LENNOX HEAD

COASTAL PROTECTION STRATEGIES

by

R. Ensbey

December 1987

Report prepared as an undergraduate project in the Centre for Coastal Management, School of Applied Science, Northern Rivers College of Advanced Education, Lismore.

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ABSTRACT

Lennox Head, a small coastal village on the North Coast of New South Wales, has experienced considerable shoreline erosion over the past few decades. Currently, several buildings in the area are located on sites experiencing erosion, and these may be vulnerable to damage in the next major storm. Residents and the Ballina Shire Council have built a number of structures to protect the eroding shoreline, but the threat of further erosion in the southern corner of the beach and north of Rutherford Street remains. It is clear that further erosion is likely, and that some form of erosion control is necessary before further development is threatened. This report examines various erosion control options and their advantages and disadvantages. The sand sausage option, combined with a dune rehabilitation scheme and modifications to the Ballina Shire Council's coastal planning policy are favoured.

INTRODUCTION

Background

The village of Lennox Head is situated 10 km north of Ballina on the North Coast of New South Wales (Fig. 1). The village, first established in 1922, began as a small centre for farming and fishing enterprises and grew slowly through the construction of holiday housing to serve the neighbouring urban and rural areas. In the past twenty years the village has grown rapidly as the tourist and retirement booms drew holiday makers and residents from a much wider area.

The shopping centre at Lennox Head, which is situated near the Southern end of Seven Mile Beach, and adjacent early housing were built close to the shoreline. Originally, the residential and commercial buildings were mainly constructed of timber and asbestos cement, and land values were sufficiently low such that coastal erosion did not present a serious problem. However, recent development has been of a more permanent nature and land values have risen dramatically with the result that investment protection has become a more important issue. Applications for approval of further building in the zone of active erosion at the southern end of the beach have put further pressure on the Ballina Shire council, which has jurisdiction over the area, to organise some form of protection of the village from further erosion (Dudgeon *et al.*, 1986).

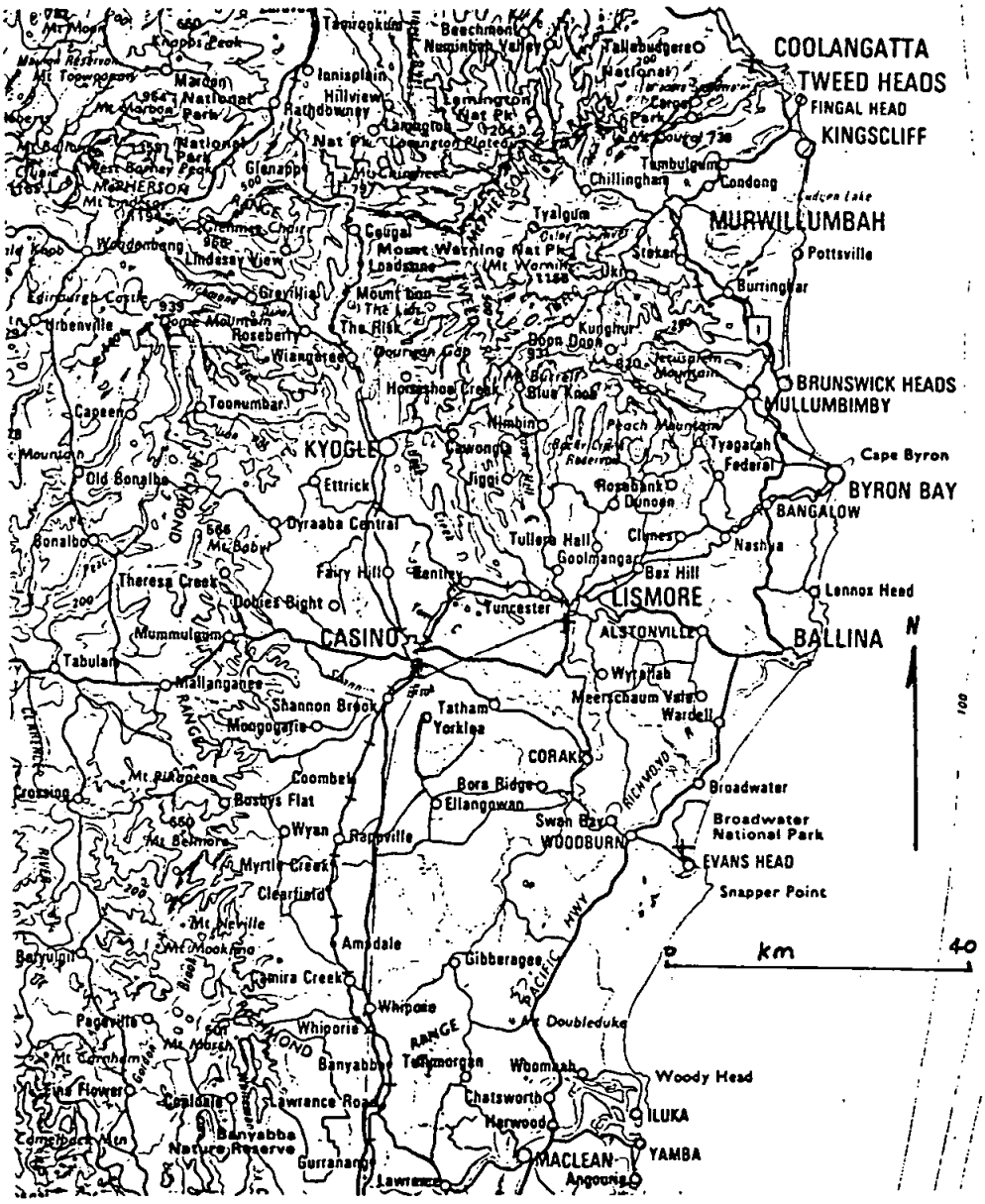

Figure 1. Map showing the location of Lennox Head on the north coast of N.S.W.

At present the Ballina Shire Council, in consultation with the Public Works Department and the Water Research Laboratory in the University of New South Wales (Dudgeon *et al.*, 1986), has recommended that a seawall be built to protect the shoreline at Lennox Head. The wall, which is estimated to cost $1 million to complete the first section at a $1000/metre, is to be funded by council and individual land owners; council will provide funds for the protection of crown lands, parks and reserves. Land owners with beach frontage will have to build their own walls before development applications will be approved, while owners of existing buildings with a sea wall will have to comply with the specifications set down for the new wall if they wish to improve their protection (Northern Star, 1987). Construction of the wall will take place as money becomes available with the council providing $50,000 per year until the wall is completed. It is proposed that the seawall be built in three sections A-B, B-C, and C northward

(Fig. 2); section A-B will be constructed first as protection in this zone is needed more urgently. However, no specific time frame has been set for completion of the wall. Completion of construction will depend on the availability of funds, and if the council dose not receive state government assistance the seawall could take considerable time to construct.

An article on the proposal to construct the seawall, which appeared in the Northern Star March 3rd 1987, has sparked heated discussion among residents and other interested parties in the district. The proposal to construct a seawall is controversial, and many people oppose its construction. This review records and evaluates alternatives to seawall construction available for shoreline protection at Lennox Head, and relates these alternatives to community opinion in the area.

Objectives

The principal objectives of this study are:

1. To review past and present coastal protection programs at Lennox Head .
2. To identify both anthropogenic and natural changes to the Lennox Head shoreline.
3. To investigate the factors affecting coastal change in the Lennox Head area.
4. To review coastal protection options for the Lennox Head area in relation to cost-effectiveness, environmental impact, and social desirability.
5. To recommend a coastal protection strategy for Lennox Head.

The Coastal Protection Act

The Coastal Protection Act (1979) set up the body known as the Coastal Council which consists of 10 members appointed by the Minister for Environment and Planning. The function of the Coastal Council includes giving advice to, and making reports and recommendations to the minister with respect to :

- Protection, maintenance, and restoration of the coastal zone;
- Having a balance between utilization and conservation;
- Planning and management;
- Co-ordination of policies and activities;
- The acquisition of land.

The consent of the minister for Public Works is required for development to be carried out in the coastal zone. This consent can be refused if development is likely to adversely affect the beach or dune system, or if the development is likely to be adversely effected by the sea. Recently, this coastal policy has shifted from a focus on the acquisition of important areas to a general development of policy and planning control (Thom, 1981).

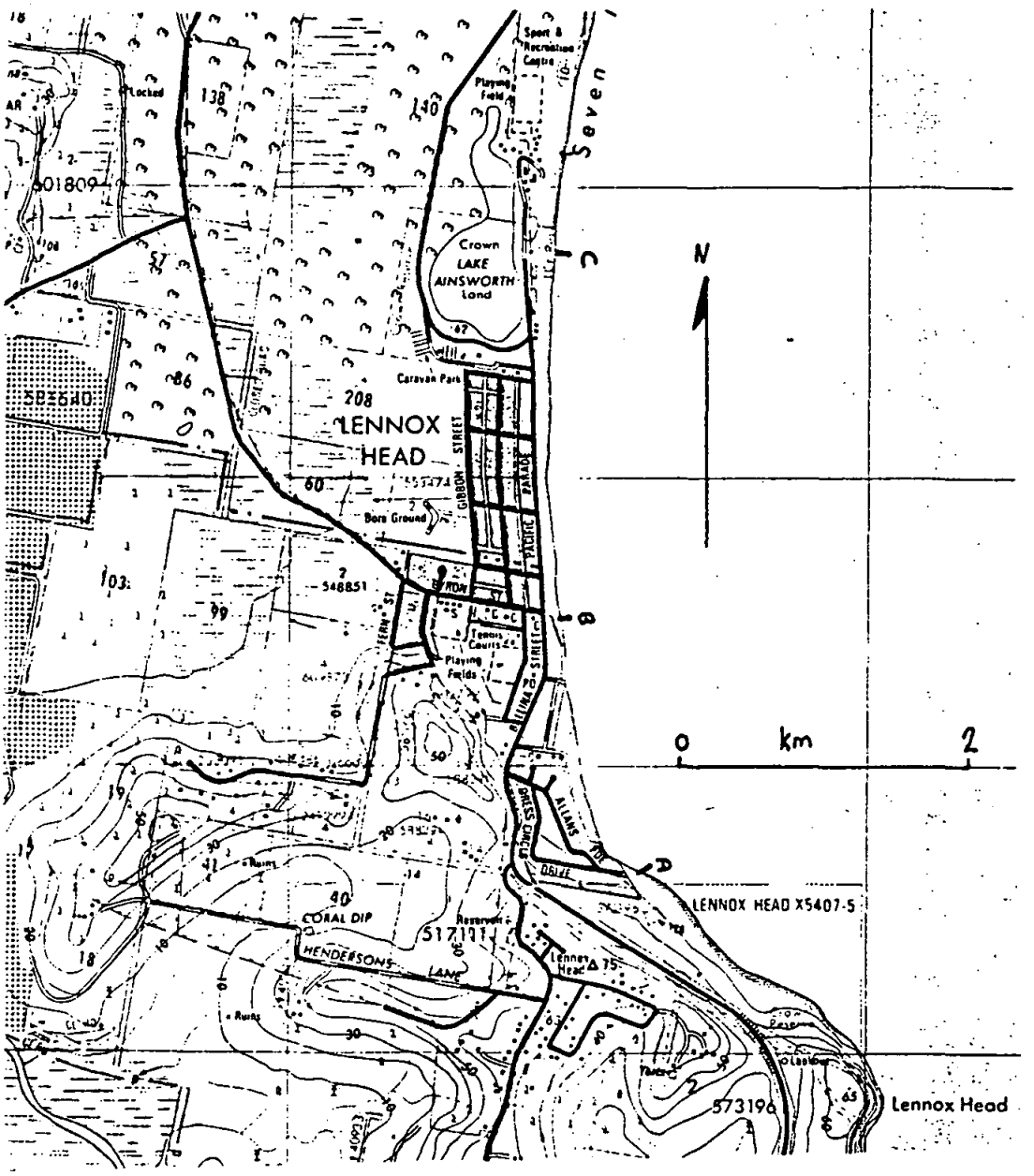

Figure 2. The Lennox Head township and the proposed seawall construction section.

