work should be jointly funded by landowners and the Crown manager. • Beach Road, Metung – weak areas in existing rock wall prone to wave attack. Additional rock is required to prevent undermining of roadway
Groynes, Headlands and Offshore Breakwaters	• Marlay Point Yacht Club – repair existing damaged groynes adjacent to boat ramp • Improve efficiency of groynes along Beach Road, Metung, coupled with sand nourishment
Sand Dykes	• Channels and breaches into wetlands adjoining Lake Wellington and McLennan Strait – including geotextile and minor rock armoring – need to identify sand source
Sand Nourishment	• East of Loch Sport on the narrow land strip between Lake Victoria and Dolomite Swamp. Should be coupled with revegetation. Will need to locate a suitable source of sand. • Sand could be used to create beaches within protected reaches such as Newlands Arm and Duck Bay, but a need has not been identified • Recreational beaches at Eagle Point, Paynesville, Shaving Point and Beach Road
Shingle Beach Creation	• Shoreline at base of steep land between Chinamans and Boxes Creeks • Low priority - Toe of eroding cliffs and headlands, such as the cliffs along Sperm Whale Head between Green Hill Point and Point Wilson, and the cliffs at Tannin and Toms Points
Engineered Revegetation Solutions (temporary nearshore breakwaters)	• Not required until a suitable salt-tolerant macrophyte is choosen as an alternative to *Phragmites australis*

Parks Victoria has commenced rock dumping from barge platforms to infill the breach between Lake Wellington and Clydebank Morass. These works relate to ongoing investigations by Parks Victoria, the Department of Natural Resources and Environment, the West Gippsland Catchment Management Authority and SKM Consultants into salinity and catchment influences on Clydebank Morass and the objective of maintaining its integrity as a freshwater wetland consistent with its listing under the Ramsar Wetland Convention (P. Kambouris, pers. com.).

Other rock work currently underway is aimed at reducing the detrimental impact of visitors at specific locations such as Tucker Swamp and Crash Boat Landing in Lake Wellington. Partial in-filling of the breach into Tucker Swamp will prevent access by larger boats, thereby reducing accelerated erosion.

6.7 Other Land Management Practices

A range of inappropriate land management activities exacerbate shoreline erosion and diminish foreshore biodiversity values, including: grazing; inappropriate or excessive vehicular, boat and pedestrian access; and clearing of Crown foreshore land.

Recommendation: Land Management Practices

- Prohibit all grazing of Crown land foreshores on the Gippsland Lakes.
- Restrict vehicle access to immediate foreshore at:
  - Crashboat Landing
  - McLennan Strait fishing spots at Wood Pile Track and Eel Farm Track
  - others as necessary
- Restrict boat access to Tucker Swamp and through breaches into smaller wetlands
- Formalise (fenced tracks and/or boardwalks) foreshore pedestrian access at:
  - Hollands Landing
  - McLennan Strait fishing spots
  - Bunga Arm camp sites (commenced)
  - others as necessary

7 PLANNING CONTROLS

Planning approval for works on foreshores around the Gippsland Lakes is granted by Councils though municipal planning schemes and by the Department of Natural Resources and Environment through the Coastal Management Act.

Section 6.3 highlights the need to integrate setback buffers into local planning policy, principally the East Gippsland and Wellington planning schemes. This could be achieved through introduction of a Local Policy and inclusion into or introduction of a Coastal Overlay. Development within buffers should only be permitted where the development caters for anticipated erosion. Responsibility for dealing with any erosion should lie with the proponent/developer.

Councils and the Department of Natural Resources and Environment, in considering planning approval of foreshore works and developments, should take fully into account the potential impact of foreshore structures on coastal processes.

Planning approval applications for subdivision of land with foreshore frontage should be referred to the Department of Natural Resources and Environment to enable negotiations with private landowners to ensure Crown foreshore reserves are of an adequate width.

Planning approval for shoreline works should also consider aspects relating to potential impacts on sites of Aboriginal significance.

Recommendation: Planning Approvals

- Integrate setback buffers into municipal planning schemes (section 6.3).
- Planning approval processes should consider:
  - all potential impacts to coastal processes of foreshore works and developments, particularly where erosion control structures may cause erosion elsewhere.
  - the need to maintain Crown foreshore reserves of adequate width.
- Consider potential impacts to sites Aboriginal significance.

8 ONGOING INVESTIGATION

This record of shoreline change around the Gippsland Lakes builds on earlier work by Dr. Eric Bird for the period 1957-83 (Bird, 1978 & 1983). Future comparisons of shoreline positions should again be undertaken to determine long term erosion rates and to review the appropriateness of erosion mitigation works. The importance of undertaking such investigations is underpinned by the potential large scale impacts of enhanced Greenhouse Effect-induced sea level rise and the extent of predicted inundation (Section 2.4 and Appendix 1). No less than a 15 to 20 year interval for aerial and land-based photographic comparison should be adopted.

Given the inherent limitations of photographic comparisons, a system of surveyed shoreline benchmarks should be established to capture smaller scale variations on a shorter time frame. Various sites at different geomorphic features could be surveyed at varying frequencies of no greater than 5 years. Ideally, fixed concrete benchmarks should be surveyed at regular intervals to allow interpretation of shoreline response to storm and flood events.

To avoid misinterpretation of shoreline change, a comprehensive record of beach renourishment should be maintained by the Department of Natural Resources and Environment, Gippsland Ports and municipalities.

All data relating to shoreline change investigations should be centrally stored for future retrieval by management agencies and the broader community.

Further detailed investigation into the likely impacts of enhanced Greenhouse Effect-induced sea level rise on the Gippsland Lakes is required, including the extent of inundation, changes to geomorphological processes, and impacts on ecological processes of the Lakes.

Further research should be encouraged into the likely effects of large sand-rich bedloads migrating down many of the rivers entering the Gippsland Lakes.

9 CONCLUSION

Ecological conditions within the Gippsland Lakes have changed considerably since creation of a permanent opening at Lakes Entrance in 1889. The Gippsland Lakes are now an estuarine system with increased saline water intrusion.

Shorelines around the Gippsland Lakes continue to change as a result of both natural and man-induced processes.

Fringing reedbeds of *Phragmites australis* will continue to die-back due to salinity intolerance, reducing protection for adjacent shorelines from wave erosion. More salt tolerant plant species such as *Juncus kraussii* and *Zostera muelleri* & *Hetrozostera tasmanica* (Seagrass) will continue to spread as estuarine conditions continue to prevail over freshwater.

Eroding shorelines, as opposed to stable or accreting shorelines, are the most common shore type and represent the greatest management issue.

Shoreline erosion will continue. Erosion rates will vary depending on site-specific characteristics with low lying silty river deltas, wetlands and salt marshes most at risk. Sandy points, spits and headlands will continue to migrate eastward under the influence of prevailing wind and waves and should be free of permanent structures.

Much of the Gippsland Lakes will exhibit a narrow sandy fringing beach as sand is liberated by erosion of sandy shorelines. Such shorelines will continue to erode as sand is transported under the influence of natural coastal process. Large sand-rich bedloads migrating down rivers will eventually enter the Lakes, adding a local sediment source for areas close to river deltas. A number of large flood events could deliver sufficient sand to the Gippsland Lakes to significantly add to lake shorelines.

Wetlands separated from the main lakes by narrow sandy barriers are potentially threatened by further erosion. Wild Dog Shore is particularly vulnerable as very little additional erosion will result in Lake Wellington “expanding” into extensive adjacent wetlands. This represents the largest likely short-term change to shoreline position on the Gippsland Lakes.

At present, very few high-value infrastructure assets are threatened by erosion.

Implementing a response to shoreline erosion is fundamentally a function of risk and shoreline values. Government policy currently adopts a “retreat rather than protect” policy for all except key infrastructure assets.

A Response Matrix is used to determine an appropriate response, which include do nothing, retreat / define minimum setback buffer, terrestrial and aquatic revegetation, and various engineering solutions.

Since continued erosion is unlikely to threaten high-value infrastructure assets over the next 100 years, it is recommended that erosion processes be allowed to continue and that shorelines be managed by specifying buffer widths within which new permanent infrastructure should not be located unless erosion is catered for at the asset owners expense.

The alternative of implementing an engineered solution for much of the Gippsland Lakes would require extensive seawalls and/or groynes along extended sections shoreline. This is difficult to justify based on cost and the current government policy to “retreat rather than protect”.

Protecting the Latrobe and Avon River deltas with rock walls similar to those on the Mitchell River Silt Jetties is also unjustifiable.

Engineering solutions are recommended only where erosion threatens high-value infrastructure assets, or the ecological character of a site, or where erosion will result in large scale changes to estuarine/fluvial processes. Further detailed site-specific design will be required in many instances prior to implementing engineered shoreline protection works.

Parks Victoria's objective of mending breaches into adjacent freshwater wetlands to maintain the integrity of their natural values (from saline intrusion) must be seen in the context of longer-term large scale changes likely to result from ongoing shoreline erosion and from anticipated sea level rise. Works implemented in one location may need to be supplemented with additional works as new breaches develop, either naturally or artificially through unauthorised intervention. Any engineering works implemented to prevent saline water intrusion to freshwater wetlands should consider geotechnical properties of the lake bed and potential end scour effects of rock walls.

