REVIEW OF HARD/SOFT METHODS OF BEACH PROTECTION THE CAPRICORN COAST CASE STUDY.

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ABSTRACT

The shore zone, which is the area most directly influenced by marine processes, interact and continuously shapes and modifies the physical features of the shore, including beaches and sand dunes. Coastal engineering, as a part of the civil engineering, concerns all engineering problems in coastal areas. Beach protection is one of the coastal engineering problems of wide concern to the community.
This paper presents principles and modern trends in shoreline protection. Generally, long-term erosion problems occur due to littoral drift gradients. Based on the sediment transport capacity, the designer can attempt to design the proper defence system. There is now a tendency to avoid the construction of groynes, sea walls, etc. as long as possible. Most types of erosion problems can be solved by the proper "soft" solution. Based on this information, and in the light of the recent demands for proper coastal management the present situation, with respect to beach protection along the Capricorn Coast, is discussed briefly.

1. INTRODUCTION

The problem of coastal management appears with the increasing of the density of population when a man has settled and exploited the coastal zone - when a techniques progressed from the land towards the coastal waters and next farther offshore. Actually, for example, it is 5 cm of the coastline per person in Holland, about 70 cm in USA and 200 cm in Australia.

Including its external territories, Australia has one of the largest marine zones in the world (8.9 million km^2) and one of the longest coastlines (approx. 70,000 km). The coastline of mainland Australia itself, including Tasmania, is approximately 36,700 km, Queensland approximately 9,500 and the Capricorn Coast, the region of our interest about 75 km. Australia has also wide range of tides from over 12 m in the north of Western Australia down to 0.5m near Perth. Figure 1 shows schematically the range of tides around Australia.

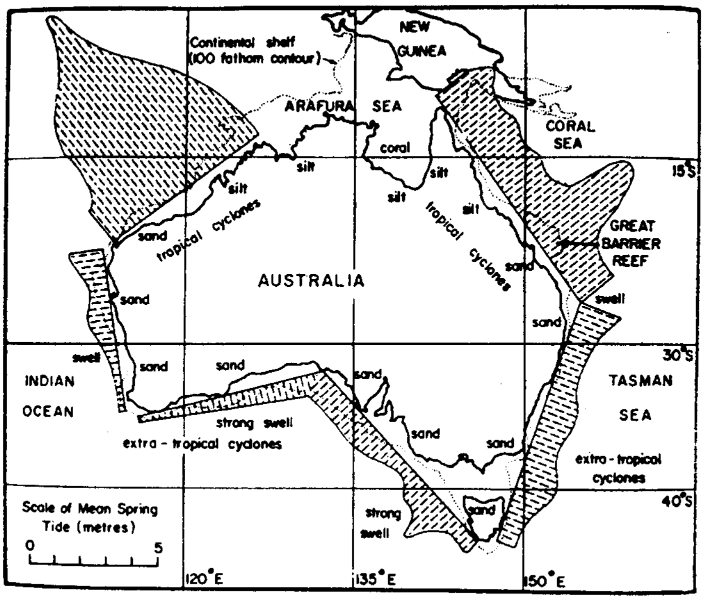

Figure 1. Tides around Australia (Silvester, Hsu 1997)

Coastal zone also contains the largest areas of coral reefs of any nation and the third-largest area of mangroves, and it has globally significant populations of a number of endangered species.

Based on the local government definition, Australia's coastal zone supports about 85 % of total population. The coastal zone is especially significant because it contains a high proportion of the resources used to produce goods and services. In particular, it is where most of the fishing industry, tourism and other service industries, and significant parts of the agriculture, forestry, mining (including petroleum) and manufacturing industries are concentrated.

Thus the coastal zone plays important role in our life. Development, and whole range of other human activities, can be successfully accommodated within the coastal zone, but proper coastal zone management should be well planned for the benefits of the present and future generations. The environment of the coastal zone is subject to continuing change brought about by natural processes. This is particularly the case in the shore zone, which is that area most directly influenced by marine processes such as the actions of waves, currents, tides and storm surges. these processes interact and continuously shape and modify the physical features of the shore zone, including beaches, spits, sand dunes and offshore sandbars. These physical features are part of a naturally dynamic system, their form and location change in response to changes in marine processes are studied by oceanographers and coastal engineers. In general "coastal engineering" is one of several specialised engineering disciplines that fall under the umbrella of civil engineering. Harbour works, navigation channel improvements, shore protection, flood damage reduction, and environmental preservation and restoration are the primary areas of endeavour.

Because coastal engineering is so extensive, a subdivision is made into three areas according to the type of problems experienced. These three main categories are Harbours, Morphology and Offshore.

"Coastal morphology" means the physical shape and structure of the coast. In other words: coastal morphology is the study of the interaction between waves and currents, and the coast, which results in sediment movement and eventually in coastal changes.

Coastal changes occur mostly as a result of changes in sediment transport along the coast. Sediment transport only occurs provided there is sediment to be transported. For example, erosion that occurs along some parts of the Adelaide beaches is largely a result of a natural lack of sand. On the other hand the Fitzroy catchment contributes significantly. Recent study of sediment transport in lower Fitzroy River found that average sediment transport towards the estuary is of the order of 5 million with the maximum up to 20 million cubic metres per year, including wash load (Franz, Piorewicz, 2001).

2. EROSION PROBLEMS

A natural beach profile changes almost continuously in shape due to varying boundary conditions. The cross-shore transports involved, cause the reshaping of the beach profile. Looking at the position of the dune foot as a function of time for an in principle stable cost, the histogram as in Figure 2 could be obtained. Over a number of years the coast is stable. At certain instances, however, the dune foot retreats over a much greater distance that the "normal" fluctuations (points A and B in Figure 2). The occurrence of a severe storm is the reason of that temporary retreat. To judge the safety of a row of dunes as an adequate sea defence, one has to be aware of the possible extreme positions of the points A and B.
In Figure 2 an essentially stable section of the coast was considered. In a steadily eroding section of the coast the cross-shore mode of sediment transport is not the only cause of the erosion problem. Continued erosion of coast occurs mostly due to gradients in the longshore sediment transport process. In Figure 3 a sketch has been given of a steadily eroding coast. It is assumed that the picture holds for a certain stretch of coast. For that specific part of the coast obviously the "outgoing" sediment transport is greater than the "incoming" transport. Generally the longshore transport can be estimated from some of several proposed formulae in the literature.

Figure 4 shows schematically what happens during a severe storm surge. Due to water level that is higher than normal and the rather high waves, sand is eroded from the unprotected dunes. This sand is transported in the offshore direction where it resettles. Prototype measurements and model test results have shown that the settlement of the eroded material occurs close to the original shoreline and there is no evidence that huge quantities of material are transported far into the sea. Dune erosion is relatively short process and erosion takes place within a few hours.