Ballina Shire Council's coastal planning policy

The Ballina Shire Council's, coastal management committee has outlined the building considerations applicable to the coastal zone. All development carried out along the shoreline at Lennox Head must comply with these regulations, which include :

- That development consent may require developers to install seawall protection in accordance with the final design accepted by the council;
- That development only be permitted on land outside a limit of 50 metres measured back from the beach erosion escarpment;
- That foundations and ground floor construction forming part of of any development be of suitable design to allow for possible inundation from the sea during a severe storm;
- That the floor level of any development be at a level determined by the council, such level to be above 2.6m Australian Height datum.

COASTAL CHANGE IN THE LENNOX HEAD AREA

History of coastal erosion and shoreline protection

Beach erosion at Lennox Head has been noticed since the turn of the century, and residents report that the southern end of beach has been the most effected. Substantial erosion of the beach face from Lennox Head to Broken Head is also indicated by aerial photographs dating back to 1947. The extent of beach recession is easily recognised in relation to coastal roads which provide fixed reference points clearly visible on aerial photographs of the Lennox Head region. The area experiences regular seasonal erosion and accretion, but large erosional escarpments are largely the products of major storm events. These periodic high energy events cause the long term recession of the coastline, with erosion averaging nearly 1m per year being indicated by aerial photographs (Dudgeon *et al.*, 1986; Stevens *et al.*, 1981).

Previous beach protection work has been carried out by individual land owners, local councils, and other New South Wales government bodies. In February 1964 the Tintinbar Shire, then responsible, was granted 500 pounds towards a rock spall wall for "Dunal Protection". This work was discontinued when in the opinion of the shire engineer, accretional trends made further work unnecessary (Chapman, 1982). In 1967 the department of education provided $35,000 for about 400 metres of protective rock wall along the beach in front of Lake Ainsworth and the Department of Sport and Recreation buildings. This wall was built to provide protection from the severe erosion of the beach and dunes in front of the lake, caused in 1966 (Chapman, 1982). Other protective measures have involved, sand drift fencing and rip rap placed along 450 metres at the southern end of the beach by the Ballina Shire Council and local property owners, following the 1974 storms. At present the fences and rip rap which haven't been eroded away, have deteriorated and need upgrading and expanding.

In 1967 volunteer workers with the Tintinbar Shire Council completed a beach protection fence constructed from tea tree poles; the fence, to protect Lake Ainsworth and the southern foreshores from erosion contained more than 8,000 poles (Northern Star, 28/8/67). This method is still being used by some residents and is regarded by them as a successful strategy for erosion control (Fig. 3). Waterfront property owners near the shopping centre have dumped assorted materials including rock, cement, bricks, and branches along and inside their property boundaries to resist erosion. Owners of property at the most southern end of the beach have had less success, and have continually placed rock fill in front of their houses after major storms in an attempt to prevent further land loss and property damage (Fig. 4).

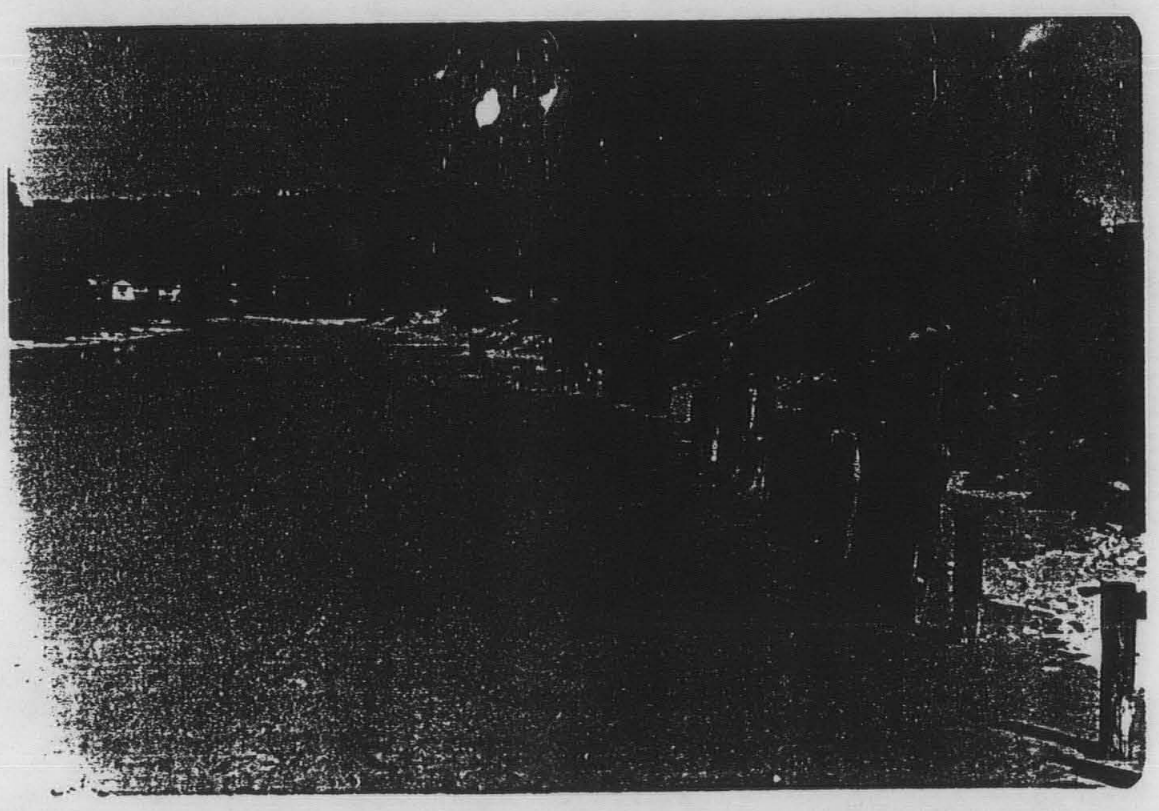

Figure: 3 - Erosion control methods used by residents at Lennox Head.

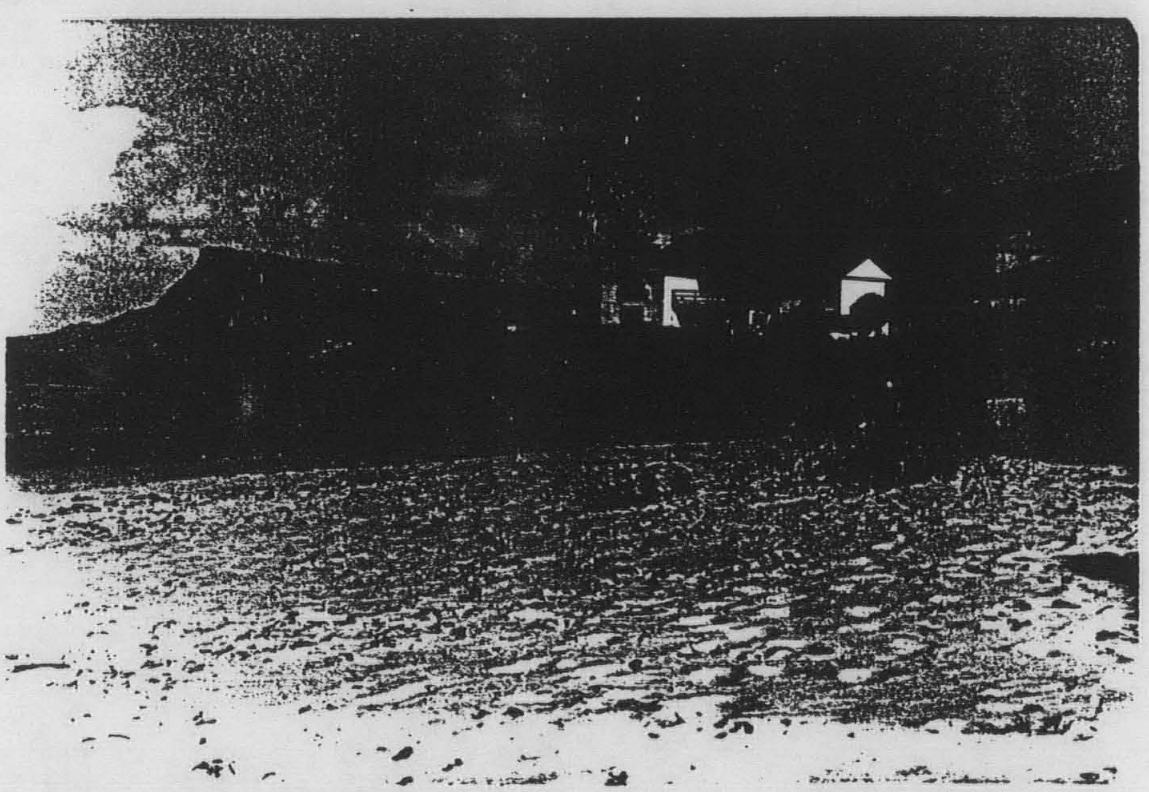

Figure: 4 - Rock protection in the southern corner of the beach at Lennox Head.

In front of the holiday units adjacent to the main shopping centre, the Ballina Shire Council has dumped rockfill to try and prevent further recession, but while this has successfully halted erosion behind the wall, the beach has suffered severe sand loss, and in places the wall is being undermined. This wall has also provided a hard point in the beach which has extended seaward relative to the adjacent coastline (Fig. 5).

Overall, previous beach protection at Lennox Head has been restricted to responses to major erosion events; the response has been fragmented, and carried out with limited attention to coastal processes. Future shoreline protection works will require more comprehensive planning and should be long term projects which take local community opinions into account.

Figure: 5 - Rock wall protecting a development from erosion at the southern end of the beach.

The present coastline

There is noticeable geomorphological variation, reflecting both anthropogenic and natural changes, within the study area. Transects along the shoreline at Lennox Head (Fig. 6) reveal the nature of this variation. On transect 1 taken south of the boat ramp, there is a lack of dunal development and a narrow beach. On transect 2 adjacent to Rutherford street, there is increased dunal development relative to transect 1, but the beach remains narrow compared with transect 3 taken in front of lake Ainsworth, where there is a well developed dune system and a wide

beach. The general trend is toward a northward increase in dunal development and beach width. Due to protection by the headland and reef, the shoreline in the southern section receives little wave energy and a low sand input under normal wave climate conditions, but is vulnerable to erosion during high energy storm events. Further north, the beach is not protected by these features and may accumulate sufficient sand during low energy periods to compensate for losses during high energy events. The northward increase in beach width also assists in the dissipation of wave energy in a manner conducive to the accumulation of additional sand.