Terrestrial revegetation will provide biodiversity and landscape values but serves only to slow erosion rather than halt it. It is concluded that no single macrophytes species will replicate the role of *Phragmites australis* and implementation of aquatic revegetation using existing species indigenous to the Gippsland Lakes is unlikely to be successful.

Introduction of non-indigenous or genetically modified plant species in an attempt to replicate the role of *Phragmites australis* requires careful consideration.

In the longer term, the extent of shore erosion will increase dramatically as the anticipated sea level rise due to enhanced Greenhouse Effect begins to take effect by the middle of this century.

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11 APPENDICES

Appendix 1. The Effects of a Rising Sea Level on the Gippsland Lakes

Prepared for the Gippsland Lakes Shore Erosion and Revegetation Project, 2002

Dr. Eric Bird, Geostudies Pty Ltd.

Introduction

In recent decades it has been realised that global climate and sea levels are likely to change as the result of an increase in the Earth's atmosphere of such gases as carbon dioxide, nitrous oxide, and methane produced by human activities, notably industrial and agricultural processes and the depletion of forests. In particular, the burning of fossil fuels (coal, oil and natural gas) is returning to the atmosphere carbon dioxide that was withdrawn from earlier atmospheres by plant photosynthesis and retained in swamp forests that became coal, oil and natural gas deposits in the geological past.

Atmospheric monitoring was initiated on a global scale during the International Geophysical Year in 1957, and has since shown that concentrations of carbon dioxide, nitrous oxide and methane in the atmosphere have been increasing. The carbon dioxide concentration, for example, increased from 315 parts per million (ppm) in 1958 to more than 360 ppm in 2000.

Such an increase will enhance the natural "Greenhouse Effect", whereby the atmosphere intercepts some of the solar radiation reflected into space from the Earth's surface, and so maintains global temperatures at a higher level than would otherwise prevail. Without carbon dioxide, nitrous oxide and methane, the so-called "Greenhouse Gases" in the atmosphere, much of the Earth' s surface would be permanently frozen, but the recent artificial increase in these gases will lead to "Global Warming", with higher average temperatures in the atmosphere and the oceans and changes in the Earth' s climate.

It is expected that the mean temperature of the lower atmosphere will increase by between 1.5° C and 3.0° C over the coming century. Such human-induced global warming will lead to a world-wide rise of sea level, due partly to expansion of the oceans as they become warmer (known as the steric effect) and partly to the reduction of the world's snowfields, ice sheets and glaciers so that large amounts of meltwater are released into the oceans. Tide gauge records suggest that the sea has already been rising at the rate of between 1 and 2 mm per year around much of the world's coastline, but further monitoring is needed to determine the pattern and scale of this rising sea level (a contemporary marine transgression).

Calculations by the Intergovernmental Panel on Climatic Change have indicated that global sea level will probably rise 10 to 15 cm by the year 2030, accelerating to between 30 and 80cm by the end of the 21st century, and reaching one metre at some time during the following century. Such a sea level rise will initiate or accelerate coastal changes around the world. An obvious outcome will be that low-lying coastal areas will become permanently submerged, and that the sea will penetrate further into inlets, estuaries and coastal lagoons, including the Gippsland Lakes.

General effects of a rising sea level

If global sea level rises in the manner predicted there will obviously be extensive marine submergence as high and low tide lines advance landward, so that at least part of the present intertidal zone will be submerged as a new intertidal zone forms at a higher level. It is possible that there will be a slight increase in tide ranges around the world's coasts as the oceans deepen, the rise that actually occurs being modified as tidal amplitude is adapted to the changing coastal and nearshore configuration.

On many coasts the advance of the high tide line landward will be accompanied by an increase in erosion as nearshore waters deepen and larger and more destructive waves break upon the shore. As sea level rises erosion will begin on coasts that are at present stable, and accelerate on coasts that are already receding. The Ninety Mile Beach, for example, has already been cut back by marine erosion along most of its length, so that the backshore dunes are typically cliffed, and with a rising sea level this erosion will accelerate. As coastal dune fringes are cut back, more blowouts will be initiated, and some of these may grow into large transgressive dunes as sand is excavated and blown landward, or over into the Gippsland Lakes.

Effects of a changing climate

As global warming proceeds, some regions are expected to receive more rainfall while others become drier. East Gippsland is thought to be a region where summer rainfall will increase and winter rainfall diminish, the climate becoming more like that of northern New South Wales. Episodes of heavy rainfall are likely to generate frequent river flooding, and cause a water table rise that will augment that caused by the rising sea level. In consequence, there will be more extensive flooding of low-lying areas along valley floors.

Increased summer rainfall, coupled with warmer conditions, will lead to more luxuriant vegetation growth on the land around the Gippsland Lakes, particularly on the sandy barriers on their seaward side. It is possible that growth of blowouts in dunes cliffed by wave attack along the Ninety Mile Beach will be impeded by the more luxuriant dune vegetation.

Erosion will increase where climatic changes that accompany the rising sea level lead to more frequent and severe storms, generating strong wave action and storm surges that penetrate further inland than they do now. On the East Gippsland coast the present dominance of south-westerly storms may give place to more frequent south-easterly weather of the kind now seen along the New South Wales coast, and as tropical cyclones extend further south in the Tasman Sea there will be strong easterly swells along the Ninety Mile Beach.

Effects on the Gippsland Lakes

As sea level rises in Bass Strait there will be increased inflow of water to the Gippsland Lakes through the artificial entrance (Lakes Entrance) so that lake levels will also rise. Existing salt marshes are likely to be cut back along their seaward margins by waves as the water begins to rise, and tidal creeks which intersect these salt marshes will become wider and deeper, extending headward as submergence proceeds. Where the land behind the salt marsh slopes gradually the retreat of the seaward margin will be matched by a landward transgression of the inner margins of salt marsh.

As the water level rises shoals and intertidal shoal areas now exposed at low tide in the Lakes Entrance area will become permanently submerged. Low-lying areas presently occupied by salt marsh, swamp paper-bark scrub and woodland and saline mudflats, as well as reedswamp, will become part of the Gippsland Lakes as they grow larger and deeper. Some low-lying sandy backshore areas, including beach ridges, will also be submerged. The accompanying map (Figure 1) shows how the Gippsland Lakes would change as the result of submergence of bordering low-lying areas by a sea level rise of about one metre. Depressions in the surrounding country, such as the interdune hollows on Sperm Whale Head and low corridors in the country north of Lake Victoria, will become new lakes as the water table rises in association with the rise in the Gippsland Lakes.

As the level of the Gippsland Lakes rises, erosion will increase on the bordering shores because in stormy periods larger waves will break over them to higher levels. Cliffs cut into sands and sandstones occur locally on the shores of Lake Victoria, and these are likely to be cut back, and to grow longer, as wave attack increases. Beaches, beach ridges and swampy plains will all be re-shaped by wave action as the water level rises, and some of the eroded sediment will accumulate at and along the higher shoreline, the sand and gravel forming beaches, spits and cuspate forelands similar to those now seen, but at a higher level. Existing shore protection works, such as the boulder ramparts lining the Mitchell River silt jetties, will become ineffective as submergence raises the level of wave attack above them. It may be possible to build them up to match the rise in water level, but where they protect low-lying land that would also have to be built up to prevent submergence.

It is difficult to predict changes in the rates of sediment inflow from rivers draining into the Gippsland Lakes likely to result from increased summer rainfall and reduced winter rainfall. Sediment inflow has already changed, probably as a response to the clearance of vegetation and the introduction of grazing and cultivation in the river catchments, as well as mining and quarrying operations, so that rivers which formerly delivered mainly silt and clay to the Gippsland Lakes now contain large quantities of coarse sand and gravel that are moving downstream in successive floods. A rising sea level, transmitted into the Gippsland Lakes, will submerge the river deltas and the lower parts of river valleys, and result in the deposition of coarser sediment (sand and gravel) around the new river-mouth locations and the dispersal of finer sediment (silt and clay) across the lake floor. There may be some areas where lake shore and lake floor sedimentation is sufficient to compensate for the rise in water level, so that salt marsh or beach ridge vegetation can persist, but generally the formation of lake shore beach ridges, mudflats and salt marshes is likely to be impeded by the continuing rise of water level. There may also be some areas where small valleys or hollows are invaded by the rising water to produce inlets and estuaries with sheltered habitats in which mudflats and marshes can form.

Tides transmitted in from Bass Strait presently attain a maximum range of about a metre at Lakes Entrance and along Cunningham Arm, diminishing westward to 10-20 cm at Metung and becoming almost imperceptible at Paynesville. As sea level rises the tides will extend further into the Gippsland Lakes, and deepening water in Bass Strait is likely to increase the tide range, so that high tide submergence around much of Lake King and Lake Victoria will be augmented, and the ebb and flow of tidal currents through the artificial entrance and along narrow straits increased, especially between Lakes Entrance and Metung, and round Shaving Point.

Water levels presently show much more variation in response to changes in barometric pressure, wind stress and the effects of rain and river inflow than to tidal forces. Short-term rises of up to 2 metres have occurred during river floods on several occasions over the past century, while pressure changes and strong winds can cause fluctuations of up to 30 cm above and below calm-weather water level. Such variations will continue as sea level rises, so that when sea level has risen one metre river flooding can be expected to further raise the water to 3 metres above the present level of the Gippsland Lakes.