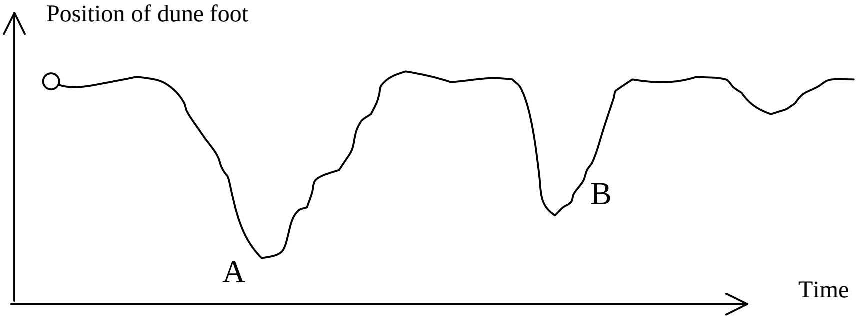

Figure 2. Position of the dune foot as a function of time

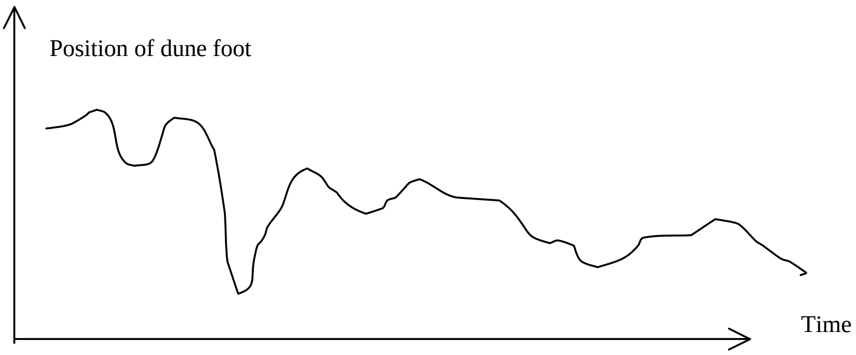

Figure 3. Steadily eroding coast

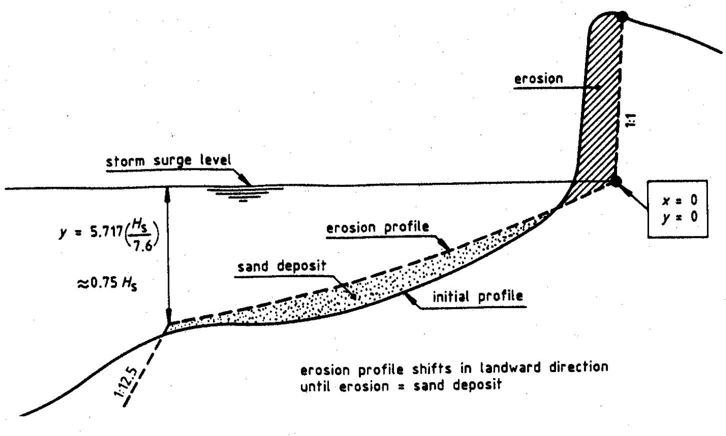

Figure 4 Post storm beach profile (Vellinga,

Inconvenient cross-shore transport is only assumed to occur during a storm surge. The problem is to decrease the expected erosion or to reinforce a dune that is obviously too weak. The response to beach/dune erosion has traditionally been the construction of artificial structures. However, these techniques have proved to be ineffective in many cases. For few decades, new "soft" methods have been considered and successfully tested. In the next section a short review of the traditional and modern techniques will be presented.

3. SHORE PROTECTION STRUCTURES

The different coastal structures have different influence on reshaping of the coastline. Figure 5 presents schematically different types of the structures and their location on the coast.

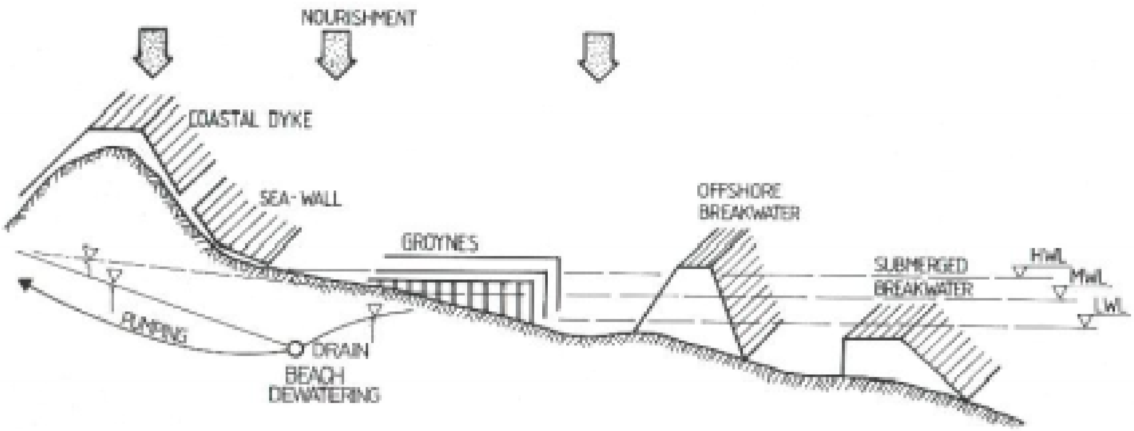

Figure 5. Different types of shore protection structures

3.1 Hard types of shore protection

Coastal dykes and rock-walls are generally defined as ***revetments.*** A revetments has been described as a cladding of stone, concrete or other material used to protect the sloping surface of an embankment, natural coast or shoreline against erosion.
Coastal dykes separate low level lands from the sea and protect them against storm actions. Dune system is a natural type of the coastal dykes. Reinforcement of the dune formation is one of the favourite solutions. Knowing the wanted safety, the actual necessary dune width and/or height can be computed. From the point of view of minimal sand supply, the widening of the dunes seems most appropriate.

Sea-walls and/or bulkhead are the massive structures built parallel to the coastline to prevent the cross-shore transport of material from the coast towards deeper water (Figure 6). They can be an appropriate counter-measure to prevent unwanted erosion due to a single occurrence of a storm surge; however, they do not diminish at all the retreat of the dunes above the highest level of the defence.

A sea-wall can make some local erosion more severe (Figure 7) by:

- erosion at the ends of the sea-wall due to superposition of the coming waves with waves reflected from the sea-wall,
- -erosion behind the sea-wall due to overtopping waves, and
- -erosion in front of the sea-wall due to strong wave currents caused by wave reflection.

Figure 6. Bulkhead on Yeppoon Main Beach at High Water

While many sea-walls have been built in all parts of the world, they cannot be recommended generally as beach protection. These structures increase the current flow by becoming hardened parallel shoreline. Gone is the absorption effect of a gradually rising beach, which drains energy from the waves by percolation and friction.

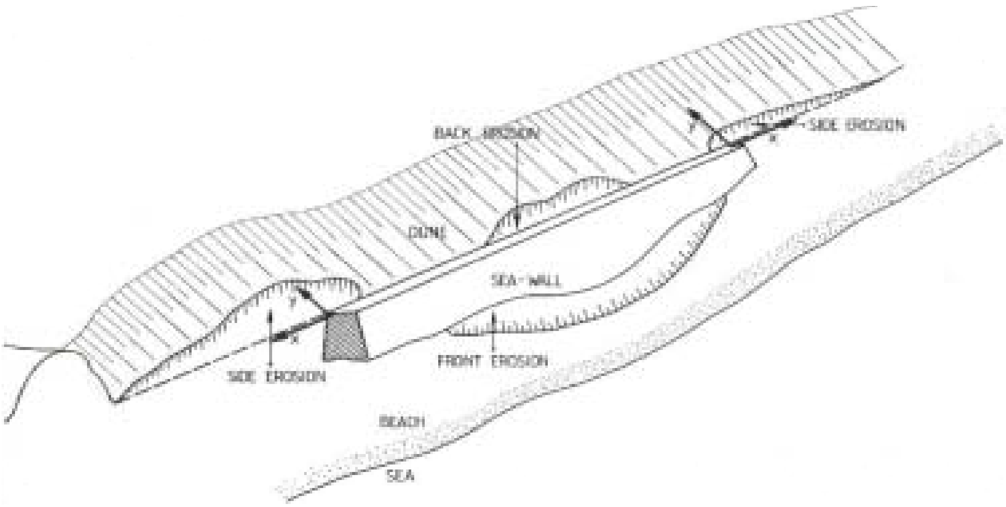

Figure 7. Possible local erosion around seawall

Sea-walls do not stabilize the shoreline in any long-term sense. These structures are more related to storm protection than stabilizing the shoreline over the daily processes which are so important in shaping the beach.