The degree of disturbance of dune vegetation varies along the beach. Where development has taken place on the eastern side of Ballina Street the dunes are poorly vegetated with only grasses and small shrubs present. North of the development area well developed dunes, with an extensive vegetation cover, provide a buffer to beach recession. Dune disturbance largely involves the clearing of trees to improve the seaviews, and damage to the vegetation cover resulting from uncontrolled access which subsequently leads to sand loss by wave action and aeolian processes.

At present the beach and dunes are in good condition due to the lack of major erosional events in the past few years; this has lead to increased development of both the beach and foredune system.

TABLE 1

Vegetation species present on dunes at Lennox Head.

Vegetation Groups	Common Name	Scientific Name
Primary species (grasses and creepers)	Spinifex	*Spinifex sericeus*
	Pigface	*Carpobrotus glaucescens*
	Ipomea	*Combretaceae*
Secondary species (shrubs and short lived trees)	Acacia	*Acacia longifolia*
	Casuarina	*Casuarina equisetifolia*
	Bitou bush	
Tertiary species (Long lived trees)	Coastal Banksia	*Banksia integrifolia*
	Tuckaroo	*Cupariopsis anacardioides*
	Pandanus Palm	

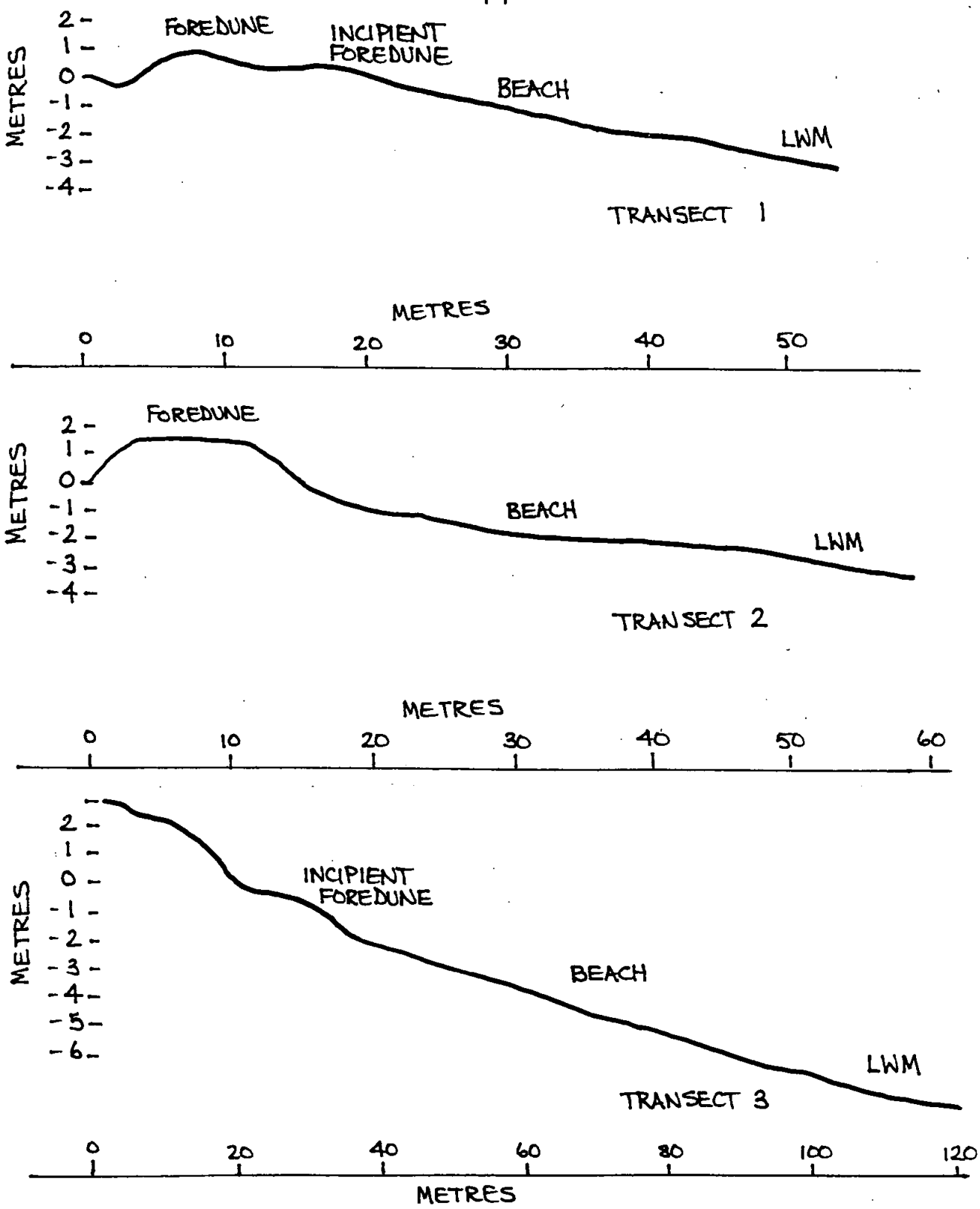

Figure: 6 - Beach profiles across the beach at three locations at Lennox Head. Transect 1 was made south of the boat ramp where there is a lack of dunal development and a narrow beach. Transect 2 was adjacent to Rutherford street where there is increased dunal development relative to transect 1, but the beach remains narrow compared with transect 3. Transect 3 was made in front of lake Ainsworth, where there is a well developed dune system and a wide beach.

The offshore boulder reef system running parallel to the beach from the headland to just past Rutherford Street forms a protective barrier for the beach behind (Fig. 7). It is unclear how much protection the reef provides, but erosion behind the reef is less than erosion further north. The headland and the reef protect the southern section of the beach during south to south easterly swells, but further north past the reef the beach is fully exposed to wave attack. The headland and the boulder reef provide much less protection from northerly and northeasterly swells.

Currently the coastline at Lennox Head is fragile, with the vegetation on the dunes disturbed, and erosion evident in many areas. Future planning for upgrading the shoreline should give serious consideration to improving the dune system with protective fencing and stabilised walkways.

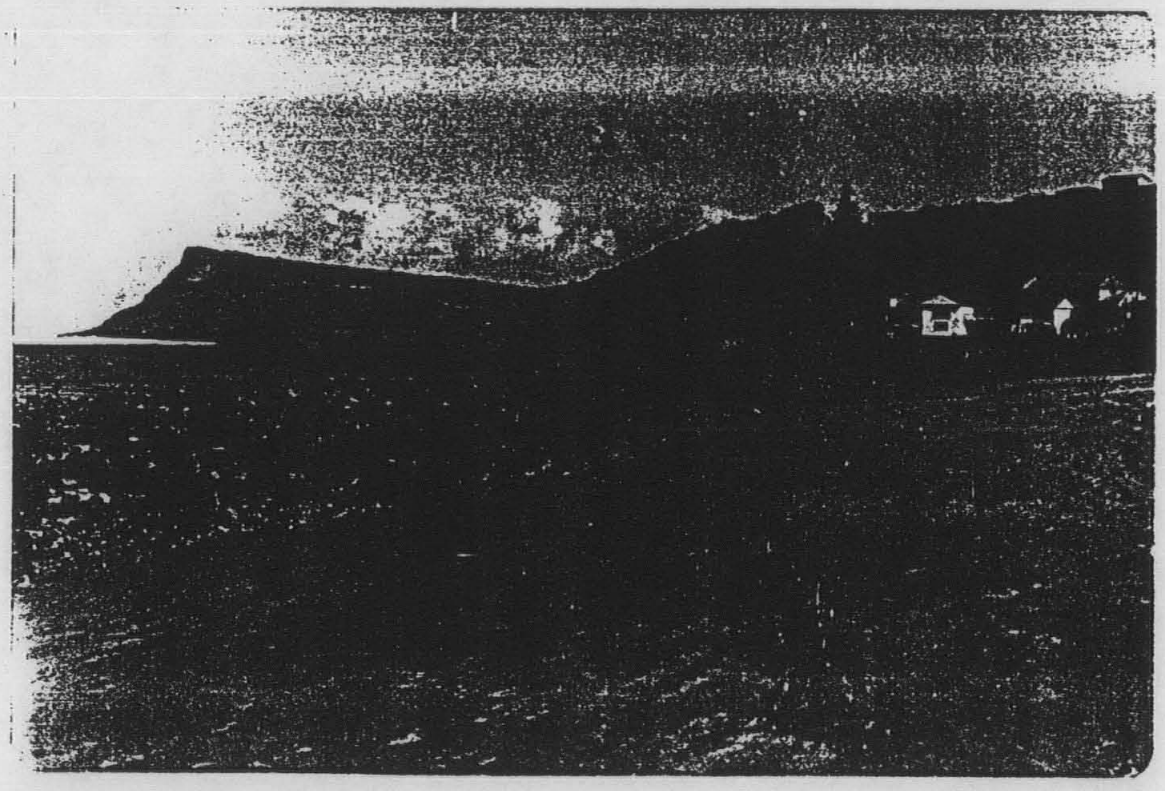

Figure: 7 - Photograph showing the boulder reef and headland at Lennox Head.

Factors influencing coastal change

The major process effecting the beach at Lennox Head is the supply and northward drift of sand. Sand movement occurs continuously on a small scale, but major storms can erode and redistribute large amounts of sand, and thereby have a longer term impact.

Man has had a major impact on coastal change in the area by trapping sand in engineering works such as the river training walls at Ballina. However, at Lennox Head, coastal engineering strategies have largely been designed to minimise the obvious impact of the periodic high energy events that regularly modify the beach profile. Little attention has yet been directed toward comprehensive planning either in the long term or in a regional context.

Wind direction

Wave directions reflect the predominant wind direction, which on the New South Wales north coast is from the southeast (Fig. 8). This southeasterly wind is largely responsible for the marked south to north littoral drift along the coastline. Winds associated with storm events approach the coast at Lennox Head from a variety of angles, and frequently exhibit major changes in direction over a few days.

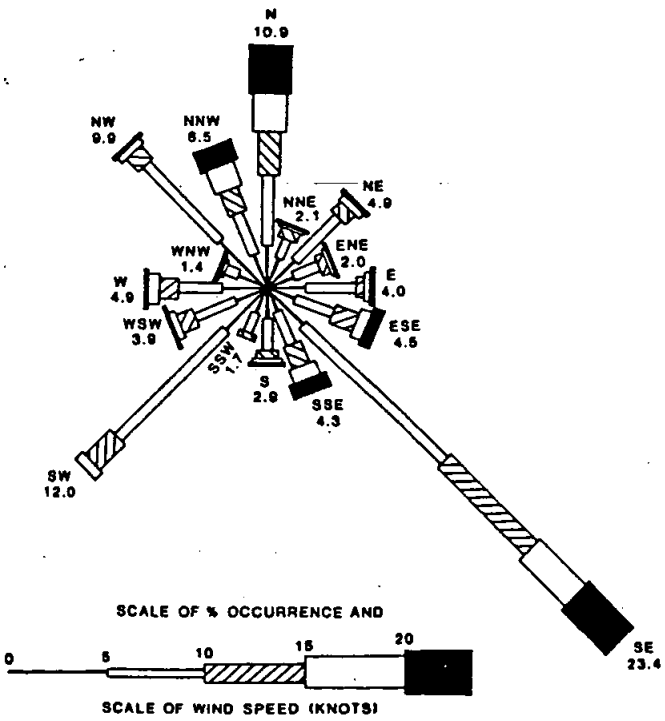

Figure: 8 - Wind rose for Byron Bay, N.S.W. (after Chapman *et al.*, 1982)

Littoral drift

Littoral drift causes the movement of large amounts of sand along the New South Wales coastline (Chapman, 1982). It takes place where waves strike the coast at an angle moving sand shorewards in a direction perpendicular to the wave crest then dragging it seawards perpendicular to the beach during the backwash; it is also locally associated with the flow of strong longshore currents. The turbulence created by waves assists in this process by causing local increases in current velocity which aid in the erosion of bottom sands; hence, sand movement is most significant in the active surf zone.