There is a strong possibility that a rising sea level in Bass Strait, combined with rising water levels in the Gippsland Lakes, will lead to the breaching of the outer sand barrier behind the Ninety Mile Beach seaward of Bunga Arm. The formation of new lagoon entrances would result in changes in current patterns in Bunga Arm and the addition of tidal movements in and out of the southern part of Lake King and the eastern part of Lake Victoria. These changes would modify channel forms and increase shoreline erosion.

The salinity regime in the Gippsland Lakes is estuarine, with a gradient from sea water (salinity about 35 parts per thousand) at the artificial entrance to fresh water in the inflowing rivers. Typically the salinity of surface water in summer diminishes gradually westward from Lakes Entrance across Lake King and along Lake Victoria, falling to less than 15 parts per thousand in Lake Wellington. In winter there is a steeper gradient, with Lake Wellington becoming fresher after heavy rain and river inflow. In addition there is typically a vertical salinity zonation, a wedge of denser sea water spreading into Lake King and Lake Victoria at depth, particularly in dry seasons, and receding towards Lakes Entrance during wet seasons.

The Gippsland Lakes were much less saline before the permanent artificial entrance was opened in 1889: they were often freshened completely by heavy rainfall and the inflow of river floods. There is much evidence to support the idea that salinity increased as sea water flowed into the lakes after the opening of the artificial entrance, and measurements made during the past half century confirm a general increase in salinity, Lake Wellington having become much more brackish. This increase is most marked in dry seasons and drought periods, but even now it is possible for the Gippsland Lakes to be briefly freshened by heavy rain and river flooding. It should be noted that some salinity, particularly in Lake Wellington, is derived from runoff from saline areas such as Lake Kakydra, connected to the lake by a drainage canal.

The impact of a rising sea level on the Gippsland Lakes salinity regime must take account of changes in rainfall and runoff from rivers as well as increased penetration by sea water. It is likely that by the time the Gippsland Lakes have risen one metre they will be much more saline than they are now, with low salinity only in the areas off river mouths.

A consequence of the increase in salinity in the Gippsland Lakes since the artificial entrance was open has been a decline in shore reedswamp, which was formerly extensive around the lakes. By 1960 it had disappeared from much of Lake King and Lake Victoria, and subsequently it has been considerably reduced even in Lake Wellington. On some sheltered parts of the shore reedswamp has been replaced by rush swamp and salt marsh, but generally the loss of the reedswamp fringe has been followed by erosion of the land that lay behind, much of which was a clay and peat plain occupied by swamp scrub vegetation. Incursions of brackish lake water into swamp scrub plains have resulted in soil salinity increase and the killing of the scrub vegetation, leaving enclaves of saline mudflat. As sea level rises, and low-lying land around the Gippsland Lakes is submerged by brackish water, there will be further damage to surrounding vegetation by salting.

On the other hand the increase in water salinity has resulted in the replacement of earlier freshwater water weeds by brackish seagrasses within the Gippsland Lakes. These are now extensive in shallow nearshore areas in Lake King and Lake Victoria, and on a smaller scale in Lake Wellington. Invasion by more brackish vegetation has been accompanied by the spread of marine and estuarine fauna, including fish such as bream and mullet, displacing the plants and animals of the earlier freshwater ecosystems. A rising sea level, leading to increasing inflow of sea water to the Gippsland Lakes, will result in further losses of freshwater communities and their replacement by salt-tolerant flora and fauna. There will also be migrations of these communities, the seagrass zone for example migrating landward to remain in the nearshore area where water depth is less than 1.5 metres.

Where the hinterland rises gradually new low-lying areas will form as the water level rises, and salt marshes and swamp scrub will migrate landward on to them, displacing terrigenous vegetation communities. When sea level has risen one metre some low-lying areas that are at present terraces, as on the broad Pleistocene deltaic plain west of Lake Wellington, will persist just above the level of the submerged swampy plains, valley floors and deltas. On these new low-lying fringes the rising water table may cause soil salting. Such areas will become wetlands with a salt marsh and swamp scrub cover if land use practices permit. The prospect of a salt marsh being maintained as the water level rises is poor, but locally, perhaps near river mouths, a salt marsh could persist if sedimentation or peat accumulation maintained a substrate that built upward at the same rate as the rise in water level.

Changes will thus be very extensive around the Gippsland Lakes as sea level rises. Structures that have been built on or near their shores will be threatened by rising groundwater, the advance of a deepening lake and increasing wave attack at higher levels, and they will need to be modified. The breakwaters that border the artificial entrance may have to be enlarged and strengthened to maintain them against stronger wave attack on a rising sea level and intensified current scour as increasing tides flow in and out. Jetties, launching ramps, groynes and sea walls designed to be effective with the Gippsland Lakes at their present level will need to be modified as rising water and stronger wave action render them useless. Roads built on low-lying areas close to the shore will be submerged, as will structures such as boat sheds, sailing clubs and houses, likely to be damaged or destroyed by submergence and wave attack. Maintaining the existing lake shoreline will be difficult and expensive, requiring not only shore protection but also the artificial raising of low-lying land to prevent its submergence: it may well make more sense to accept the loss of low-lying areas as submergence proceeds and the shoreline retreats. Perhaps the time has come to restrict development in low-lying shore areas to structures that can be abandoned or shifted in response to a rising water level in the next few decades.

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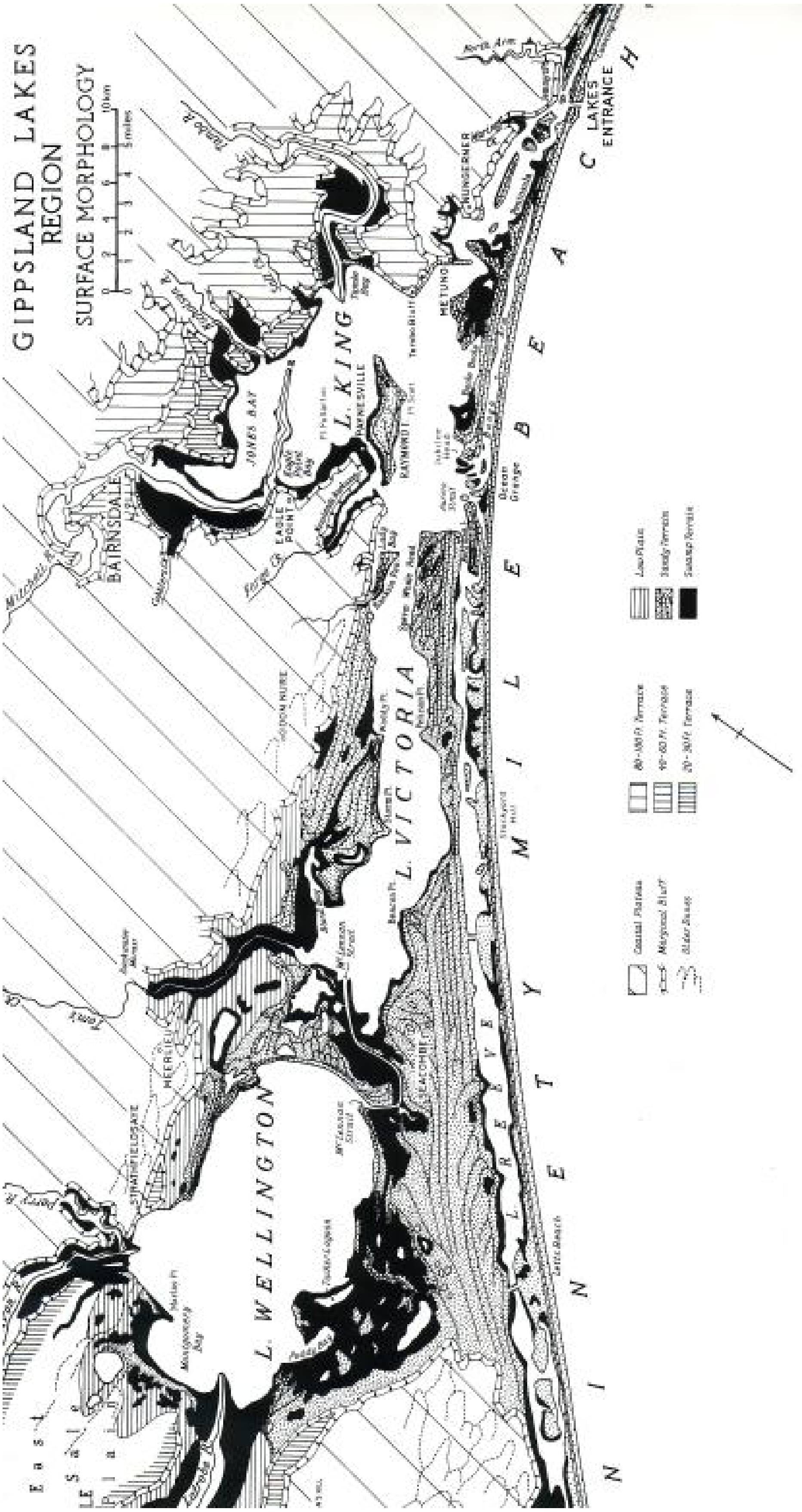
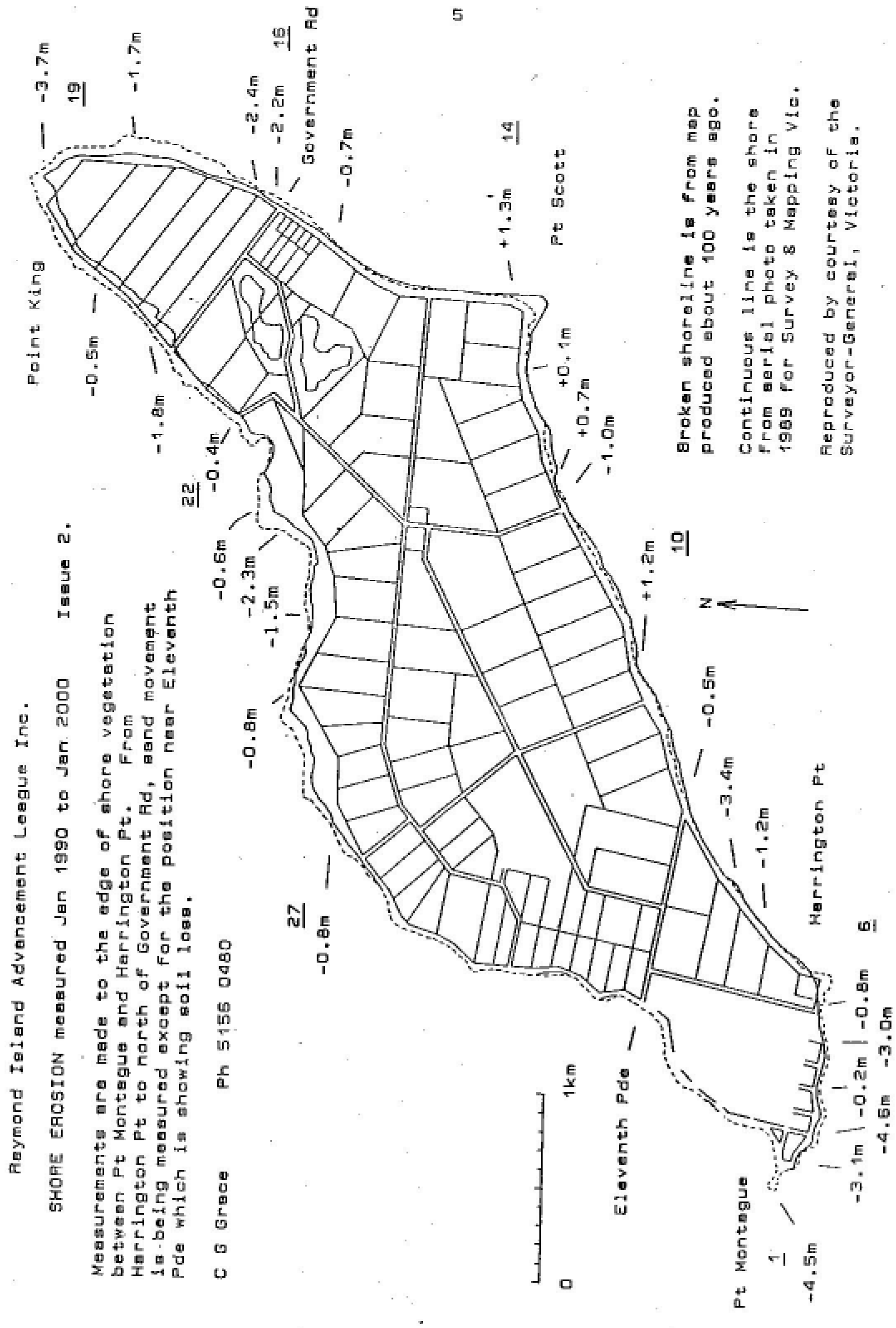