Groynes have been installed across the path of littoral drift in order to retain beaches where they have been needed. The groynes must extent through the breaker zone and have crests above the still water level to be completely effective (Figure 8). The area protected by the groins will not erode but will interrupt the longshore drift. Therefore severe erosion will result down drift of the last groin (Figure 9). The groynes simply displace the erosion problem. Still the groynes functional behaviour is the least understood.

Figure 8. Example of groynes application in Holland

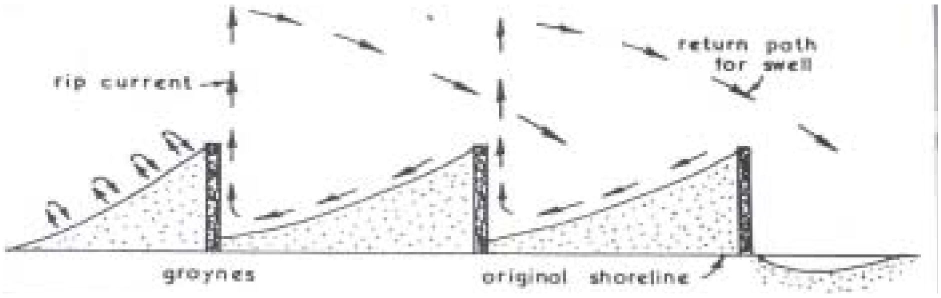

Figure 9. Shore-normal groynes

Offshore or detached breakwaters are built offshore parallel to the coast (Figure 10). These structures are constructed offshore in 3 to 5 m depth parallel to the coast, with spacings varying from ½ to 5 times their individual lengths. A group of breakwaters modify the wave pattern between them and the coast. Since wave heights are reduced behind the breakwater segments by diffraction and later also by refraction, the sand transport capacity behind the breakwater is reduced leading to the deposition of material supplied from "updrift" in the lee of the breakwater. Under certain conditions (wave climate, segment length, gap width, distance from the original coastline) sand will accrete behind a breakwater segment until it reaches the breakwater itself and forms a tombolo.

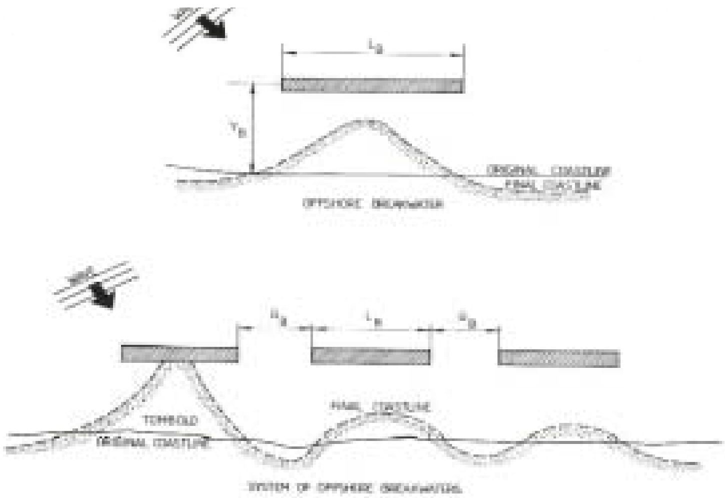

Figure 10. Principles of detached breakwaters

Submerged breakwaters are built parallel to the coast on a such depth that breaking wave will happen above the crest. The aim of the submerged breakwater is a gradual absorption of wave energy and accumulation of sediment transported towards the sea (Figure 11). It can influence the water quality by induced the water stagnation in the lee side of the structure during calm conditions.

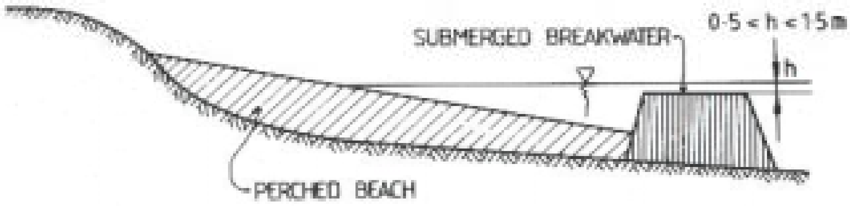

Figure 11. Submerged breakwater

Since the only way to retain sand where it is wanted is to reorient the beach normal to the incoming waves, a new concept has been developed by implementation so called headlands. That concept can be classified as "soft" solution.

3.2. Environment-friendly soft techniques for shore protection

“Hard” shore protection methods, such as seawalls, groins and detached breakwaters, no matter how well designed and implemented they may be, can hardly avoid fortification of the concomitant erosive, often devastating, effect on the down-drift shores, and anyway do not constitute an environmentally and financially attractive solution to be applied to long stretches of eroding shoreline. Engineers and scientists practising design and implementation of shore defending schemes are, for a few years now, aware of the public and private demand for improved shore protection technologies and encourage efforts that promise enrichment of the log of environmentally sound and financially attractive methods that can be safely applied.

Adverse environmental impacts and high cost of “hard” protection schemes have created interest to examine in detail the potential and range of applicability of the immerging and promising category of “soft” shore protection methods against such erosion. “Soft” methods, e.g. beach nourishment, headlands, artificial reefs, gravity drain systems, floating breakwaters, plantations of hydrophyle shrubs etc, applied mostly during the past 20 years, are recognised to possess technically, environmentally and financially advantageous properties deserving more attention and further developmental experimentation than has been given hitherto. A short review of this method is discussed below.

Beach nourishment is probably the simplest and most dependable means of maintaining an eroding beach by supplying sand from other sources. In order to carry out artificial nourishment, several questions must be answered: what kind of nourishment should be used, what size of material should be used, what amount of sediment should be suppled, where should the sediment be obtained. Methods of beach nourishment are shown schematically in Figure 12.

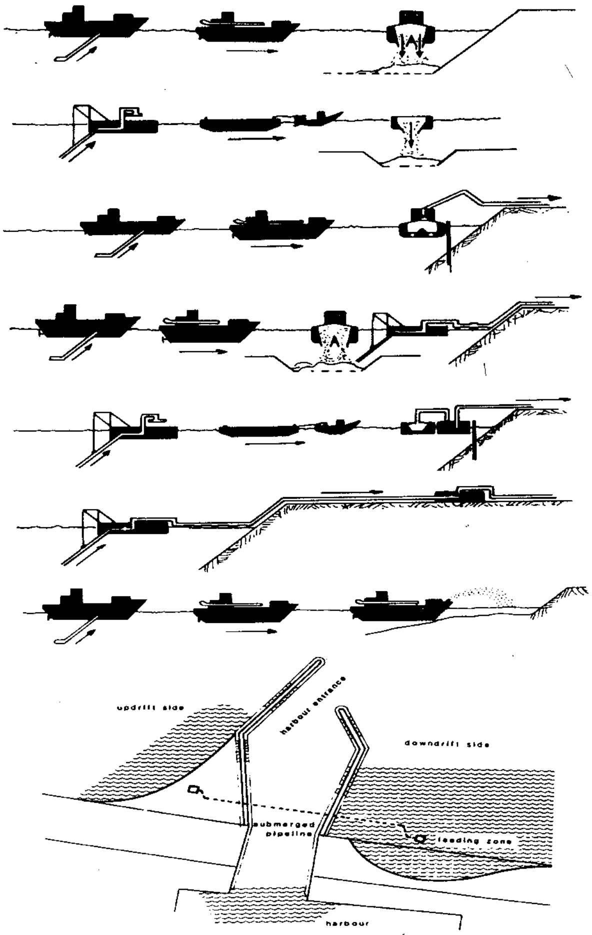

Figure 12. Different methods of beach nourishment (CUR Report 130)

Increasingly, sand supplies do become an adequate solution for (gradual) erosion problems. Contractors are able nowadays to supply large amounts of sand at still (relatively) decreasing costs. The seaside maintenance, its natural looks and one avoids the construction of “strange elements” in the coastal system which can hamper a next generation of probable higher-skilled coastal engineers. It should , however, be remembered that the same wave climate exists as before, which is oblique persistent waves in an erosive situation. Thus the never-ending repetition of supplying sand will occur. It may happens that up to 50% of any initial renourishment is lost in the natural process of a beach reshaping and repetition could be at as short as 2 years intervals. However, in USA, as it is shown in the last edition of the Coastal Engineering Manual (2001) up to 80% of coastal protection works has been done with the beach nourishment (Figure 13).