A littoral drift differential refers to the difference in the input and output of sand to and from a coastal compartment. When inputs exceed outputs, a positive differential leads to beach accretion, but when outputs exceed inputs a negative drift differential leads to beach erosion.

The north coast of New South Wales consists of large coastal embayments, separated by headlands, and sand is transported around the headlands from embayment to embayment by littoral drift. Studies by Stephens *et al.* (1981) have shown that Byron Bay has a negative drift differential and is a typical zetaform beach with its greatest rates of recession in the southern hook of the bay. In the southern hook of the bay sand is eroded from the backshore to met the negative drift differential demand, and as the shoreline erodes the bay becomes more indented (Stephens *et al.*, 1981).

Although Lennox Head does not have such a predominant headland as Byron Bay, a similar drift differential affects the southern section of the beach. Long term erosion here is indicated by the presence of a back barrier peat deposit outcropping in the surf zone, where it is now partially protected from further erosion by basalt. This type of peat originally formed in a swamp environment behind the foredune system and its present position indicates that the shoreline once lay seawards of the present surf zone; the original foredune seaward of the back swamp has also been lost to erosion (Stephens *et al.*, 1981).

Sea level oscillations and past sea level changes

On a local and world wide basis, long term changes in sea level are undoubtedly a major factor influencing coastal change. A future rapid sea level rise caused by the postulated warming of the earth due to increases in certain gases in the atmosphere, otherwise known as the "Greenhouse Effect", could become a significant factor in sea level changes. It is predicted by the United States Environmental Protection Agency that a world wide rise is likely to be between 1.44 m and 2.17 m by the year 2001. However, there is considerable dispute as to the exact extent of any rise, and even as to whether there will be a rise at all (D. McConchie, N.R.C.A.E. pers. comm.). In the past 100 years, data collected from several tidal gauges

around the world suggest that sea level has increased at an average rate of just over 1 mm per year (Wynne *et al.*, 1983). However, many of these data have been recorded in tectonically unstable areas of the world, and some conflict directly with others; for example, a tide gauge on a tectonically stable base at Fort Denison in Sydney does not support the suggestion of a 1mm rise per year. The Fort Denison record shows a net increase of 4 cm with a long term oscillation of up to 7 cm, over the past 80 years (Fig. 9).

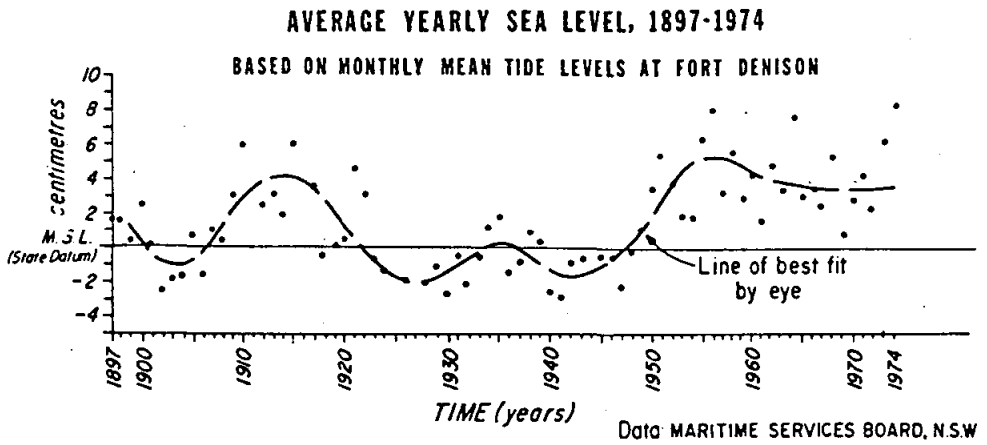

Figure: 9 - Sea level changes for the past 100 years. (After Chapman, *et al.*, 1982)

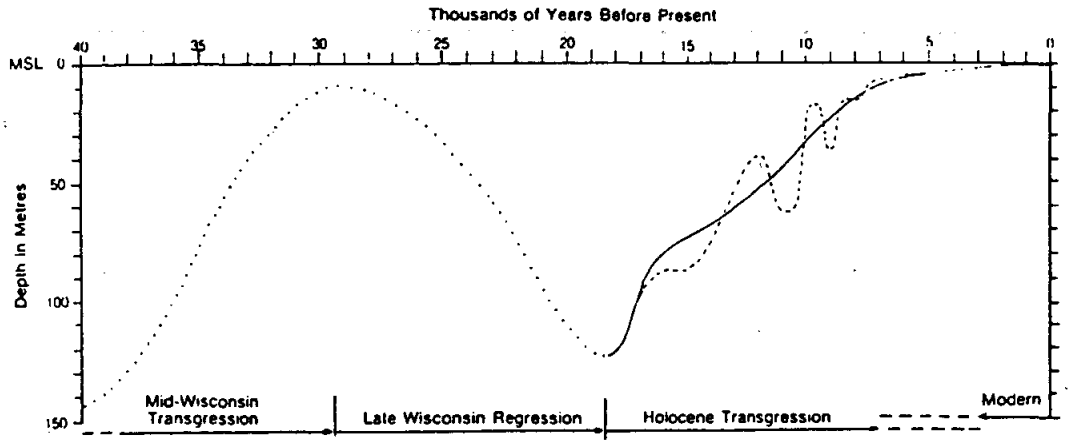

Figure: 10 - Sea level changes for the past 30,000 years. (After Chapman *et al.*, 1984)

Over the past 6000 years it is unlikely that the sea level oscillated by more than plus or minus 1 metre (Fig. 10), and has thus been remarkably stable (Chapman *et al.*, 1982).

The concept of sea level change, like weather patterns, carries important implications for coastal erosion management. However, predictions of likely future changes cannot be made with any confidence, due to the substantial uncertainties in the models. Hence, while sea level

fluctuations need to be considered in coastal management strategies, it is not presently possible to predict future trends accurately, and it may therefore be advisable to plan for larger shifts than have occurred in the past 100 years.

Tidal factors

The tidal regime on the New South Wales coastline is semidiurnal, with a tidal range of less than two metres. Extremes of high and low tidal range occur monthly as spring and neap tides respectively, and the combination of spring tides with storm activity results in much greater erosion than normal tides due to the higher sea levels (Chapman, 1982).

On the open coast the tide regime is remarkably uniform along the entire New South Wales coastline with a mean tidal range of 1.6 metres; this varies from less than one metre for neap tides to more than two metres for spring tides.

Storm related sea level rises

There are two general types of storm related sea level rises, storm surges and wave setup. Both of these are caused by strong winds associated with migrating low pressure systems, and both can create low frequency rises in mean sea level. In many instances the rises in mean sea level are far more destructive to beaches and property than are the storm waves themselves (Beer, 1983).

Storm surges result from the combination of, low barometric pressures, wind induced water pile up during the storm, and the resonance of swell waves with the effects of wave set up (Beer, 1983). If factors combine during an unusually high tide, then the resulting flooding of nearshore zones can be substantial. In 1974 a storm surge of up to one metre along the New South Wales coastline, caused widespread property damage and beach erosion.

Wave setup refers to the rise in sea level resulting from the sustained shoreward transport of water. This piling up of water against the shore can produce sea level rises of up to to 20% of the wave height (Mahony, 1978). Along the open coast wave setup appears to have a greater effect on beaches than storm surge, and during the 1974 storms it was estimated that waves were 1.5 to 2.5 metres higher near Sydney due to wave setup (Mahony, 1978).

Scales of shoreline change

Three time scales of shoreline change, long term, itermediate, and short term, refer to the recurrence interval of the events causing the change (Chapman *et al.*, 1982).

Short term changes are those small scale day to day, week to week, and even month to month changes associated with wave, wind, and current processes. The beach zones effected by these changes include the subaerial to the nearshore zones (Fig. 11). Beaches along the New South Wales coast are regarded as among the most dynamic in the world (Chapman, 1982), in terms of variations in beach shape and shoreline position. Local residents suggest that Lennox Head is one of the most dynamic beaches they have seen, with dramatic beach changes occurring over a 24 hour period.

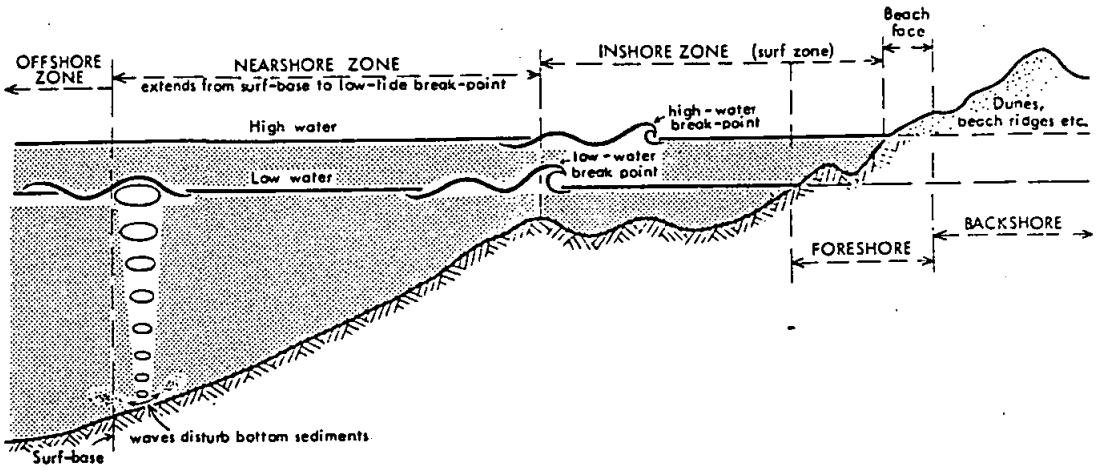

Figure: 11 - The active shoreline zones. (After Chapman *et al.*, 1982)

The system in figure 11 reflects a natural mechanism for the dissipation of wave energy; high energy dissipation during storms widens the system to dissipate the energy over a greater area. The beach profile extends both seawards and landwards with sediment taken from the frontal dunes and being redistributed in the nearshore zone as offshore bars. During storms the surf zone may double or triple in width (Fig. 12) extending the zone of high sediment movement. During calmer periods sediment tends to be reworked back toward the foreshore area rebuilding the beach face and dune systems. The shoreline itself is a self regulating system which is generally able to adjust in response to the increased energy of storm waves.

Where man has interfered with the natural processes of beach dynamics by building seawalls and groynes, the energy still has to be dissipated. In these circumstances the energy may be redirected to other parts of the shoreline where it may accelerate rates of shoreline change, or be reflected seawards where it may substantially modify the existing bathymetry.