Figure 1: Swampy Terrain (black) around the Gippsland Lakes is likely to be inundated by a sea level rise of about one metre.

Appendix 2: Raymond Island Shore Erosion Measurement Project.

By: Grace, C. G., 2000 (Extract of data only)



Shore Erosion Changes in Metres

1/90	6/90	3/91	9/92	3/93	6/93	9/93	1/94	4/94	6/94	9/94	12/94	6/95	9/95	12/95	4/96
1	-3.0					-0.6							-0.5		
2	-0.8			-0.2		-0.2		-0.2		-0.2		-0.1	-0.1	-0.7	-0.1
3	-1.3	-1.8	-0.1	-0.2			-0.1	-0.3				-0.2			-0.1
4	-1.0					-0.2	+0.4	-0.1							
5	-2.3							-0.2	-0.2						
6	-0.2			-0.3											
7						-0.8		+0.2							
8			-1.0		+0.5	-0.6	-0.4								
9	-0.1							-0.5			+0.1				
10							+0.5	-0.1							+0.1
11						-0.2									
12						-0.2									
13	+0.3				+0.2	-0.2									
14	-2.3	+4.0	-1.5	-2.4		+0.2	+1.7		+2.2	-0.2	+1.0	+0.4	-3.2	+1.6	+0.9
15	+1.0		-0.2	-1.1	-0.5		+0.3	-0.5	+0.3	-0.3		+0.5	-2.2		
16			-1.8		-0.2	-0.8	+1.8	-1.3	+0.1			+2.7			
17			-1.0	+0.5	-1.0		+0.1	-0.8		+0.2					
18		-0.1	-0.5	+0.3		-0.3	-0.2						-0.1		-0.2
19			-1.3		-0.4	-0.6					-0.5		-0.1		-0.4
20						-0.2									
21			-0.1			-0.1		-0.1			-0.1		-0.3	-0.3	
22				-0.1			-0.1								
23	-0.1			-0.3		-0.2									
24	-0.2		-0.2			-0.3	+0.1					-0.1	-0.1		
25			-0.1	-0.1			-0.1	-0.1		-0.1	-0.1		-0.2		-0.1
26			-0.5	-0.2		-0.1									
27		-0.1	-0.1								-0.1				

High rainfall months in mm preceding increased loss measurements.

143 4/90 111 6/92 150 9/93 192 2/94

109 11/92

115 9/92

127 12/92

Not all high rainfall months precede increased loss. Consider also wind and its direction.

Shore Erosion Changes in Metres.

6/96	10/96	1/97	3/97	6/97	9/97	1/98	3/98	7/98	9/98	12/98	6/99	9/99	1/00	Total
								-0.4						-4.5
							-0.1	-0.4						-3.1
								-0.5						-4.6
							+1.3	-0.6						-0.2
								-0.3						-3.0
	-0.1							-0.1					-0.1	-0.8
								-0.6						-1.2
-0.6	-0.2							-1.1						-3.4
														-0.5
				+0.9				-0.2						+1.2
								-0.6					-0.2	-1.0
					+0.6	+0.6		-0.3						+0.7
								-0.1		-0.1				+0.1
+0.3	+0.5		-2.0	+2.0			+0.2	-3.6	+2.8	-0.7			-0.6	+1.3
	-0.1				-0.1									-0.7
	-0.1	-0.1						-0.5	+1.4	-1.4			+0.7	-2.2
	-0.4													-2.4
	-0.2							-0.1		-0.2	-0.1			-1.7
	-0.3												-0.1	-3.7
								-0.1		-0.2				-0.5
	-0.3							-0.2			-0.3			-1.8
								-0.1					-0.1	-0.4
														-0.6
	-0.1		-0.1		-0.1	-0.1		-0.1			-1.0			-2.3
		-0.1			-0.1	-0.1		-0.1					-0.2	-1.5
														-0.8
		-0.1				-0.1	-0.1	-0.1			-0.1			-0.8

High rainfall months in mm preceding increased loss measurements.