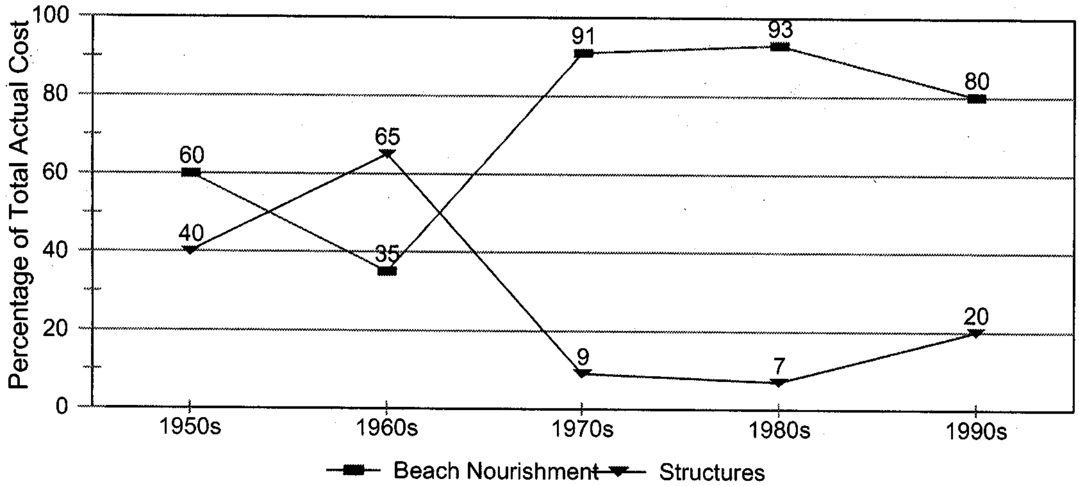

Figure 13. Implementation of beach nourishment in USA (CEM, 2001)

Headland Control. The observations of coastline behaviour of the seas or oceans, or analysis of aerial photographs indicate the existence of bays which are in stable conditions over geological time (Figure 14).

Figure 14. The Capricorn Coast, example of natural beach shaping in the form of bays.

Silvester (1972) first proved the principles of equilibrium shaped bay between headlands in the presence of persistent oblique swell and defined them as “crenulate shaped bays” (Figure 15). The term “headland control” is used when crenulate shaped bays are artificially created between man-made headlands. The aim is to give the beach a natural stable shape over the long term, possibly without need of any renourishment. Efforts have been made since early 1970s to understand the effects of headlands and to model stable bay characteristics. Guidelines in the design of the headland are given in Silvester and Hsu (1993).

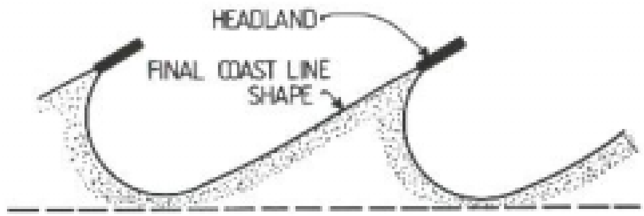

Figure 15. Headland control on straight beach

Beach Dewatering. The effects of water-table position on accretion and erosion of the beach face has been well documented in the literature (Weisman et al. 1995). One mechanism suggested is that with a low water table under the beach face, a relatively large fraction of the water volume in the uprush can infiltrate through the beach face, diminishing the volume and erosive effect of the backwash (Figure 16).

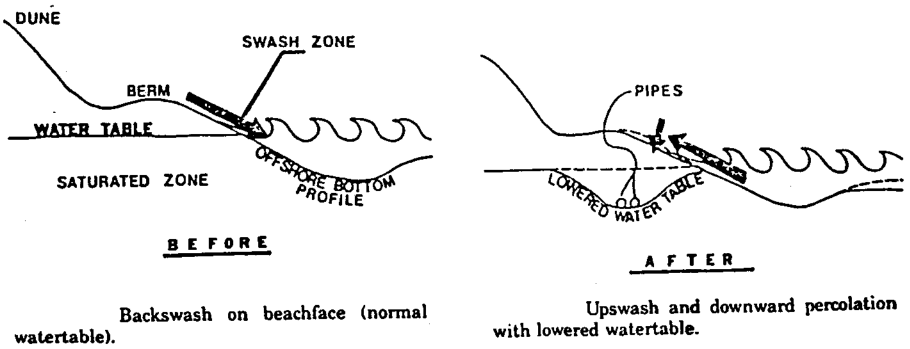

Figure 16. Principles of beach dewatering

The sediment deposition during uprush combined with a reduced backwash yields an accretion of the beach face. Basically, creating an unsaturated zone under the beach can be done by using low energy pump to draw water from buried horizontal perforated pipes. There have been several field tests of this technique in Denmark, USA, England, Italy, Japan, and Australia. The techniques experimented in New South Wales achieves lowering of the watertable without pumps (Davis and Hanslow, 1991). Drains were in this case normal to the shore and transfer water from the upper beachfront to the surf. Similar test was conducted on Yeppoon Main Beach as a final year engineering student project (Steedman, 1996). Unfortunately, the project was not continued on the following years.

The advantage of this method is that all the hardware is buried therefore invisible and no hazardous. This method helps the eroded beaches to recover faster than in natural conditions. The major questions for engineers concern the design and operation of a drain system. There are still many unsolved questions like location of the drain, specifically the depth and the distance behind the still water level, or drain system's effectiveness against tidal range.

There are a few patents connected with this type of beach protection:

- Pressure Equalisation Modules patented by S/C Skagen Innovation Centre, Denmark. They advertise effectives of their method almost in every condition. An example is shown in Figure 17 and 18 taken from their web site (www.skagen-innovation.dk)
  The later aerial photo (Figure 18) from 1999 illustrates very clearly that pressure equalisation modules are far more effective than the conventional groynes from 1950. As can be seen from the photo, these groynes are now completely covered by sand on the new and sustainable beach.

Figure 17. Aerial photo of the groynes at Gl. Skagen, before the implementation of pressure equalisation modules. (www.skagen-innovation.dk)

Figure 18. Aerial photo of the same location in 1999, 15 months after the implementation of pressure equalisation modules. (www.skagen-innovation.dk)

- Undercurrent stabilizers patented by Holmberg Technologies, USA. They are low profile geotextile tubes that run at right angles from dune or toe of the bluff, across the beach face to an appropriate distance offshore. As patented, no more general information is available.Some example of the effectiveness of their method is shown in Figure 19 (www.erosion.com/shore.html).