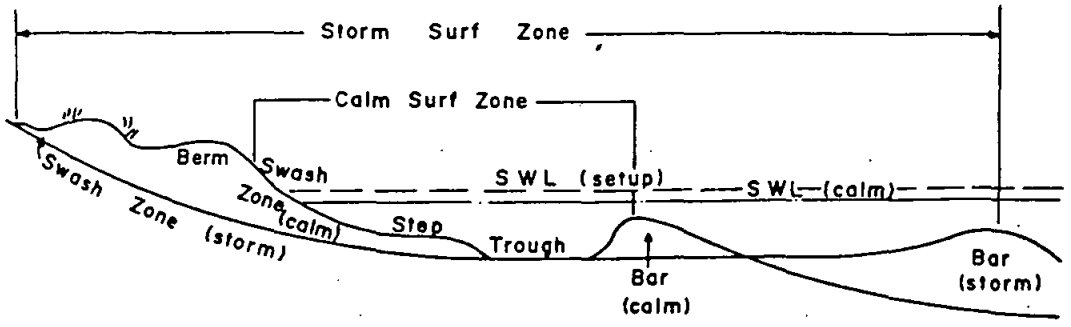

Figure: 12 - Beach cut and fill. (after Chapman *et al.*, 1982)

Intermediate or medium term changes operate over a time scale of one to a hundred years, and are probably the most important changes for planners and engineers. This time frame encompasses the major storm and cyclonic events which typify much of the north coast of New South Wales. These changes are observable in the incipient and established foredunes, both as erosion and accretion.

Prediction of future shoreline changes on the immediate timescale, requires an understanding of the causative processes, but there are two major difficulties which need to be overcome to do this.

1. Low frequency, high magnitude events, such as the 1974 storms and cyclones pose two types of problems for coastal planning. Firstly, these rare events, may cause long term changes to beach system that cannot be anticipated by the extrapolation of the effects of more common, but lower energy events. For example the storms of 1974 which occurred along the east coast of New South Wales, eroded 80% of the Lennox Head beach (Chapman *et al.*, 1982). This event left the beach with no dunal protection and transported sand so far offshore that it was permanently lost from the local sediment budget (Fig. 13). In comparison, the normal seasonal storms which occur through the winter months simply move sand about in the sediment compartment without causing permanent loss. During the smaller storms, sand is moved from the beach face to offshore bars, and returned to the beach face during periods of low wave energy. Secondly, prediction of the occurrence of severe events is almost impossible and this, together with their low return frequency, means that few data on their impact as a function of time are available; this causes problems for engineers and planners in developing coastal management strategies.

2. Unidentified fluctuations in the magnitude of low frequency processes may influence the frequency of major storms, particularly those processes involving changes in the atmospheric or oceanic circulation systems. Other, less direct factors which may influence the occurrence of storms include, the perigee syzygy tides which raise natural sea levels (Foster *et al.*, 1975), and changes in sunspot activity (Thom, 1974).

Long term changes take place over thousands of years and include, the formation of coastal dune systems, tectonic emergence and submergence of the landmass, eustatic readjustment, and erosive (e.g., the erosive loss of a narrow headland) or depositional (e.g., delta progradation) modification of the coastline. Rates of change are usually very low with the direction and magnitude of net change, remaining constant for long periods of time. The low rates of change mean that these shifts usually have a low significance in coastal zone management and their effects can be confidently predicted.

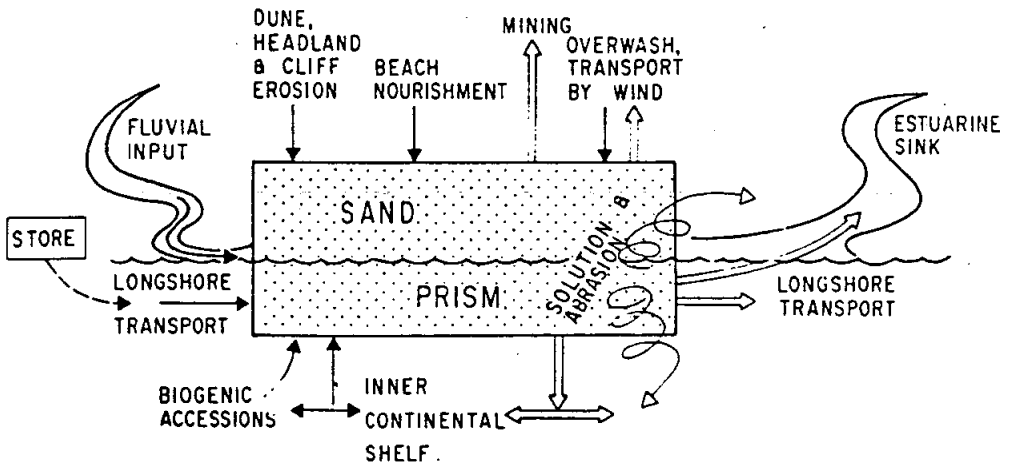

Figure: 13 - Sediment budget. (After, Chapman *et al.*, 1982)

Major erosional events

Two major erosional events have affected the North Coast of New South Wales in the past 20 years. These occurred in 1967 and 1974 and both caused considerable modification to the coastline and damage to structures built in the erosional zone.

<u>1967</u>

During 1967, southeast Queensland and northern New South Wales experienced five cyclones, four low pressure disturbances, and several storms associated with frontal changes. Winds were predominantly from the southeast and on five occasions exceeded 50 knots. Cyclone

generated rises in sea level were often more than 0.3 metres and reached a peak of 0.9 metres (Mahony, 1978.).

Erosional events associated with these storms were particularly severe because during the first six months of 1967 heavy seas caused a general lowering of beach levels and shoreline retreat, thereby reducing the sediment available for reworking during subsequent storms. Along the Gold Coast the most severe damage occurred toward the end of June when damage totalling $600,000 was caused and massive waves threatened houses, esplanades, roads, and surf club buildings. Although the immediate cause of damage was wave attack over a few days, the vulnerability of the beach to this attack was a result of the cumulative effect of storms during the previous months. Similar conditions were witnessed along the north coast of New South Wales where coastal dunes were eroded and property damage occurred in many areas including Lennox Head and Byron Bay.

1974

Erosion of the New South Wales coastline between February and June in 1974 involved some of the most extensive changes to the geomorphology of the coast this century. As with 1967 storms, beach levels were steadily lowered by several months of heavy seas before the final sequence of severe storms.

Toward the end of May a depression with a steep pressure gradient developed in the Tasman Sea with gale force southerly winds, rough seas, and a heavy swell; the rough seas continued to the end of the month. In early June further tropical cyclones developed, which generated highly destructive waves along the New South Wales coastline. Foredunes and beaches were severely eroded and undermined by the five months of storms and many roads and buildings were threatened or damaged. Over a three day period of storms, the beach profile along much of the north coast of New South Wales was lowered by one metre vertically and retreated shorewards by up to 22 metres; at Lennox Head 80% of the beach was eroded with no beach or dunal protection left.

A study carried out along the north coast revealed that beach aspect had a considerable influence on the extent of erosion (Chapman, 1982); beaches facing NNE were moderately affected while those facing SSE were heavily eroded. The southern end of beaches with an easterly aspect also experienced less erosion, particularly where they were protected by headlands.

From the data collected on these two major storm events it is evident that in the short term the amount of erosion occurring on the beach depends on four factors :-

1. The energy of the storm waves,
2. The erosional state of the beach prior to a major storm,
3. The presence or absence of of a stable foredune, and
4. The extent of sea level rises caused by tides , storm surge, and wave set up.

Man's influence on the coastline

The shoreline at Lennox Head has been significantly affected, both directly and indirectly by human activity over the years since the subdivision of Lennox Head in 1922. Figure 14 shows Lennox Head during the 1930's, when the then lake and swamp area was open to the sea via a small creek. During the 1950's this opening was sealed (Fig. 15), using rock taken from the southern corner of the beach and placed across the lake entrance. This change had two effects on the beach area. Firstly, when Lennox Head experienced heavy rain and high seas, the lake area would fill up, and the ponded water would place pressure on the back of the dunes, weakening them and enhancing the erosive capacity of heavy seas. Secondly, the rock was taken from in the southern corner of the beach, where it had previously formed natural protection for the area behind. This action created a weak section in the dunes, and permitted accelerated erosion in this area; the southern section of the beach is now indented relative to adjacent beach.

Rock was also removed from the reef area and a channel was cleared to allow boats to be launched safely from the beach. This action may also have increased the vulnerability of beach shoreward of the reef to subsequent erosion.

Residents of Lennox Head claim that poor drainage has also increased the natural rates of erosion in the area. When Lennox Head receives heavy rain, runoff collects in Dress Circle drive and builds up at its eastern most point. At times when rain is intense it runs over the bank into the sea causing noticeable erosion to the extent that the use of rock and cement blocks along the bank has become necessary to try and resist furthur damage.

Seven Mile beach north of the Lennox Head township was subjected to sandmining, between 1930 and 1970, which weakened the dunal barrier substantially. Material was removed from between the low water mark and the foredune area, and a large amount of this was not replaced, resulting disruption of the profile of equilibrium of the beach.

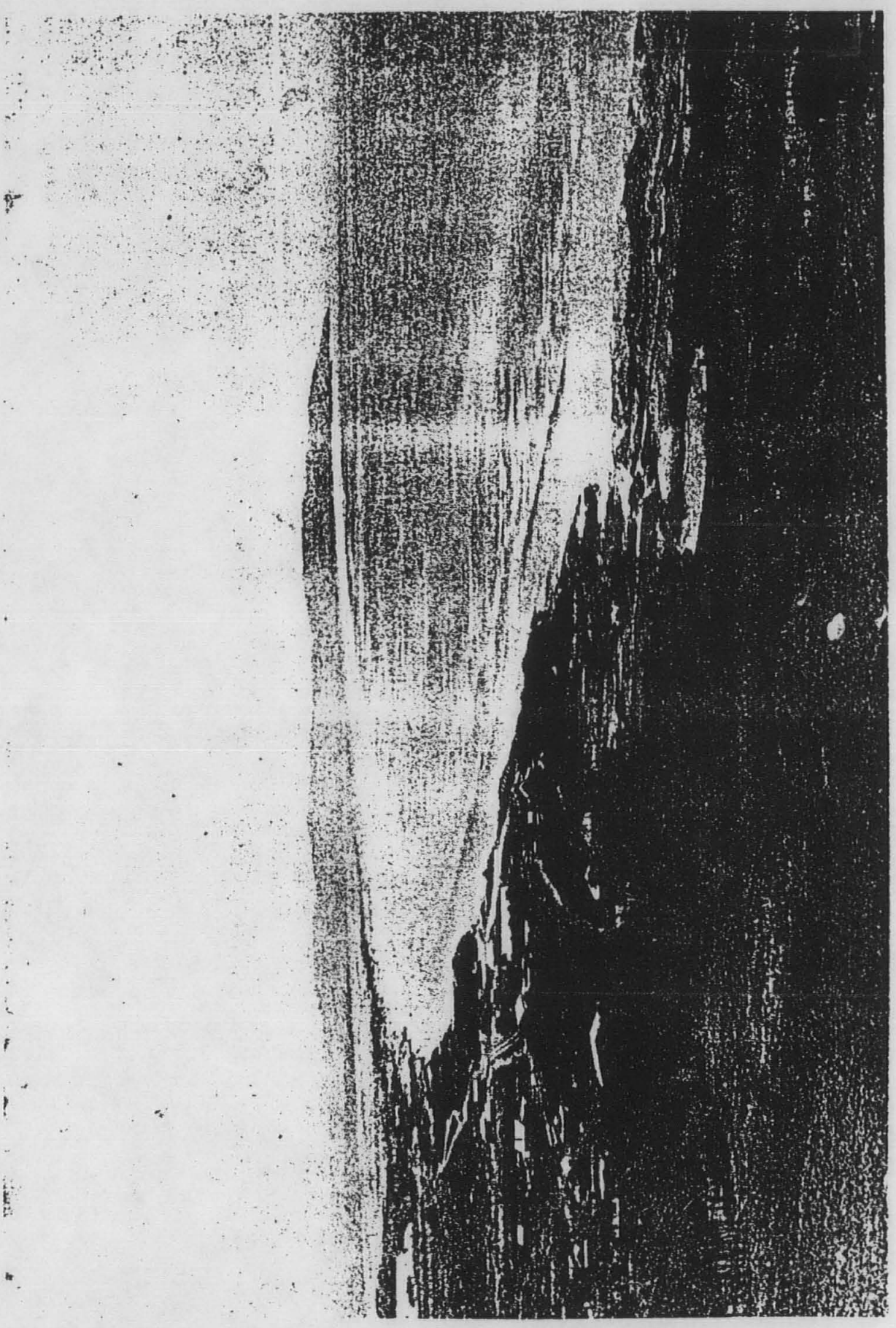

Figure: 14 - Photograph of the Lennox Head area taken during the 1930s.