89 7/96 272 6/98

Table 1: Gippsland Lakes Shoreline Classification

Local Name	Description	Further description	Status	Rate of Erosion	Action	Buffer Classification	Start Easting	Start Northing	Finish Easting	Finish Northing	Aerial Comp-arison Compare	Photo Years Used for Aerial Comparison (Photo Set #1) 1935/1940	1966/1967 /1976	1984/1991	1997	Photo Set #3 Photo No.	Photo Set #4 Photo No.
							Note:Datum = AGD66										
Trouser Point, Sperm Whale Head	Location-Sand spit indicating northward sand movement	Has moved tip about 100m east, but eroded on western face	Accreting but mobile		No Development on spit	G	558200	5796600			yes	x			x	360p	276m
Trouser Point, Sperm Whale Head	Beach from inner barrier sand		Eroding-slow	<0.2 m/year	Setback	E2	557500	5796100	558300	5796600	yes	x			x	360p	275m
East of Trouser Point, Sperm W H	Dune scrub		Eroding-slow	<0.2 m/year	Setback	B2	558300	5796600	558600	5796700	yes	x			x	360p	
Between Trouser & Green Hill Points	Swamp paperbark		Eroding-slow	<0.2 m/year	Setback	E2	558600	5796700	559800	5797200	yes	x			x	360p	
Green Hill Point, Sperm Whale Head	Location-Sand spit indicating southward sand movement		Accreting but mobile		No Development on spit	G	560000	5797500			yes	x			x	221p,360p	277m
West of Green Hill Point SWH	Swamp paperbark	Wide tract of swamp paperbark & marsh	Eroding	0.3 m/year	Keep off low land	D3	559800	5797200	559950	5797500	yes	x			x	219p	
Green Hill Point, Sperm Whale Head	Beach from inner barrier sand	foreshore protected by spit, erosion will start when spit moves eastward	Stable, but previously eroded	Nil at present	Setback behind spit	B1	559800	5797200	560100	5797500	yes	x			x	218p	
Sperm Whale Head	Swamp paperbark		Eroding-slow		Setback	E1	560100	5797500	560600	5797600	yes	x			x	218p	
Sperm Whale Head	Cliff about 5 m high, Murphy swamp lies behind	Active erodible cliff	Eroding-slow	0.2 m/year	Setback	F2	560600	5797600	560800	5797650	yes	x			x	220p	
Sperm Whale Head	Swamp paperbark		Stable		Setback	D1	560800	5797650	561300	5798000	yes	x			x	218p	
Sperm Whale Head	Cliff about 5 m high, Lake Killarney lies behind	Less active eroding cliff	Eroding-slow	0.1 m/year	Setback	F2	561300	5798000	561350	5798100	yes	x			x	218p	
Sperm Whale Head	Swamp paperbark		Stable		Setback	D1	561350	5798100	561900	5798350	yes	x			x	218p	
Sperm Whale Head	Cliff about 5m high	Less active eroding cliff	Eroding-slow	0.1 m/year	Setback	F2	561900	5798350	561950	5798400	yes	x			x	218p	
Sperm Whale Head	Swamp paperbark		Stable		Setback	D1	561950	5798400	562200	5798650	yes	x			x	222p	
Point Wilson	Location-Sand spit		Accreting but mobile		No Development on spit	G	562450	5798800			yes	x			x	222p,360m	
Point Wilson	Beach from inner barrier sand		Stable		Nil	B1	562200	5798650	562600	5798600						222p,360m	
Sperm Whale Head-Rotamah Channel	Dune scrub	Low marsh & swamp behind	Eroding-slow	<0.2 m/year	Setback	B6	562600	5798600	562950	5798150						225p,360m	
Sperm Whale Head-Rotamah Channel	Cliff, previously eroded referring to EB photos, now revegetated	Could not detect change in aerial photo comparison	Stable		Setback	F1	562950	5798150	563150	5797900	yes	x			x	225p,360m	
Sperm Whale Head-Rotamah Channel	Dune scrub-extending to Trapper Point		Stable		Setback	B1	563150	5797900	563300	5796900						225p,360m	
Rotamah Island	Juncus Marsh		Eroding ?		Setback	H1	562700	5796000	564600	5797900							
Rotten island, facing Lake Victoria	Location-Low lying swamp paperbark or dune scrub		Stable		Setback	D1	565200	5798600								223p	
Barton island, facing Lake Victoria	Location-Low lying swamp paperbark or dune scrub		Stable		Setback	D1	565800	5798600								224p	
Jubilee Head to Point Jones	Swamp paperbark with beach pockets		Eroding-slow		Setback	E1	567200	5799600	568000	5800900						226p	
Jones Point	Location-small sand spit, backed by extensive swamp area		Eroding-slow		No Development on spit	B6	568000	5801200	569500	5800700						227p,359m	
Wollaston Bay	Swamp paperbark with beach pockets		Stable		Setback	E1	569500	5800600	572700	5802000						228p	
Purran Corner	Salt marsh and low lying land	Appear to be some shacks on foreshore	Minor erosion		No development	H5	572700	5802000	572700	5802400						229p	
North shore of Purran Corner	Swamp paperbark		Stable		Setback	D1	572700	5802400	571750	5802400						229p	
South side of Round Head	Newly pumped up beach	Sand recently pumped on to foreshore, performance can't be gauged	Stable ?		Setback	B2	571750	5802400	571500	5802500	yes	x			x	230p	306,307m
Round Head	Swamp paperbark		Eroding-slow		Setback	D1	571500	5802500	572000	5803400						230p231,232p	305m
Western end of landing field	Salt marsh		Stable		No development	H5	572000	5803400	572300	5803750							
Point Tyers area	Swamp paperbark with beach pockets		Eroding-slow		Setback	D1	572300	5803750	574700	5804400						233,234,235p	304m
Opposite Shaving Point	Salt marsh		Stable		No development	H5	574700	5804500	575500	5804100						236p	
Opposite Shaving Point	Beach from inner barrier sand		Stable-accreting		Nil	B6	575500	5804100	575550	5804300	yes	x			x	238p	
Opposite Shaving Point	Swamp paperbark with beach pockets		Eroding-slow		Setback	D2	575550	5804300	575700	5805100	yes	x			x	238p	173,174m
Opposite Shaving Point	Sandy (cleared) shoreline stabilised by jetty/groyne structures		stable but cyclical movement	0.2 m/year	Setback	C1	575700	5805100	576800	5805400	yes	x			x	238p	175,176m
South of Flannagan Island	Swamp paperbark		Stable		Setback	C1	576800	5805400	582800	5805300						263p	334m
Baxter Island	Location-cleared, grassed, sandy beach poclets facing channel		Stable		Setback	C1	577500	5805150								239,240p	
Ninety Mile Beach	Outer barrier sand beach-groynes & jetties-outside of bend	Brush-timber type groynes	Stable to erosional		groynes, seawalls OK if needed	B1	582800	5805300	583300	5805300	yes	x			x	245p	303m
Ninety Mile Beach	Salt marsh		Stable		No development	H3	583300	5805300	584150	5805700							300m
Ninety Mile Beach	Outer barrier sand beach-groynes & jetties & seawall - manmade changes		Stabilsed by structures		Further structures OK if needed	B1	584150	5805700	585100	5806000	yes	x			x	247p	302m
Fraser Island south end	Location-Spit		Accreting but mobile		No Development on spit	G	582250	5805800			yes	x			x	246p	
Rigby Island south west end	Location-Spit, double sided	Sand pumped on to SW corner	Accreting but mobile		No Development on spit	G	582450	5805750			yes	x			x	246p	
Rigby Island south shore	Swamp paperbark		Stable		Setback	D1	582600	5805700	583200	5805750						248p	
Rigby Island south shore	Swamp paperbark		Undercut		Setback	D1	583200	5805750	583300	5805800							
Rigby Island south shore	Salt marsh		Stable		Setback	H1	583300	5805800	583400	5805900							
Rigby Island south shore	Swamp paperbark		Stable		Setback	D1	583400	5805900	584000	5806150						249p	
Rigby Island south shore	Dune scrub		Eroding-slow		Setback	D1	584000	5806150	584500	5806000	yes		x		x	249p	
Rigby island east end	Location-Spoil ground-manmade		Changing		No development w/o study	G	584600	5806300			yes		x		x	249p	
Southern shore	Manmade		Changing		Can harden to stabilise	R	585200	5806100	585450	5806050	yes		x		x	249p	
Southern shore	Outer barrier sand beach		Stable		Setback	B1 + G	585450	5806050	586800	5806450						250p	
Southern shore	Location-Cuspate Spit		Mobile		Keep hard structures off	B1 + G	586850	5806500			yes	x			x	253-256p	
Southern shore	Outer barrier sand beach		Stable		Setback	B1 + G	586900	5806450	587300	5806600	yes	x			x	253-256p	
Southern shore	Location-Cuspate Spit at foot bridge		Mobile		Keep hard structures off	B1 + G	587300	5806650			yes	x			x	253-256p	
Southern shore	Outer barrier sand beach with cuspate spits		Spits are mobile		Keep hard structures off spits	B1 + G	587350	5806650	589800	5807650	yes	x			x	253-256p	
North Shore	All man modified - not in scope																
Developed southern shore	All man modified - not in scope																
Eastern Creek embayment	Swamp with silty fringe & minor clumps of Phragmites opposite bowling club		Stable		Setback	H5	586800	5807200	586900	5807400						258p	
Headland north of Eastern Creek	About 80m of ad hoc rock wall 20m of timber wall+ natrual silt/sand areas		Eroded		Formalise seawalls if requ'd	F1	586900	5807400	586800	5807850						258p	
East shore	Phragmites		Stable?		keep clear	H4	586800	5807850	586800	5807750						257,259p	
East shore	Juncus Marsh-narrow fringe		Stable?		Setback	H4	586800	5807750	586650	5807850						257,259p	
2nd headland	Developed above, appears stable		Stable?		Setback	F1	586650	5807850	586650	5807950						257,259p	
Gully	Juncus patches		Stable?		Setback	H4	586650	5807950	586600	5808000						257,259p	
East shore, residentail on top of cliff	Remnant Rain Forest with varied Juncus and swamp paperbark fringe		Minor erosion		Setback	F1	586600	5808000	586000	5808700						257,259p	
3rd headland	Location, Cliffed		Eroding		Don't develop headland	F2	586000	5808700								257,259p	
East shore, residentail on top of cliff	Stable varied shoreline from sand to Phragmites & Juncus		Stable		Setback	F1	586000	5808700	586350	5809150						257,259p	
West shore	Remnant Rain Forest with some weed, particularly for the southern area		Stable		Setback	F1	586150	5809150	585850	5808600						257,259p	