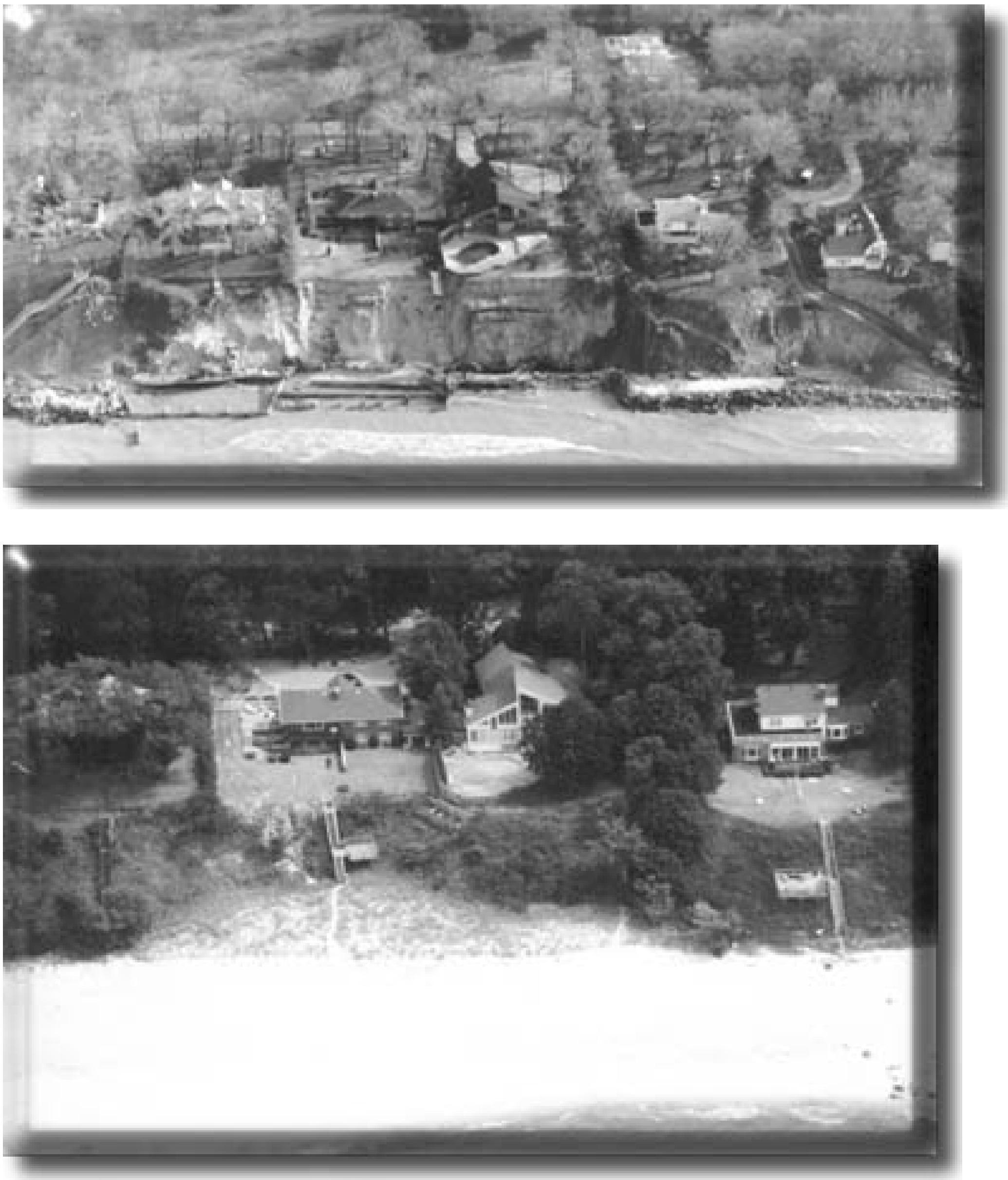

Figure 19. Example of undercurrent stabilizers application. (www.erosion.com/shore.html).

3.3 General comments

Coastal engineering and management in the past consisted of providing protection against erosion and flooding. Life in coastal areas was a continuous battle of man against the sea and all possible methods were mustered to take part in this battle. However, in modern approach we understood that beach profile respond to storm-calm cycles by shifting sand in the cross-shore direction, forming a dynamic equilibrium. But any beach profile will need additional material during sever cyclones causing combination of high wave action and storm surge. Nature has provided for such emergency by stockpiling large quantities of sand in dunes. The dunes are a long-term protection against coastal erosion, because they provide adequate elevation of the land contours to prevent flooding and form emergency reservoirs of sand. Therefore the modern coastal engineering design and coastal management consider:

- Not disturb existing dune-beach systems
- Encourage growth of dune-beach systems, and
- Emulate dune-beach systems wherever possible

Critics of shore protection will say that all shore protection is temporary – so why build it in interfere with nature, which eventually will have its own way? On a geological scale, protection is not even temporary, but neither is the coastal system we are trying to protect. On engineering time scale protection is indeed temporary. Even the very large protection systems require constant watchfulness, repair and change in management techniques. But temporary with respect to shore protection is long enough to be of benefit for most applications. In any case, economic considerations decide if a coast should be protected.

Given the necessity of shore protection, we should do it right. Unfortunately, there are few guidelines on how to build shore protection and any existing guidelines suffer from either too much simplification or too much generalization. As a result, much shore protection is build without adequate knowledge or appropriate design. Thus for the design of coastal protection the following questions need to be asked:

- Do we want (or need) shore protection?
- What are the available alternatives?
- How can we implement protection and leave the coast as natural and attractive as possible?

It is a wisdom in the phrase: “Man masters nature not by force but by **understanding**” (Jacob Bronowski, 1908 – 1974)

How do these questions apply to our Capricorn Coast? Let’s discuss it in the next chapter.

4. CAPRICORN COAST CASE STUDY

The Capricorn Coast is the name of the Central Queensland coastline from Cattle Point on the northern side of the Fitzroy River mouth northward to Stockyard Point, a distance of about 75 km (Figure 20). Yeppoon is the major town on the coast where the offices of the Livingstone Shire Council are located. The other is Emu Park located about 18 km south of Yeppoon. The favourable climate and recreational opportunities have encouraged extensive residential and commercial development. At present (year 2001) Yeppoon is the third fastest developing coastal township in Queensland. Its population is 12,000 people and up to 17,000 people has been living along the whole Capricorn Coast.

Figure 20. The Capricorn Coast - Locality plan

This region become also popular as a tourist destination for national and international tourists. This year the Capricorn International Resort celebrated its 16 anniversary. Rosslyn Bay has been for many years mainly a fishing port. After construction of a new breakwater and inside development it was official opening of the Keppel Bay Marina having 180 berths on 27 April 1996. It is the only safe, all weather harbour for 500 kilometres between Gladstone and Mackay.
It is evident that the attractiveness of the Capricorn Coast is growing. In such situation the problem of the beach conditions, its stability and vulnerability to erosion is very real. Any erosion caused by storms cause public demand for implementation of more and more effective measures to protect coast and public assets against possible erosion.

Beach Protection Authority, Queensland (BPA, 1979) carried out extensive field measurements and analyses of the Capricorn Beaches and estimated the likely dune erosion for this area, based on 50 years of the assessment of buffer zone. The BPA has adopted a planning period of 50 years based on the practical life of beachside structures, the maximum reasonable forward projection of estimated present beach erosion trends, and changing attitudes to beach management. Taking the 100 year return period, for wave condition of 6 hours persistence, there is an overall probability of 10% that this wave conditions will coincide with the higher of the two high tides on any day in the 50 years planning period. For such conditions the nearshore wave heights, run-up levels and likely dune erosion has been calculated. The results are summarised in Table 1. Definition of erosion distance is shown schematically in Figure 21.