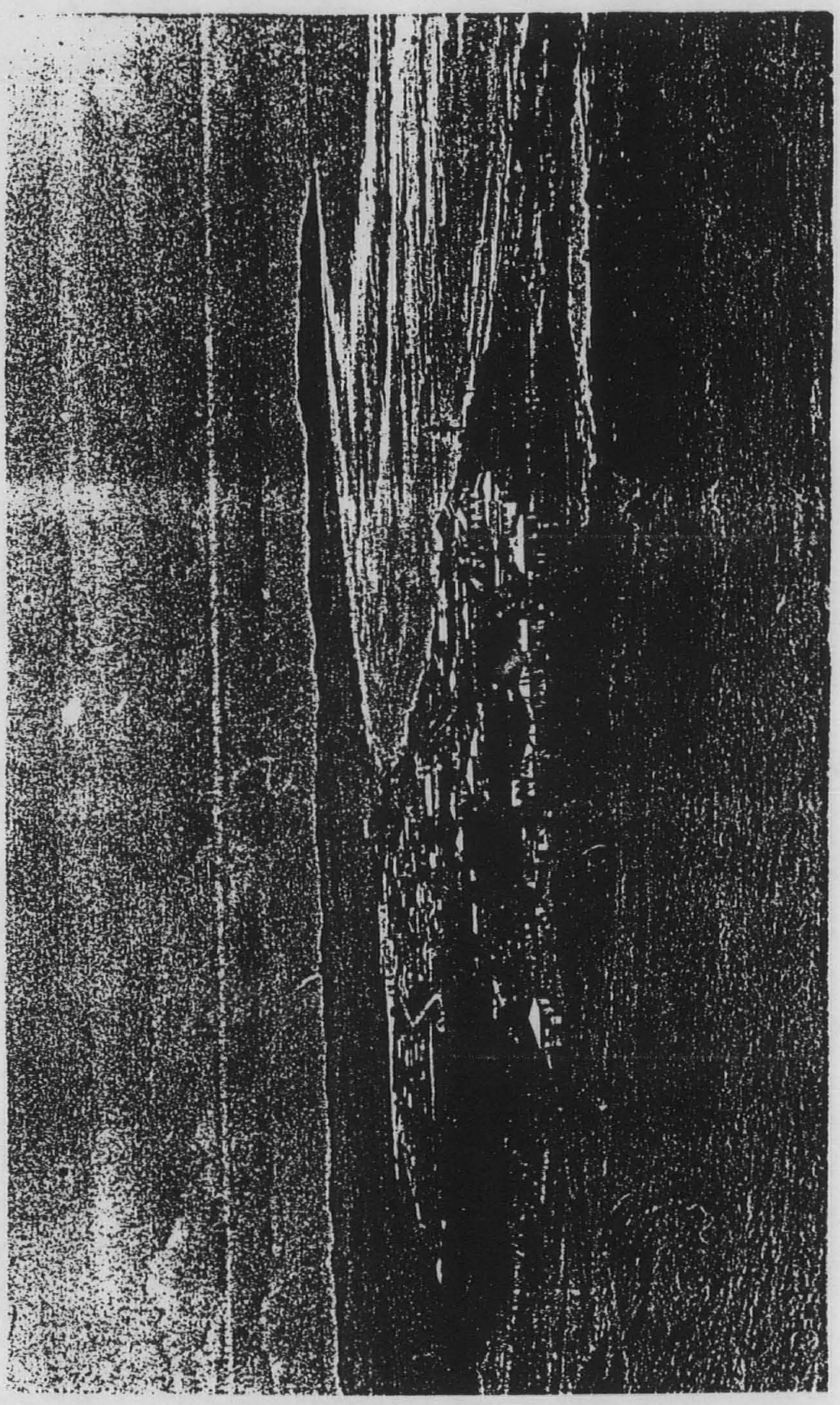

Figure: 15 - Photograph of the Lennox Head area taken during the 1950s.

Figure: 16 - Lennox Head with its present development along the shoreline

The major indirect effect of man's activities on erosion in the area involves the disruption of the sediment supply to the beaches by the river training walls at Ballina. Walls built on estuary mouths further south, such as the Evans and Clarence rivers may also have had a minor effect on the sediment supply to Lennox Head. These walls intercept the longshore drifting sand and store it behind the updrift wall. Normally, this sand would be available to beaches as it is transported along the coastline, with rates of supply approximately balancing rates of removal, but beaches downdrift of river training wall receive a reduced supply while sustaining normal loss, and hence erode.

Dredging of the Richmond and Wilsons rivers has further reduced the amount of sediment available to beaches downdrift of the Ballina estuary. Fluvial sand supply constitutes a significant part of the input of sand in the sediment budget (Fig. 13), and where it is reduced by dredging, supply to coastal sediment compartments down drift of the river mouth is diminished.

Overall, in many places where erosion has occurred on the northern New South Wales coastline it can be linked wholely or partly to human interference with natural beach dynamics.

STRATEGIES FOR COASTAL PROTECTION IN THE LENNOX HEAD AREA

Non-structural options for beach erosion control

At present the Lennox Head shoreline is well nourished relative to its condition in the 1960's and 1970's, but it is in a poor state relative to similar beaches such as Broken Head where a well nourished beach and dune system is present. Land at Lennox Head which has been developed and is under the greatest threat of erosion is notably low lying because most of it is reclaimed swamp or flattened dunes. This low lying land, with no natural dunes or wide beaches to protect it from erosion, is particularly vulnerable to beach recession, and damage to property could occur during the next major storm event. Hence, either the potential for property damage must be accepted and adapted to, or some action must be taken to prevent furthur shoreline recession.

Under the circumstances prevailing at Lennox Head some action to limit further shoreline recession is probably warranted. There are three options avialable:-

1. No action, allowing nature to take its course and accepting the resulting property loss.
2. Relocating development back from the coastline and restoring dunal systems. This allows coastal processes continue while overcoming the problems they may cause in the short term.
3. Resisting erosion using some form of structural protection .

<u>No Action</u>

A decision to take no action and to allow erosion to continue is the best course of action when the threatened development has little value. Such a course of action requires no expenditure on protective measures and involves minimal interference with existing beach dynamics. However, residents will naturally take action to protect their property and government agencies will also wish to protect their assets and amenities, often making this method impractical.

Before this course of action is rejected as unacceptable, it is necessary for the cost of the protective measures and the value of the assets to be protected be compared objectively. Furthermore, this cost-benefit analysis would need to be viewed in the context of the probability that the damage would occur within the useable life of the structures affected. Assessment of this option at Lennox Head is thus complicated by the lack of useful data on the likely rates of beach attack in the future; rates will depend on the various factors discussed above.

Development relocation

The option of relocating development back from the coast is often resisted by residents and, for intensely developed coastlines, it frequently cannot be justified when costed over normal planning periods. However, it may be the least costly option when considered over longer planning periods of one to two hundred years.

In circumstances where development can be relocated at reasonable cost, buffer zones can be provided. The creation of a significant buffer zone at Lennox Head between the current line of coastal fluctuation and development sites would require a large proportion of the property between Ballina Street, Allens Parade, and the sea to be vacated. The estimated cost to move about 20 buildings to an erosion free location is $2 million dollars assuming the owners were prepared to accept a new block of land and a house which wasn't situated on shorefront land (Dudgeon *et al.*, 1986). This option also assumes that the council has suitable land to be developed at $20,000 per block, and can erect dwellings at $60,000 each. If existing housing is moved, the cost would be at least $1,000,000 with litigation and compensation costs probably also being high (Dudgeon *et al.*, 1986).

This option has largely been disregarded by the council, but it should be further investigated. The affected property owners and the council should discuss the issue to evaluate its merits in a rational manner. It may be that the cost could be offset be using some of the resumed land in the buffer zone as a recreational amenity which would increase the cash flow to the township in general and the council in particular. Areas of relocation, such as behind the present township, and the costs involved with the relocation should be discussed. The costs presented in the Ballina Shire council's report appear to have been slightly exaggerated to make this alternative look less attractive.

Buffer Zones

Following the relocation of development, buffer zones could be established to absorb the natural effects of nearshore processes. This management concept is based on the principle that the beach is a natural self regulating system which will adjust to, and recover from, erosional events, provided space is allowed for shoreline fluctuations to occur. Buffer zones may be created by the reservation of land, regulation of development, creation of new land by beach nourishment and dune formation, by land acquisition through development relocation (as in this case) or by a combination of these options (Chapman, 1981). In Florida, in the United States, it was recognised that a buffer zone system was needed in 1971. Taking into account the factors such as storm surge, predicted maximum storm wave uprush, and the dune characteristics, the buffer zone was established back as far as 122 metres inland from the high water mark.

The Queensland Beach Protection Authority has evolved buffer zones as their basic philosophy. The authority estimates the width of the foreshore which is likely to be vulnerable to erosion in the future and attempts to restore and carefully manage this land so that it remains available as a buffer between the ocean and nearby development.

The width of the buffer zone required is calculated by using the equation :

$$\text{Buffer zone width} = (N \times R) + C + F$$

Where

N = planning period (usually 50 years)
R = the long term erosion rate (metres/year)
C = extent of design of storm erosion (metres)
F = safety factor (metres)

The width of foreshore needed to create a suitable buffer zone at Lennox Head can be estimated using:- N = 50, R = 1m, C = 20m, and F = 5m. this indicates a required buffer zone width of 75 metres.

If this option is chosen then the dune system right along the shoreline will need to upgraded by revegetation and protected from uncontrolled access by fencing and the provision of accessways.

Public acquisition of the Hazard Zone

This is a management strategy whereby endangered properties could be resumed and leased back to the present occupants at an agreed rate. If catastrophic erosion occurs the occupiers may abandon the property and preserve their capital, but if it does not, the status quo is preserved, while the local council or whoever the owner may be receives income from the asset. However, this procedure may also meet some resistance from the local residents.

Beach Nourishment

Beach Nourishment is becoming a more popular method of shoreline protection; the Gold Coast City Council has recently approved a three million dollar beach nourishment programme for the North Kirra beach in front of the present seawall. This shoreline protection method involves the artificial supply of sand to eroding beaches either by, pumping material dredged from offshore, or by trucking sand from a nearby source. Beach nourishment is carried out in an attempt to restore an adequate buffer zone in front of a threatened property.