Table 1: Gippsland Lakes Shoreline Classification

Local Name	Description	Further description	Status	Rate of Erosion	Action	Buffer Classification	Start Easting	Start Northing	Finish Easting	Finish Northing	Aerial Comp-arison Compare	Photo Years Used for Aerial Comparison (Photo Set #1) 1935/1940	1966/1967 /1976	1984/1991	1997	Photo Set #3 Photo No.	Photo Set #4 Photo No.
							Note:Datum = AGD66										
West shore	Grazing land with intermittent Juncus fringe		Stable, except for localised undercutting		Setback, shingle beach or rock wall if undercutting becomes unacceptable	H4	585850	5808600	586400	5807700						257,259p	
West shore, headland north of long gully	Location-Cliff		Eroding slowly		Setback, could wall if req'd	F2	586400	5807650								257,259p	
Long gully	Location-Juncus fringed (heavily) gulley approx 200m x 75m		Stable		nil	H4	586400	5807600								257,259p	
West shore,1st, main headland	Location-Mainly grazed , slow erosion at southern & northern corners		Eroding corners		Setback but could wall if req'd	F1	586450	5807550	586400	5807400						257,259p	
West shore	Balance of undeveloped land leading to Juncus filled gully		Slight erosion		Setback, could armour if req'd	F1	586100	5807300	586400	5807400						257,259p	
West shore	Location, Gully with Juncus & rain forest above		Stable		nil	H4	586000	5807050								257,259p	
North shore	Bridge to Deja Vue, developed headland, vegetated slope		Stable		Nil	F1	585200	5806750	586100	5807100							
Bridge to Narrows	Manmade reclamation via dredge spoil and seawall		Stable		Setback from Beach	S	584700	5806600	585200	5806700	yes	x			x	260p	
North shore of Rigby Island	Manmade spoil grounds and training walls		Changing		Study and/or setback	G	584000	5806700	584900	5806200	yes	x			x	261p	298m
North shore	Continuous Seawall		Stable		nil	R	583850	5807050	584000	5806700	yes	x			x	261p	297m
Rigby Island north shore	Swamp paperbark (1940 photo indicates little swamp paperbark	Eroding at west end (300m)	Eroding	0.2 m/year	setback	D2	583400	5806500	584000	5806700	yes	x			x		299m
Rigby Island north shore	Salt marsh		Changing		setback	H1	583200	5806450	583400	5806500	yes	x			x		
Rigby Island north shore	Swamp paperbark (1940 photo indicates little swamp paperbark		Changing		setback	D1	583100	5806500	583200	5806450	yes	x			x		
Rigby Island north shore	Salt marsh		Changing		setback	H1	582750	5806500	583100	5806500	yes	x			x		
North shore	Narrow beach from erosional Tertiary cliff around Maringa Creek entrance		Changing		setback	F1	583000	5807000	583850	5807050	yes	x			x	262p,339m	
Nyerimilang	Tertiary slumping cliff due to groundwater effects	Full height of cliff potentially unstable - nothing to do with waves	Slumping can occur		setback to behind ridge line	T	580700	5807000	583000	5807000						338m	
Nungurner Hill	Narrow beach from erosional Tertiary cliff with Phragmites in bays at each end		Stable		Nil	F1	578650	5806900	580700	5807000						265p	
Nungurner	Narrow beach from erosional Tertiary cliff		Stable		Nil	F1	578350	5806750	578650	5806900						265p	296m
Nungurner	Dumped rock wall		OK		Nil unless damaged by storm	R	578315	5806725	578350	5806750						266p	
Nungurner	Vertical seawall		Stable		Nil	R	578150	5806450	578315	5806725						266p	
Bull Point	Narrow beach from erosional Tertiary cliff, generally stable-dumped rock at slipway+some accretion either side of headland		Stable generally		Rock or shingle beaching OK if needed	F1	576900	5806900	578150	5806450	yes	x			x	267,268p	
Fraser Island	Salt marsh		Stable		Setback	H1	582300	5806550	582500	5806000						263p	
Fraser Island	Juncus & beach		Stable		Nil	H1	582000	5806550	582300	5806550						263p	
Flannagan Island	Swamp paperbark with beach pockets, heavily grazed by goats		Stable		Setback	D1	578500	5805800	581700	5806600							
Flannagan Island	Spit at east		Mobile		No Development on spit	G	581700	5806600	581900	5806600	yes	x			x	263p	
Headland midway along eastern coast	Seawall recently upgraded		Stable		Nil	R	576650	5806850	576800	5806800						331,332m	294,295m
North shore	Narrow beach from erosional Tertiary cliff		Stable ?		Add shingle beach fi req'd	F1	576000	5806900	576650	5806850							292,293m
North Shore	Headlands		Eroding slowly		Add shingle beach	F1	575600	5806900	576000	5806900						269p	292,293m
Chinaman Creek	Residual Phragmites patches, boat moorings		Stable		Nil	H4	576400	5806950	575600	5806900						270p	289-291m
Shaving Point	Beach from erosional Tertiary cliff	Ultimately expect that either a compartmentalised beach is made or all seawall	Eroding slowly		Upgrade seawall as req'd	U	573950	5806400	575200	5805050	yes	x			x	237p, 271,272p	177-180m
Metung north shore	Sandy accreting beach						573800	5806400	573950	5806400	yes	x			x	272p	
Metung north shore	Seawall		Stable		nil	R	573550	5806400	573800	5806400	yes	x			x	273p	
East of Tambo Bluff	Beach from erosional Tertiary cliff		Eroding slowwly		Setback	F1	572100	5806400	573550	5806450						273p	181m
Tambo Bluff	Location-headland and lower terrace		Mobile		Keep off unless totally seawalled	F2	572100	5806450			yes	x			x	275,276p	170-172m
North of Tambo Bluff	Beach from erosional Tertiary cliff		Stable		Setback	F1	572100	5806500	572000	5807600	yes	x			x	275,276p	170m
North of swamp, Tambo Bluff	Beach from erosional Tertiary cliff		Eroding slowly		Setback	B1	572000	5807600	571900	5809000						277p	
Tambo Bay	Cleared land for pasture		Changing		Setback or rock wall if req'd	C1	571900	5809000	570100	5809600	yes	x			x	277,278p	
Tambo River entrance	Silt Jetties		Changed		Rock armoured-extend if req'd	H5, R	570100	5809600	569800	5809800	yes	x	x		x	280p	164-169m
Swan Reach Bay	Cleared land for pasture		Changing		Setback, allow to stabilise naturally	H5, R	569800	5809800	569500	5810600	yes	x	x		x	279p	162-163m
Slaughterhouse Creek	Western spit		AccretingChanging		Setback, allow to stabilise naturally	G	569500	5810600	569200	5810300	yes	x			x	279p	
North shore Slaughterhouse Cr to Reef Point	Cleared land for pasture-localised cliff erosion of varying degrees	locally at eroded area	Changing		Setback, could armour but expensive	C1	569200	5810300	566200	5809700	yes	x			x	282p	162-163m
Reef Point to Nicholson R	Cleared land for pasture		Stable		Setback/nil	C1	566200	5809700	564500	5811000						283p	382,383m
Jones Island	Cleared land for pasture, shingly headland at eastern end-hard point		Eroding slowly		Setback, could armour but expensive	C3	564500	5811000	563250	5811400	yes	x	x		x	287,288p	386m
Old Nicholson R entrance	Phragmites(dry) on west and Juncus on east		Stable		Setback	H1	563250	5811400	562900	5811350						288p	385m
Jones Bay north shore	Low erosion scarp pasture land		Erdoing between shingle spits		Setback/nil let shingle spits hold in place	C1	562900	5811350	562100	5810800	yes	x			x	289p	386m
Jones Bay north shore	Eroding pasture land with scrap tyre "protection"		Erdoing	0.2 m/year	Tyres messy, formalise by filling with concrete or remove & use rock	C2	562100	5810800	561200	5810600	yes	x	x		x	289p	387-391m
Jones Bay north shore	Pasture, low lying		Minor erosion	0.1 m/year	Setback	B6	561200	5810600	560500	5809500	yes	x	x		x	289p	392m
Point Norgate	Low swampy pasture		Eroding slowly		Tyre protection, messy	B6	560500	5809500	560200	5809500	yes	x			x		393,394m
Point Norgate	Pasture, low lying- low value?		Eroding slowly		Tyres messy, remove & allow erosion or formalise by filling with concrete or remove & use rock	C2	560200	5809500	559700	5809200	yes	x			x		395m
Point Bolodun	Phragmites patches		Stable?		setback	H5	559700	5809200	559000	5808950	yes	x			x		
Point Bolodun	Juncus patches		Stable?		setback	H5	559000	5808950	558550	5809800							
Upper Jones bay	Phragmites & Juncus fringed (wide0 , some melaleuca at north-some erosion		Generally stable		setback	H5	558550	5809800	557500	5809300						290p	396m
West shore Jones bay	Localised erosion area with tyres		Slight erosion		remove tyres, setback	H2	557500	5809300	557500	5809200						290p	397m
West shore Jones bay	Phragmites & Juncus fringed , patches of swamp paperbark		Stable, minor stress		setback	H1	557500	5809200	559500	5806950							398,399m
Mitchell silt Jetties	All weak areas have been armoured with rock. Where rock is failing, it is at wide segments of jetties where there is little chance of ersoion causing a breakthrough		Stabilised except for minor weak spots		Nil, check after major floods	R,H5	559500	5806950	560050	5809500						291,293p	374-381m, 157-161m
Eagle Pt beach to start of jetties	Beach & natural foreshore		Beach supplies shore to north		Sand placed on Eagle Point beach moves north-suggest groyne at north end of Eagle Pt beach and allow slow erosion of foreshore to north-will stabilise	S	560050	5806500	560150	5805750						294,295p	156m
Eagle Point to boat ramp	Rock wall, vertical		Stable		nil	R	560190	5805630	560250	5805550						294p	
Boat Ramp to Point Fullarton	Cleared to foreshore or being prepared for development	All very low lying	Unknown		seawalls, groynes & beaches?	H5	560250	5805550	562500	5805200						296p	
Point Fullarton	Swamp paper bark around point and juncus elsewhere		Eroding		setback-do not develop	H1	562500	5805000	563300	5805000	yes	x			x	298p	152-155m