Table 1 Events with 10% probability of occurrence in 50 years (BPA. 1979)

LOCATION	NEARSHORE WAVE HEIGHT [m]	RUN-UP [m AHD]	EROSION QUANTITY [m^3/m]	EROSION DISTANCE [m]
Farnborough (up to Sandy Pt)	5.3	4.3	175	35
Bangalee	3.0	4.4	75	25
Yeppoon	3.5	4.4	80	40
Lammermore	3.5	4.5	130	50
Kemp Beach	3.5	4.6	50	35
Mulambin	3.8	4.7	115	50
Kinka Beach	3.9	4.8	65	50
Emu Park	4.5	5.0	80	50
Keppel Sands	2.7	4.4	60	20

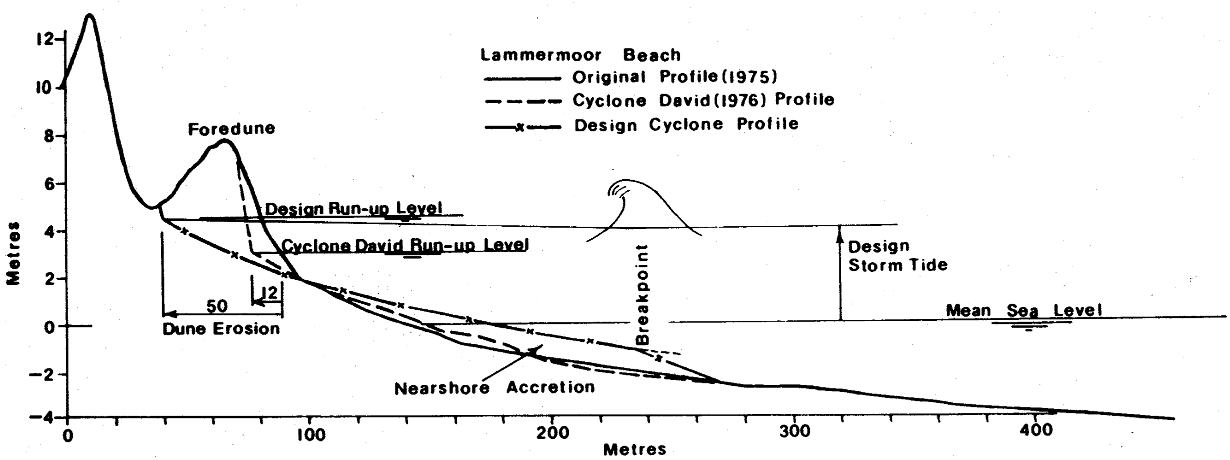

Figure 21. Cyclone dune erosion for Lammermore beach (BPA, 1979)

The results of the analysis presented in the Table 1 show serious erosion problem along all beaches of the Capricorn Coast. Therefore proper management is essential when development is considered. Discussion of the particular locations and some actions undertaken are shortly described in the next section.

5. MAINTENANCE OF THE LOCAL BEACHES

Farnborough

The Farnborough Beach, about 15 km long, exhibits extensive dune blowouts formations which have apparently been a more or less permanent features historically, allowing considerable vertical growth of dune heights. It represents a well established natural system of the dunes exposed to periodical erosion/sedimentation processes. In the region of the Capricorn International Resort erosion process in the years 1988-90 caused erosion up to 20 m. Since 1993, foredune redevelopment is clear and up to 30 m of foredune has been naturally rebuild. (Figures 22 and 23).

Figure 22. Farnborough beach near the Capricorn International Resort, situation in April 1989

Figure 23. Farnborough beach near the Capricorn International Resort, situation in January 2002

Bangalee

Bangalee area and further south towards Barwell Creek a new foredune ridge has been accreted in recent years, however, development adjacent to Barwell Creek is vulnerable to cyclonic erosion. In view of the general trend of accretion in the area no action had been considered so far. In the recent years the output from the Creek moved significantly southward, since 1989 for a distance of about 1000 m causing serious problem to the stability of the existing dunes (Figure 24). In the view of the progressing erosion in the last years some action connected with Barwell Creek stabilisation is required.

Figure 24. Farnborough beach near Barwell Creek, situation in January 2002.

Yeppoon

A seawall was constructed along most of Yeppoon Main Beach in the early 1930's and after being partly damaged by cyclonic wave attack in 1976, it was reconstructed and extended in the form of rubble mound rockwall (see Figure 6). In the light of BPA analysis, shown in Table 1, this reconstructed wall is inadequate to withstand severe cyclonic conditions. In early 1990's it was visible severe erosion of the beach causing some threatening to the stability of the existing seawall (Figure 25).

Figure 25. Erosion of the Yeppoon Main Beach, situation in early 1990's.

In 2001 additional reconstruction of seawall was conducted following BPA recommendation to strength the existing rockwall (Figure 26) before any works would be undertaken with the esplanade next to the beach for so called beautification of the Yeppoon recreation area.

Figure 26. Reconstructed rockwall on Yeppoon Main Beach, situation in January 2002

Kemp Beach

No serious erosion problems are evident at Kemp Beach and only a dune management program should be carried out to stabilise and protect foredune vegetation. (Figure 29).

Figure 29. Kemp Beach, situation in January 2002

Mulambin

Because of the high level of stability provided to Mulambin beach by the adjacent headlands and the relatively strong onshore transport of sand from offshore, Mulambin Beach has not experienced any measurable erosion in the last 50 years (Figure 30).

Figure 30. Mulambin Beach, situation in January 2002

Kinka Beach

Significant changes have taken place along the Kinka beach, particularly in its north and central parts since a causeway was constructed across the Mulambin Creek estuary, adjacent to Pinnacle Point, in 1939 (Figure 31). Extensive erosion in the central beach area reduced the dune width from about 90 m to almost none in the period 1960 - 1985 in spite of rockwall construction. Such situation threatens local residents about possible erosion of the Yeppoon - Emu Park road, and their properties (Figures 32,33).