Suitable sand supplies must be compatible in grain size and of equal quality to that of the sand existing on the beach where it is to be placed. During the dredging of the source sand, environmental problems may occur which can reduce the overall management benefits of this procedure.

Beach nourishment works are commonly used in association with groynes, breakwaters, and seawalls to alleviate the erosion problems created by the artificial structures; for example, sand may be placed in front of a seawall to combat the erosive loss of beach. This approach has no adverse effect on adjacent beaches and is currently recognised as one of the best solutions to erosion problems in areas where a suitable sand source is available. However, beach nourishment only offers a temporary solution, and expensive long term maintenance is required. Unless sufficient sand is provided to form a foredune able to withstand storm erosion, beach nourishment is only a short term solution.

This option may need to be used at Lennox Head, if seawalls or breakwaters are constructed, to alleviate the resulting loss of useable beach. Possible sand sources exist near Ballina and north of the main beach at Lennox Head.

Dune Rehabilitation and stabilisation

Sand dunes serve as a natural protection for the shoreline. They act as buffers providing an erodable reservior of sand which can be circulated between the dune, beach, surfzone and seabed in response to changing sea and wind conditions (Chapman, 1982). When dunes are flattened and built on they loose this natural dynamic characteristic of erosion and deposition, and erosional events become more noticeable (e.g., at Lennox Head and on the Gold Coast).

When the equilibrium dune line has been built over, the creation of a new dune system would require massive beach fill, as a stable system will be only restored if the entire swept prism is relocated seawards. In association with dune reconstruction, fences need to be built to trap wind blown sand, and dunes need to be seeded with grasses and shrubs and fertilised to enhance stability. Access points for both 4WD's and people must be properly controlled with fences, chain and board walkways, etc.

The option of upgrading the dunes at Lennox Head has considerable merit. The dunes could be nourished with sand, revegetated, and fenced to establish a stable foredune which could act as a sand reservoir to accommodate erosional events. This option could be incorporated with the construction of a sand sausage and has the advantages of returning the shoreline to close to its original state thereby enhancing the aesthetic value of the area.

Structural options for beach erosion control

There are several structural options for managing beach erosion in areas such as Lennox Head, but these are generally costly, and frequently transfer the original problem elsewhere. The principal structural options for the Lennox Head area are summarised below.

Seawalls

Seawalls or revetments are one of the most commonly used shoreline protection methods. They are surprisingly expensive, but can be provided at short notice, and for this reason they are commonly used for erosion control after severe storms (Gibb, 1979). Seawalls are used to protect eroding shorelines against further recession, and usually involve a sloping rubble mound or concrete armour wall (Chapman, 1981). Although providing protection to the land behind, a seawall may lead to deterioration of the beach. Beach loss occurs as a result of wave reflection, and the resulting clapotis effect increases beach scour at the toe of the wall, thereby increasing sand loss and hampering post-storm recovery. Undermining, and the subsequent collapse of the wall, is also common where the wall has been constructed without adequate toe foundations. In addition to scouring associated with wave reflection, the increased turbulence during wave reflection may accelerate longshore drift and lead to furthur loss of beach sand.

Seawalls frequently have adverse effects on neighbouring properties, particularly on the down drift side of the wall where increased beach erosion is likely. The updrift end of the wall will also experience increased scouring due to the increase in turbulence associated with the wave reflection.

Other adverse effects of seawalls include the reduction of beach access, loss of useable beach, and reduction of aesthetic appeal of the beach.

In areas such as the Gold Coast where heavy development was carried out along the coastal fringe and in the erosion zone, before planners fully understood the natural coastal processes, coastal protection works may be necessary. The construction of seawalls may be justified in areas where the coast is highly developed and commercialised, but in areas where land values are lower, and the social value of the beach is higher, engineering intervention is seldom a satisfactory option.

In the Ballina Shire Council's report a seawall is the preferred option for coastal protection at Lennox Head. The wall (Fig. 17) is to be built in three sections, with the southern section to be built first. The report estimates the cost of the wall at $1000/m, with the full distance of the proposed seawall being about 3 km. Estimates of the costs involved in maintenance, landscaping and repairing the seawall are not addressed in the report. Maintenance costs could

be high in the long term, as common estimates of these costs for a seawall approximate 2% of the original cost per decade (Chapman, 1981).

Additional points related to seawall construction not addressed in the Ballina Shire Council's report include:-

1. If the area were to experience a major storm while the wall was under construction, the effect could be disastrous, with the partially completed wall enhancing natural erosion.
2. The possible need for beach nourishment to offset erosion caused by a seawall; this would add to the overall cost of the seawall option.

If the option of constructing a seawall is implemented, then it is likely that significant degradation of parts of the Lennox Head Shoreline, and the loss of beach sand in front of the wall, would be inevitable. The costs will be high for both the individual land owner and for the council, and ongoing maintenance costs will be significant.

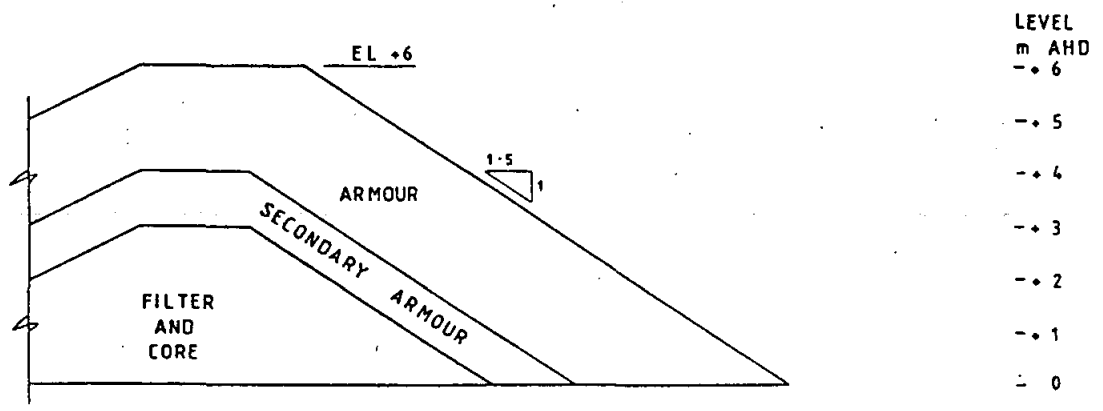

Figure: 17 - Conventional stable seawall, such as that proposed for construction at Lennox Head, with primary and secondary armour.

Groynes

Groynes are a widely used method for shoreline protection. On the Gold Coast, especially along Coolangatta and Kirra beaches, groynes have been used to increase the sand supply. A groyne is designed to intercept the longshore drift of beach material (Chapman *et al.*, 1982; Thorn *et al.*, 1981). They trap sand on their updrift side while starving the beach on the downdrift side of sand. The main problem with groynes is that they don't solve the problem of erosion, but merely transfer it further along the beach. This often leads to the development of a groyne system (groyne field) along the beach.

A classic example of downdrift erosion occurs at the Kirra point groyne on the Gold Coast where a considerable volume of sand has accumulated on the updrift side, but the protected downdrift side suffers markedly increased erosion.

The design of groynes can vary according to local conditions and requirements. Most are built to be impermeable and to trap all passing littoral drift, with the lengths being determined by the amount of sand trapping required and the degree of erosion that can be tolerated on the downdrift side. Permeable groynes, built from wood or rock, allow some sand to proceed down drift while still trapping significant volumes. Varying heights in groyne design can also allow sand to overpass the groyne while still trapping the required volumes of sand.

Groynes have proven successful in increasing sand retention on updrift beaches, where there is an adequate supply of sand from longshore drift but, they have no effect on preventing overall erosion, and commonly cause increased downdrift erosion, or erosion where none previously existed (Fig. 18).

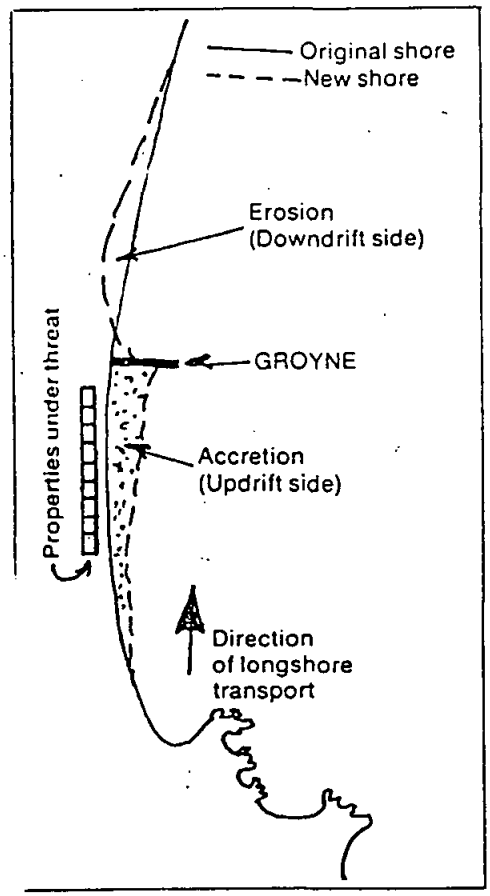

Figure: 18 - Diagram showing changes in beach morphology following groyne construction.

Because secondary wave patterns and storm waves can arrive from a variety of directions (Silvestor, 1979), the presence of groynes can also cause irregular rip currents in unexpected areas, due to differing wave interference patterns, which may present a hazard for some beach users.

Groynes could be used to retain more sand on the beach at Lennox Head under normal weather conditions, but would be unlikely to eliminate erosion during major storms. Since a costly groyne field would be needed at Lennox Head if the erosion problem is not to be transferred northward along the beach, it would appear that groynes alone are not a viable option for beach protection in this area.

Offshore breakwaters

Offshore breakwaters are constructed parallel to, or at a low angle to, the coast to protect a section of the shore. They act to intercept incomming waves thereby reducing the potential erosive impact of the waves on the shoreface. By providing a low energy shadow area, they reduce the capacity for waves to transport sand along the shore (Beer, 1983), with the result that sand tends to accumulate in the shadow zone eventually forming a spit, or eventually a tombolo.

As with groynes, breakwaters tend to cause increased erosion on the downdrift side of the construction which may need to be corrected by beach nourishment unless the loss of land and beach is acceptable in the downdrift area (Fig. 19).

Offshore breakwaters are rare in Australia due to the difficulty and expense in constructing them; costs are generally prohibitive unless other benefits such as a small craft harbour are linked to their construction.

An offshore breakwater, either continuous or discontinuous, could be used to dissipate wave energy under both storm and normal conditions at Lennox Head. A continuous breakwater built to above high water level at the outer edge of the reef, in combination with a groyne at the northern end could provide a calm boat harbour (Dudgeon, *et al.*, 1986). An intermittent offshore breakwater system could be used to retain sand on the beach with the amount of wave energy to reach the shore being controlled by the height of the wall. It may be worth evaluating this option further, but construction costs are likely to preclude it as a viable alternative. As with the seawall option, an offshore breakwater is likely to have some adverse effects on the Lennox Head shoreline which would need to be assessed.