Table 1: Gippsland Lakes Shoreline Classification

Note:Datum = AGD66

Local Name	Description	Further description	Status	Rate of Erosion	Action	Buffer Classification	Start Easting	Start Northing	Finish Easting	Finish Northing	Aerial Comp-arison Compare	Photo Years Used for Aerial Comparison (Photo Set #1) 1935/1940	1966/1967 /1976	1984/1991	1997	Photo Set #3 Photo No.	Photo Set #4 Photo No.
Paynesville north shore	Being cleared and filled to extend canals		Engineered		seawalls, groynes & beaches	H5	563300	5805000	564200	5804300						297p	
Paynesville balance up McMillan Strait	Developed and outside scope																
North shore Raymond Island	Developed for housing which is generally well set back		Stable, maybe slow erosion		Setback	C1	564300	5804000	564700	5804300						300p	149m
North shore Raymond Island	swamp paperbark with low beach in front-eroded from previous reed fringe		Eroding slowly		Setback	D1	564700	5804300	564950	5804400						301p	150,151m
North shore Raymond Island	Salt marsh		Eroding slowly		Setback	H1	564950	5804400	565300	5804600						301p	
North shore Raymond Island	Swamp paperbark & cleared		Stable except where cleared		Setback & local shingle beach could be built	H5	565300	5804700	565800	5804650						301p	
North shore Raymond Island	Salt marsh		Stable		Setback	H1	565800	5804650	566300	5804600						301,302p	
North shore Raymond Island	Cleared for acreage block		Stable?		Setback	H5	566300	5804600	566400	5804700						301,302p	
North shore Raymond Island	Salt marsh		Stable		Setback	H1	566400	5804700	566950	5805000						301,302p	
North shore Raymond Island	Swamp paperbark		Stable or slow erosion		Setback	H5	566950	5805000	567500	5805000						301,302p	
North shore Raymond Island	Salt marsh or lowlying poor pature		Stable or slow erosion		Setback	H5	567500	5805500	568100	5806000						301,302p	
Point King	Swamp paperbark		Eroding		Setback or private land owner could armour	B6	568100	5806000	568300	5806000	yes	x			x	302,303p	316m
East shore of Raymond Island	Swamp or low lying		Eroding		Setback or private land owner could armour	E3	568300	5806000	568200	5805000	yes	x			x	305p	
East shore of Raymond Island	Sandy beach from inner barrier sands-probably historic erosion where cleared to shoreline		Stable		Nil/setback	C1	568200	5805000	567700	5804000	yes	x			x	305p	315m
Point Scott	Spit		Mobile		Setback	G	567700	5804000	567300	5803500	yes	x			x	304,306p	
South shore Raymond Island	Beach from inner barrier sand-variable erosion & accretion		Slowly mobile		Setback	B2	567300	5803500	564300	5802000						307p	309-314m
South shore Raymond Island	Southern end including spit		Mobile		Setback, possibly groynes for local control	B2	564300	5802000	563200	5802100	yes	x			x	310p	
McMillan Strait	Foreshores developed and outside scope																
Paynesville Beach	Sandy beach that is renourished, extension of groyne at boat ramp would asist stability		Slow erosion		Extend groyne, maybe add sand	S	563150	5802700	563350	5802600						310p	
Newlands Arm	Vertical seawall		Stable		nil	R	562260	5802730	563150	5802700						309p	
Newlands Arm	Various shoreline protection methods-not engineered		slow failure of walls		setback or make continuous wall of constant standard	R + F1	561780	5802960	562260	5802730						309p	
Newlands Arm	Ad hoc rock wall approx 7 m long	Could fail, upgrade as required				R + F1	561970	5802860								309p	240m
Newlands Arm	Timber wall about 30 m long	Is failing, upgrade/replace with other wall as required				F1	561900	5802950								309p	
Newlands Arm	Rock wall about 150 m long					R + F1	561800	5802900								309p	
Butler Point	Slowly accreting spit		Mobile		Don't develop spit	G	562600	5802300								309p	
Butler Point to Bluff Head	Very slowly eroding shoreline from Tertiary cliff		Slow erosion		Setback	F1	562600	5802300	562300	5801000							242m,243m
Butler Point up south shore of Newlands Arm	Cleared for development or Juncus fringed shoreline		Generally stable		Setback	H4	562600	5802300	559500	5802100							
Lady Bay (west of Bluff Head	Cleared pasture		Generally stable		Setback	C1	562600	5802300	560000	5800150						311p	244m
South shore Duck Bay	Swamp paperbark		Generally stable		Setback	E1	560000	5800150	558250	5799300						311p	
North shore Duck Bay	Cleared pasture		Generally stable		Setback	F1	558250	5799300	560200	5799900						311p	
James Point	Spit		Mobile		Setback	G	560150	5800000			yes	x			x	311p	245,246m
East shore Banksia Peninsula	Beach from prior barrier sand, brush protection to eroded cliff		Slow erosion		Setback, seems to have stabilised	F1	560200	5800000	560650	5799200	yes	x			x	312,313p	252m
Point Turner	Spit		Mobile		Setback	G	560700	5799100			yes	x			x	312,313p	
South shore Banksia Peninsula	Beach from prior barrier sand , some cliffing	Cliffing near Point Turner	Slow erosion		Setback, seawall or shingle beach if erosion needs to be stopped	F1 = F2 at local eroded cliff areas	559300	5799000	560650	5799100	yes	x			x	314p	253m
Elbow Point to Mason Bay	Beach from prior barrier sand, pastures		Variable but slow moving		Setback	C1	557550	5799000	559300	5799000	yes	x			x	315p	
Tannin, Toms & Terrace Points	Beach from prior barrier sand (cliffed) , accretion and significant change	Toms Point has low terrace in front that should be ignored re buffer	All three points changing		Setback from edge of cliff	F1	555850	5797500	557550	5799000	yes	x			x	316,317,319p	254m
Wattle Point	Spit		Mobile		Setback, upgrade rock walls if fixed land area required	G	555700	5796850			yes	x			x	318,320p	255,256m
West of Wattle Point	Active erosion of cliff		Eroding	0.2 m/year	Setback	B2	553350	5795100	553550	5795100						321p	257m
Wattle point to Gorcrow Pt	Swamp paperbark plus locally cleared		Slow erosion		Setback	E1	553550	5795100	555700	5796850						322p	
Steel Bay north shore	Juncus fringe, no beach		Stable		Setback	H1	552500	5794900	553350	5795100						325p	
Steel Bay west shore	Beach from prior barrier sand		Stable		Setback	S	552500	5794000	552500	5794900	yes	x			x	323p	
Waddy Point	Spit		Mobile		Setback	G	552700	5793950			yes	x	x		x	324,326p	258-260m
South west of Waddy Point	Swamp paperbark		Eroding		Setback	D3	551600	5793400	552700	5793950	yes	x	x		x		260m
Cliff to east of track to shoreline	Eroding cliff in front of cleared land		Eroding		Setback	F2	551400	5793300	551600	5793400	yes	x			x	327p	
Bteween Storm & Waddy Points	Swamp paperbark		Eroding slowly		Setback	D1	548700	5792000	551400	5793300						328p	
East side of Storm Point	Accreting beach from Tertiary cliffs to the west		Accreting		Nil	S	548800	5791000	548700	5792000	yes	x			x	330p	261-263m
West of Storm Point	Eroding Tertiary cliff - active		Eroding		Setback	E2	548400	5790900	548800	5791000	yes	x			x	330p	261-263m
Luff Point to Storm Point	Swamp paperbark, cleared in 1940, now mostly revegetated		Eroding slowly		Setback	E1	543800	5791200	548400	5790900	yes	x			x	331p	261-263m
Luff Point	Swamp paperbark, cleared in 1940, now mostly revegetated		Eroding		Setback	D3	543800	5791200	548400	5790900	yes	x			x	331,332p	264,265m
Blond Bay	Mostly fringed by Juncus, often thick, small sand build up north of Luff Point		Stable		Setback	H3	542800	5791000	543800	5791200						334p,369m	
Between Jones & Blond Bays	Swamp paperbark fringing pastures		Eroding slowly		Setback	E1	541500	5790450	542800	5791000						336p	
Jones Bay	Juncus fringed to east and north, Phragmites on west close to L Victoria		Stable		Setback	H1	540950	5790000	541500	5790450						335,336p	266m
South of Jones Bay	Swamp paperbark		Eroding slowly		Setback	H5	541000	5789800	540950	5790000						335p	
Settlement between Bull Bay & Jones Bay	Foreshore cleared and timber and rock seawalls installed		Stable		Repair/replace walls if required.	H5	541000	5789500	541000	5789800						336p	267m
Bull Point &Bull Bay	Swamp paperbark with Phragmites patches		Slow erosion		Setback	H5	541000	5788200	541000	5789500						335,336p	
Mclennan Strait entrance to Lake Victoria	Silt jetties, eroding at tips		Eroding	0.5 m/year		H1	540500	5788000			yes	x			x	337p	
Bannon Bay	Swamp paperbark with Phragmites patches at heads of Bull Bay		Griffin Pt eroded, balance stable		Setback	H5	540300	5786000	541150	5787950	yes	x			x	337p	
Spoon Bay	Swamp paperbark fringing low lying swampy land		Generally stable		Setback	H5	541000	5785800	540300	5786000							
Hybla Point	Shoreline change since 1970 due to drainage channel?		Appears stable		Setback	D1	541000	5785800								338,339p	
Hybla to Thalia Point & east	Swamp paperbark, negligible beach		Slow erosion		Setback	D1	543650	5785800	541000	5785800						340p	
Balance Thalia Pt to Red Bluff	Swamp paperbark, fringing beach		Slow erosion	0.2 m/year	Setback	D2	543650	5785800	546000	5788000	yes	x			x	341p	
Red Bluff	Spit		Accreting, mobile		Setback	G	546000	5788000			yes	x	x		x	341,342p	
RedBluff Beach	Beach		Accreting		nil	S	546000	5788000	546500	5787500	yes	x	x		x	343p	
Waverley Point & adjacent shoreline	Swamp paperbark		Eroding	up to 0.4 m/year	Setback, if developed will ultimately need to be stabilised	E3	546500	5787500	549500	5787900	yes	x			x	344345p	
Loch Sport	Outside brief																