Figure 31. Causeway just after construction in September 1939

Figure 32 Aerial Photo August 1961

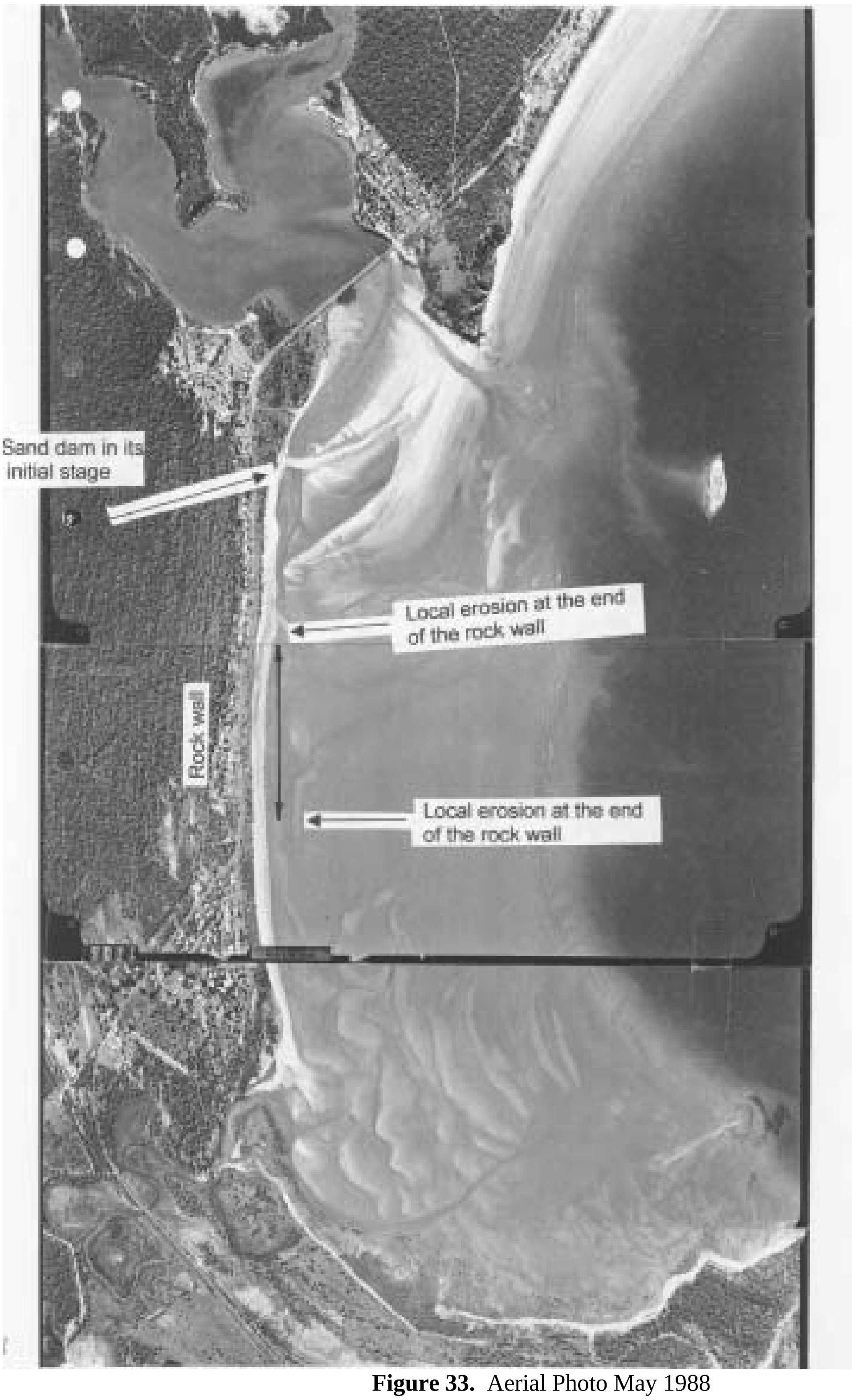

Figure 33. Aerial Photo May 1988

The Central Queensland University, CQU (previously Capricornia Institute) undertook investigations in 1987/88 to remove the risk of further erosion in the area (Piorewicz, 1999). A "soft" solution, which is compatible with environmental conditions, was recommended. This "soft" solution involved a new dredged channel and tidal lagoon as shown in Figure 34.

Before sand dam construction, the only used method of beach protection in this region was rock dumped directly on the dunes. This type of protection did not stop process of erosion, but only shifted it southward. The slow process of beach rebuilt started since the sand dam was constructed in 1988 with the visible and effective dune system improvement since 1993. Between 1993 and 1997, 80 percent of the rock wall was completely buried under the naturally accumulated sand and dunes get their natural shape and become covered with grass and shrubs. It is visible increase in dunes and dry beach (above MHWS mark) width (Figures 35, 36).

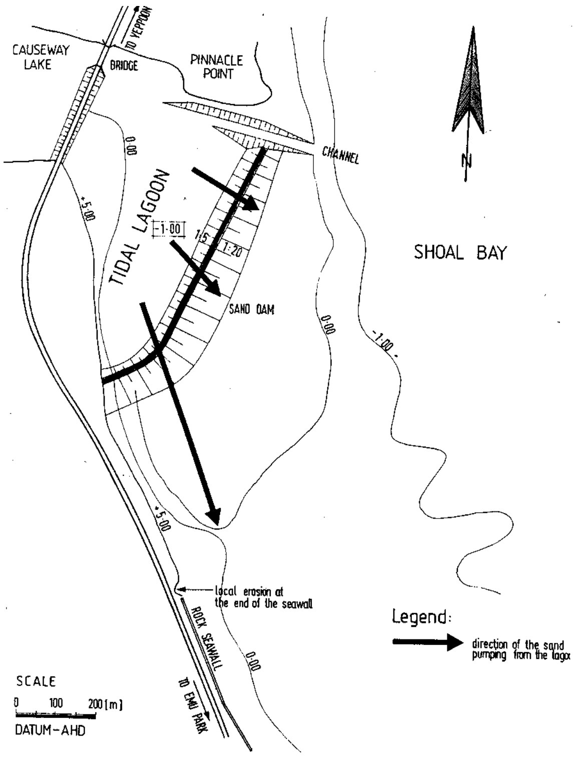

Figure 34. Implemented solution to restore north part of Kinka Beach

Figure 35. Improvement of Kinka Beach dune conditions for the period 1989 - 1998 - 2002

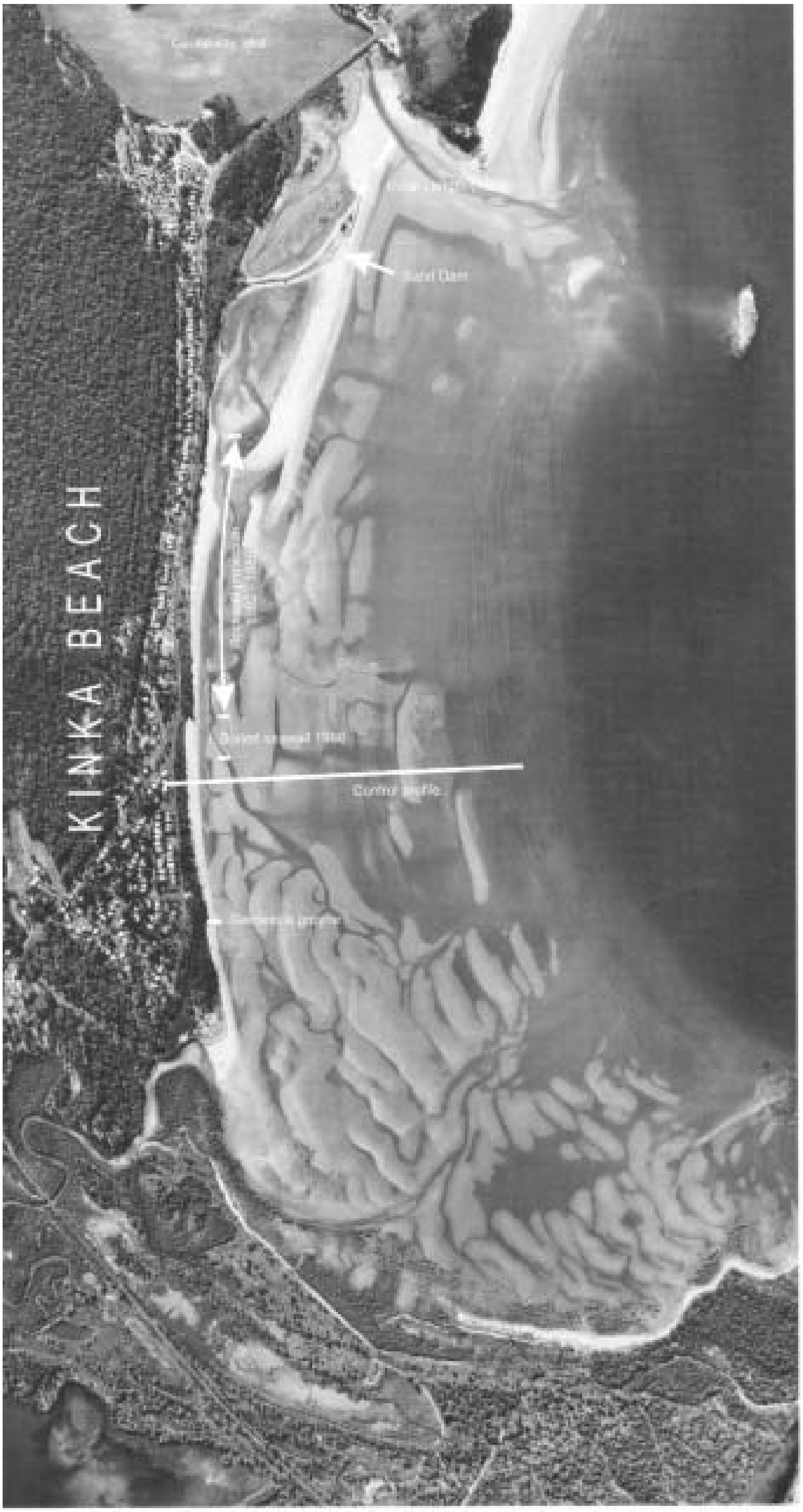

Figure 36. Aerial Photo 1996

The recent surveying shows significant accumulation of sand along the distance of about 700 m southward from the implemented sand dam. The source of this sand is likely to be the persistent swell actions from E to SE reshaping the beach agree with the Silvester’s theory about crenulate shaped bay (Silvester, Hsu, 1993). Numerical modelling is planned to evaluate this expectation and compare actual situation of the beach with expected initially 10 years ago.