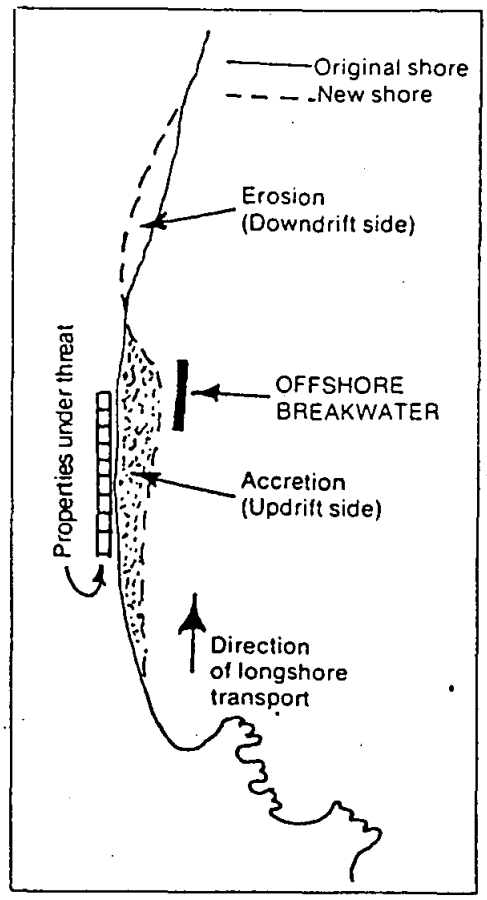

Figure: 19 - Diagram showing changes in beach morphology following construction of an offshore breakwater.

Sand Sausages

Sand sausages are an artificial attempt to copy natural oceanic features, such as reefs which reduce the impact of waves. The sand sausage is a flexible membrane filled with sand or mortar and can be built up to a specific depth below mean sea level or to the high water mark in order to break incoming waves under all conditions, or to selectively reduce wave energy transfer under particular conditions (e.g., storm surge conditions). Sand sausages can effectively maintain shorelines normal to persistent swell arrival (Silvester *et al.*, 1980); they have been used on the Gold Coast at North Kirra beach to increase the beach sand retention and decrease the erosion threat.

This option could be used at Lennox Head to alleviate the erosion problem, placing sand sausages at the end of the reef and further along the beach. Their design (continuous or intermittent) and the extent of protection in the northerly direction would have to be further

investigated, but this option has the advantage that the structure can be removed or resited as and when changing conditions require it.

FACTORS INFLUENCING BEACH EROSION CONTROL PLANNING

The beach as a recreation amenity

The beach amenity at Lennox Head is the main attraction to the area. Lennox Head is a popular tourist and holiday destination relying heavily on visitors to fill the local caravan park, motels, flats, and seaside units. Local business houses depend on the seasonal influx of tourists during the school holidays to supplement an otherwise low turnover. If the beach was adversely effected by inappropriate shoreline management strategies, these local businesses could suffer substantial losses in revenue due to a decrease in visitor numbers.

The value of the beach is high for both the local community and visitors to the area, and any management strategies which may have an adverse effect on this amenity would be extremely unwise. It is difficult to place a monetary value on the beach at Lennox Head, but a beach value estimate was given as part of the Adelaide Coastal Protection Strategy Review (Wynne *et al.*, 1984). Although the beaches are not identical, the study valued a tidal beach at $24,500/100m in 1982, and this figure is probably realistic for Lennox Head.

The value of Lake Ainsworth

A seawall, which is the preferred option chosen by the Ballina Shire Council (Dudgeon *et al.*, 1986), may have a major adverse effect on Lake Ainsworth. If the seawall option were to be implemented controversy would arise over where to terminate it, and as indicated above, erosion occurs at the ends of the wall, particularly at the downdrift end. Hence, property downdrift of the wall will experience enhanced erosion and Lake Ainsworth is in a vulnerable location.

The report to the Ballina Shire Council states that if a seawall is constructed then eventually Lake Ainsworth would become a salt water inlet, open at times to the sea. This opening to the sea would drastically change the nature of the lake from a coastal freshwater dune lake to a saline inlet. Lake Ainsworth is of high scientific value with a unique flora and fauna which would be extensively modified or destroyed if the lake was opened to the sea. Lake Ainsworth is classified as a lowland dune lake, examples of which are relatively uncommon in Australia (Timms, 1986). Most existing lakes of this type have been disturbed or threatened by mining, mobile sand, eutrophication, and exotic biota (Timms, 1986). It is therefore important that Lake Ainsworth be preserved in its present state.

Besides having a high scientific value, Lake Ainsworth is a popular recreational area. The lake, which is relatively shallow and has no currents or rips, is a relatively safe area for children and receives high usage from the adjacent caravan park and from visitors to the area. Commercial operators rely on the lake for business; sailboard and sailboat hire services operate here during the summer, with the lake receiving high usage from these activities.

The Department of Sport and Recreation has a permanent camp, situated at the northern end of the lake, which is regularly used by primary school students on fitness and recreational camps. These facilities, as well as the lake itself, would be adversely effected if the seawall was to be terminated at the surf club.

The alternative option of terminating the wall past the existing buildings on the northern boundary of the camp would seem more logical if a seawall is to be constructed. This option would maintain Lake Ainsworth as a freshwater dunal lake and pose no threat to the camp facilities, but it would add substantially to the cost of the wall.

Environmental impact

Various environmental problems may occur with many of the shoreline protection strategies mentioned, but the main impact which would occur with the development of a seawall, is the opening of Lake Ainsworth to the sea, if the wall is terminated south of the lake.

Other environmental impacts which may occur with the construction of rock walls include the loss of beach habitats which are important for molluscs, crustaceans, worms, and fish in the area. The present dune system and its communities will also be effected by the dumping and the construction of the wall. Trucks dumping material in front of the dunes will damage the present vegetation, and during the construction of the seawall itself the dunes will be significantly altered if they are reconstructed to fill in behind the wall. Thus, the natural vegetation will be altered to the detriment of existing species. The rock fill will create new habitats for exotic, possibly undesirable species.

Environmental problems may also occur with beach nourishment. The main problems here involve the source areas where the sand is obtained, whether they are offshore or onshore sources. Onshore sites include estuaries and other areas with suitable sand supplies which can be obtained either by dredging or by using bulldozers and trucks. Offshore sand is generally obtained by dredging. Dredging and digging sand from either source areas can have various environmental impacts (Hogan, 1987) including:-

- increased turbidity and reduction of light penetration
- Turbidity plumes
- Benthic community disturbance or burial
- Reduction of oxygen availability and increase in biochemical oxygen demand
- Disruption and removal of productive bottom material
- Loss of habitat
- Modification of current flow patterns
- Kill resident organisms.

To determine the likely effects of planned coastal protection works on the surrounding environment requires a thorough environmental impact assessment to be undertaken, and this will need to be supplemented by monitoring before, during, and after construction (U.S. Army Corp of Engineers, 1984).

COMMUNITY OPINION SURVEY FINDINGS

A survey was undertaken to gauge local opinion on the need for a seawall at Lennox Head. forty residents living along the shoreline of the township, ie from Dress Circle Drive , Allens Parade, Raynors Lane , Rutherford street, and Ballina Street were surveyed with the following results.

On the need for a seawall along the shoreline, the results were; no seawall - 52.5% ; yes seawall - 25%; not sure - 25.5%.

Reasons given against a seawall included:-

- Loss of beach (9)
- Too costly (8)
- Won't solve the problem (5)
- Beach has stabilised (3)
- Looks ugly (2)
- Have witnessed the problems the can cause elsewhere (2)
- Seawall only a short term measure (2)
- Reduction of access (1)

Reasons given for a seawall were:-

- Protect development (4)
- Prevent further erosion (3)
- Extend beach (1)
- To extend land seawards (1)
- Insurance reasons (1)

The survey reveals that a significant proportion of the community disagree with the Ballina Shire Council, that a seawall is needed to protect the shoreline. The section of the community which disagreed with the seawall proposal seemed to have a better understanding of how seawalls operate and of the possible detrimental side effects they may have. This was reflected in the understanding shown in the reasons given for the opposition of the seawall proposal. Residents living along Raynors lane, which is one of the most threatened areas, also thought that a seawall was either not necessary, would not work, or both. It became apparent during the interviews that many of those opposed to the construction of a seawall had very strong feelings on the proposal and intended to organise active opposition to it should its construction be approved.

The residents who agreed with the seawall proposal hoped it would prevent further erosion of the shoreline and protect present and future development, but were largely unaware of the possible adverse side effects of seawall construction; most either had no knowledge of, or had no interest in, the possible environmental impact of seawall construction.

A surprisingly large section of the community surveyed were not sure of the best method, if any, to be used for erosion control in the area. Some were aware of the erosional problem, but hadn't lived in Lennox Head long enough to witness a large erosional event.

Before any options are finally decided on, as to what type of shoreline protection should be implemented at Lennox Head, public opinion must be evaluated more fully. At present there appears to be strong resistance among many residents to the proposal to build a seawall.

CONCLUSIONS AND RECOMMENDATIONS

Coastal erosion is a complex phenomenon resulting from the interaction of a number of physical processes. The probability of erosion at a particular site, within a specified time frame reflects the combined probabilities of the individual contributing processes, not all of which are statistically independent. For example storm surge, heavy seas, and strong onshore winds are often contemporaneous, and there are cumulative effects which also need to be addressed.

The coastline is a naturally a dynamic system and man's constructions often conflict with this natural variability.

At Lennox Head, erosion is particularly marked in the southern corner of the beach, and in the area north of Rutherford street; in this area erosion due to natural beach processes has been accelerated by human activity.

The beach is at present relatively well nourished, when compared to its status in previous years, but it is not possible to predict whether, or for how long this condition will persist. It is clear that erosion will continue in future, but to what extent is unknown.

Various coastal protection strategies have been discussed here, and all have their advantages and disadvantages, but overall, this review gives rise to the following recommendations for the Lennox Head coastline.

1. Seawall construction is not seen as the best option for coastal protection for the following reasons:-
   - The loss of beach amenity, which is the towns main attraction.
   - Survey results indicate that most residents oppose the construction of a seawall along the beach.
   - Possible damaging effects on Lake Ainsworth.
   - High costs for seawall construction, maintenance, and beach nourishment.
   - Overall detrimental effects on the sediment budget and natural beach processes.

2. If a seawall were constructed, erosion of the beach in front of the wall would impose the need for beach nourishment to replace the lost sand. This would be expensive to sustain.

3. If any structural protection is necessary, the sand sausage option would seem the most viable because of their flexibility.

4. In association with the sand sausage option, the dune system along the entire Lennox Head shoreline will need to be upgraded. This should incorporate the Soil Conservation Service's guidelines on dune management and include:-
   - Revegetation with natural dune species.
   - Dune fencing to trap wind blown sand and protect the dune vegetation from uncontrolled access to the beach.
   - Provision of dune access points at regular intervals using fenced board and chain walkways.
   - Signposting the dunes to provide information to the importance of dune management.
   - Prohibition on clearing dune vegetation to improve the seaviews.

5. A property relocation scheme for the buildings immediately threatened by beach erosion should be considered. Property owners affected, and the Ballina Shire Council, should discuss suitable areas for relocation and the costs involved. This option of relocation will create a buffer zone area.

6. The Ballina Shire Council's coastal planning policy should be altered to incorporate the following:-
   - Development should be kept back 75m from the dune system as discussed in the text.
   - Any further development east of Allens Parade and Tresise Place should be prohibited because the land is extremely low lying and subject to flooding during heavy seas. If further development is allowed here it will place more capital at risk, and further pressure would be placed on the Ballina Shire Council to provide coastal protection.

7. Any future planning for coastal protection at Lennox Head should include a full public participation phase, and full account should be taken of community opinion.

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