Table 1: Gippsland Lakes Shoreline Classification

Local Name	Description	Further description	Status	Rate of Erosion	Action	Buffer Classification	Start	Start	Finish	Finish	Aerial Comp-arison	Photo Years Used for Aerial Comparison (Photo Set #1)				Photo Set #3	Photo Set #4
							Easting	Northing	Easting	Northing	Compare	1935/1940	1966/1967 /1976	1984/1991	1997	Photo No.	Photo No.
							Note:Datum = AGD66										
Pelican Bay to Pelican Point	Eroding inner barrier cliff to mobile/accreting spit		Erding/accreting		Setback, Dolmite Swamp monitor	F1	553600	5791100	554000	5792700	yes	x			x	350,352,354p,365m	272,273m
Pelican Point	Spit & headland		Mobile		Setback	G	554000	5792700	554200	5792650	yes	x			x	353,355p	274m
Trouser Bight to Point Walker	Mobile dune scrub & Swamp paperbark		Erosion/accretion sequences		Setback	E1	554200	5792650	557100	5795600						356,357p	
Point Walker to Trouser Point	Mobile dune scrub & Swamp paperbark		Erosion/accretion sequences		Setback	E1	557100	5795600	558000	5796500						358,359p	275m
Betsy Lagoon	Breach into lagoon - present in 1967 aerial photos (no 1935/40 photos)		Has enlarged		Has been saline for over 30 years. Can't see it affecting Victoria lagoon	H1	539700	5787800			yes		x		x	337,361p	270m
Woodpile Track	Cleared land for hunting access - needs to be managed (PV)		Stable		monitor and manage	H5	539000	5786400									
Little Morley Swamp	Recent man-made breach from Mclennan St (nil in 1967, existed in 1984)		Has enlarged		probably saline for at teast 10 years	H1	538500	5786000									
Wetland on opposite side of McLennan St to Morley swamp	Recent man-made breach from Mclennan St (nil in 1967, started in 1991)		New, unsure of impact		concern is re chance of new flood break out of McLennan St	H1	539100	5784800									
Eel Farm track	Shoreline erosion due to people and boat access including launching		Local erosion		manage or formalise	H5	538500	5782400									
North of McLennan Str	1935 photo gives impression of eroded shoreline, present day erosion of swamp paperbark is minor	Probably represents loss of Phragmites	Slow erosion	0.2 m/year	setback	H2	536600	5783200	536700	5783700	yes	x		x		363p	
Eastern Beach (south)	Patches of remanant Phragmites & Juncus-1935 photo has larger remnant patches at same location, elsewhere sandy beach		Loss of reeds but beach stable/growing slowly		Setback	S	536700	5783700	536700	5784200	yes	x		x		364p	204m
Eastern Beach	Sandy beach		Accreting		nil	S	536700	5784200	535500	5788500	yes		x	x		365-368,370p	199-203m
East of Roseneath point	Eroding cliff active, and other significant changes		Eroding & unknown		Setback, armouring may lead to downstream (to east) erosion	F1	534500	5789000	536700	5784200	yes		x	x		369p	197-199m
Roseneath Point	Ersoion on west side & other changes & patch of Phragmites		Erdoing & changing	0.5 m/year	Setback, armouring may lead to downstream (to east) erosion	E3	533300	5789050	534500	5789000	yes	x		x		371-373p	196m
North Shore between Roseneath and Swell Points	Intermitteny Swamp paperbark and beaches from prior barrier sands		Erdoing & changing	Up to 0.4 m/year	Setback, armouring may lead to downstream (to east) erosion	E3	528000	5788300	533300	5789050	yes	x		x		374-377p	195m
Swell Point to Storm Point	Swamp paperbark		Slow erosion	0.2 m/year	Setback, armouring may lead to downstream (to east) erosion	E2	526200	5788100	528000	5788300	yes	x		x		378-381p	194m
Storm Point	Cuspate lagoon with breach that appears in all aerial photos	Buffer from edge of dune/cliff	Changing very slowly		Setback	E2	526000	5781300	526200	5788100	yes	x		x		380-381p	193m
Strathfieldsaye to Storm Point	Beach from erosion of Tertiary cliffs		Slow erosion		Setback, armouring may lead to downstream (to east) erosion	C1	525000	5789200	526000	5781300	yes	x		x		382-383p	192m
Strathfieldsaye	Beach from erosion of Tertiary cliffs, some recent dune/bank revegetation		Eroding cliff slow		Setback, armour is necessary	C1	524000	5789200	525000	5789200	yes	x		x		383p	189-191m
Avon R entrance to Strathfieldsaye	Diminishing Phragmites		Erosion started		Setback	H1	523500	5288600	524000	5789200	yes	x		x		384p	
Avon R Silt jetties	Swamp paperbark		Eroding		Setback, little consequence	H1	523400	5788500			yes	x		x		385p	187,188m
Clydebank Morass & Diamond Creek	Extensive changes and erosion, recent flood flow path, concern to PV		Extensive erosion		Keep clear or close off?	H1	521850	5787400	523200	5788600	yes	x	x	x		386p	186m
Marlay Pt Ramp area	Already eroded in 1935, & continuing plus wall protection (timber, rock & concrete)		Eroding & armoured		Repair & upgrade when req'd	R + C2	521700	5786500	521850	5787400	yes	x		x		387p,373m	182-185m
Marlay Point Reach	Phragmites patches and eroded grazing land & swamp paperbark		Eroding		Setback, but if land req'd will need engineered solution, seawalls, contained beach etc	C3	521400	5785000	521700	5786500	yes	x		x		388-390p	
Grebe Bay- Frawley drain to Marley Point	Swamp paperbark & Phragmites patches		Eroding		Setback	H1	519350	5785000	521400	5785000	yes	x		x		391,393p	238m
West shore north	Phragmites including wide healthy areas-seems like significant regeneration since 1991 photos		Changing all the time, note considerably patchy pahragmites in 1935		Setback	H1	519300	5780900	519350	5785000	yes	x		x		394-397p	233-237m
West shore south	Low lying land		Changing all the time, note considerably patchy pahragmites in 1935		Setback	H1	519300	5780900	519350	5785000	yes	x		x		398,399p	233-237m
Latrobe Delta	Loss of extensive Phragmites areas near end of delta		Eroding		Setback	H1	519800	5779700	519300	5780900	yes	x		x		400,401p	230-232m
South of Latrobe Delta to start of Sheepwash Point	Phragmites patches and swamp paperbark		Eroding		Setback	H1	519800	5779700	523000	5778800	yes	x		x		402,403p	
Sheepwash Point	Swamp paperbark		Eroding		Setback	E2	519800	5779700	523000	5778800	yes	x		x		404p	
Poddy Bay	Swamp paperbark with some Phragmites patches,		Eroding		Setback	H1	523000	5778800	524500	5778600						404,405p	228,229m
Willow Point to Tucker point	Swamp paperbark with beach patches (already eroded in 1935)		Eroding		Setback	H1	524500	5778600	526600	5780300	yes	x		x		406-410p	223-227m
South of Tucker Point	Swamp paperbark with Phragmites patches		Eroding		Setback	D1	526600	5780300	526750	5779500	yes	x		x		411p	
South shore	Swamp paperbark with beach patches (already eroded in 1935)		Eroding		Setback	H1	526750	5779500	529400	5779300						412-414p	221,222m
South shore	Phragmites		Eroding		Setback	H1	529400	5779300	529550	5779200						414p	
Wild Dog Shore	Swamp paperbark with beach patches (already eroded in 1935)		Eroding		Setback	H1	529550	5779200	531800	5780600	yes	x		x		415-417p	219,220m
Bull Point to Bull Bay	Swamp paperbark with Phragmites patches		Eroding	0.2 m/year	Setback	D2	531800	5780600	532800	5780200	yes		x	x		418,419p	
Bull Bay	Derelict jetty &boatshed PV concern (already derelict in 1991)			0.5 m/year		E3	532800	5780200			yes		x	x		418,419p	215-218m
Bull Bay to Plover Point	Swamp paperbark with beach patches (already eroded in 1935)		Eroding	Up to 0.4 m/year	Setback	E3	532800	5780200	536100	5783300	yes	x		x		420-424p	212-214m
Plover Point	Headland & spits		Mobile	Up to 0.4 m/year	Setback	G + E3	536100	5783300	536500	5783200	yes	x		x		362,363,425p	205-207,211m