Figure 35 shows how the beach with initially strong erosion slowly return to its natural shape with dunes covered by greens. The process is still in progress. But it could be stopped if process of washing away the sand dam is not stopped. With not spending money for maintenance of the sand dam for the last 12 years it is now time to do it if one does not want that erosion problems on north Kinka Beach will come back.

The southern part of Kinka Beach was not considered at this stage of study. However, it was found in continues erosion process. Particularly at the south end of the temporary rockwall local erosion become very critical in 1996 (Figure 37). Buried seawall, length of 280 m, as well as groyne made of geo-textile bags were implemented at the beginning 1998, as recommended by BPA. Buried seawall was constructed as a southward extension of the existing temporary rockwall in the area shown in Figure 37. Cross-section of buried sea-wall is shown in Figure 38. View of buried seawall just after construction and at present, in January 2002, is shown in Figure 39. Geo-textile groyne marked on Figure 36 is shown in Figure 40. The effect of implemented solution has been currently monitoring by CQU (Piorewicz, 2001).

Figure 37. Erosion on south end of Kinka beach, March 1996

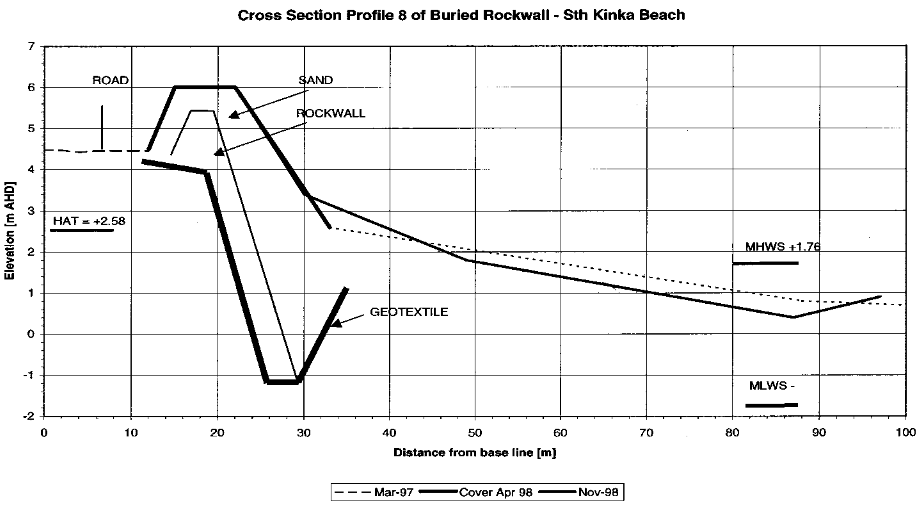

Figure 38. Buried seawall cross-section

Figure 39. Buried seawall April 1998 and January 2002

Figure 40. Geo-textile groyne on South Kinka, January 2002

Last year, LSC did beach renourishment in central part of Kinka Beach. It helps to accelerate natural buried process of existing temporary rockwall at its southern part. In the nearest future it is also recommended restoration of sand dam as well.

In the existing situation the weakest point of Kinka beach is its south part which can be flooded during a sever cyclone.

Emu Park

Erosion is not a problem along this section of the coast. At Emu Park the dune area is some 80 to 100 m wide and remains undeveloped and available for accommodate potential future erosion (Figure 41).

Figure 41. Emu Park beaches, January 2002

Keppel Sands

Keppel Sands beach is vulnerable to erosion and temporary protection with rubble and sleeper rockwall has been inadequate to protect the dune if "design" storm happens. Very flat and wide (up to 1 km) intertidal zone, shown in Figure 42, causes that any option for beach protection is very expensive. Some study has been carried out by BPA and CQU to find economically and environmentally accepted solution to improve natural sedimentation in this area. The optimal solution suggested by CQU, in its recent study, was extension of the existing groyne for another 100 m, creating this way headland which should help to restore the beach (Figure 43). View of extended groyne is shown in Figure 44. Monitoring has been carried at present and some conclusion about this approach to the beach restoration should be expected at the end of this year. Particularly the conclusions about south site of the beach where rockwall is exposed to the wave action (Figure 45).

Figure 42. Aerial photo of Keppel Sands

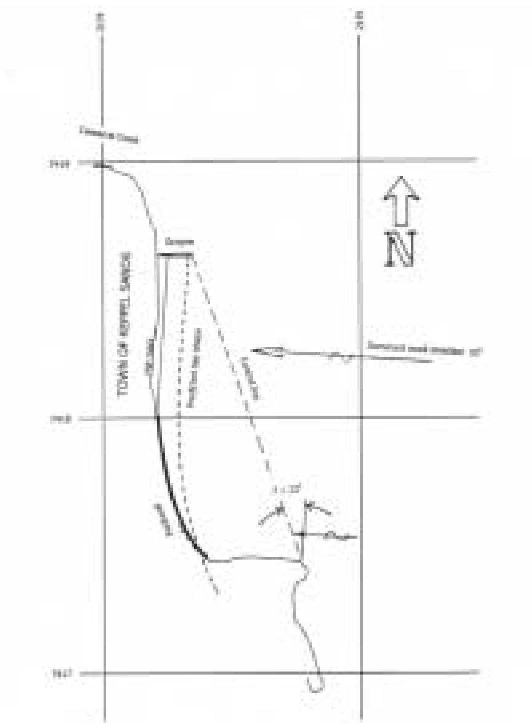

Figure 43. Expected shoreline changes as a results of groyne extension (Crenulate shaped bay approach)

Figure 44. Extended groyne on Keppel Sands Beach, January 2002

Figure 45. Keppel Sands, southern site of the beach. December 2001

6. CONCLUSIONS

Coastal zone management becomes recently the main national problem, as more and more people understand the value of the coastal zone as a national asset. Coastal engineering is a part of coastal management. One of the coastal engineering problems is beach protection. With the still increasing knowledge about coastal processes it is well accepted that no ideal solution exists for erosion control. The wave climate, tidal range, longshore transport, is among the many variables that must be considered at each individual site. Traditional engineering approaches to stabilisation of beaches near river mouths or estuaries were to use jetties or groynes, seawalls and nourishment. Nourishment, now widely used, has the advantage of leaving the beach uncluttered with structures and of not risking damage to adjacent shores. Its main disadvantage is the need to replace the losses seaward and/or alongshore periodically.

Engineering structures are generally more related to storm protection than stabilisation of the shoreline on the basis of the daily processes that are so important in shaping the beach. The concept of the existence of stable crenulate-shaped bay or beach dewatering could be promising means of stabilising a shoreline.

The Capricorn Coast is an area of extensive residential, tourism and commercial development. Short review of the beaches of the Capricorn Coast indicates its serious vulnerability to the design storms; however, costly solutions are not yet economically justified. Therefore implementations of simple solutions where natural processes are involved are very encouraged.

It is well known in coastal engineering that projects connected with the beach stability are usually realised without the satisfaction of knowing a prior what the success will be. Monitoring of those solution and structures, which are in place, therefore, is very important in order to learn more from nature. That information together with a continuous development in theoretical studies will allow for more rational criteria for design and construction of features to stabilise coastlines.

Remember: “MAN MASTERS NATURE NOT BY FORCE BUT BY **UNDERSTANDING**”

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