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Research Report No. CE2
April 1991

The James Goldston School of Engineering Research Reports.

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SOFT SOLUTION TO KINKA BEACH IMPROVEMENT PRESENT SITUATION (YEAR 1990)

BY

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RESEARCH REPORT NO. CE2

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UNIVERSITY COLLEGE OF CENTRAL QUEENSLAND

APRIL 1991

Paper presented at the 3rd Workshop on Coastal Zone Management organized by QUT and UCCQ in Yeppoon on September 13 – 16, 1990

ABSTRACT

Progressive erosion of Kinka Beach and instability of the outflow channel from Causeway Lake was stopped by excavation of a new channel and construction of a sand dam 1.5 years ago. The new dam has created a tidal lagoon to accumulate a sufficient tidal prism to keep the new channel free of siltation. At the same time the dam may be considered as a natural headland for nearby Kinka Beach where a crenulate–shaped bay is expected to develop. This relatively cheap solution is being monitored to obtain information for future rational designs of beach stabilization compatible with environmental situations. The results of these field observations are analyzed.

CONTENTS

1. INTRODUCTION

Kinka Beach is located in Shoal Bay, in the central part of the Capricorn Coast. On the northern side it is bounded by a rocky headland and the outflow from Mulambin Creek and on the southern side, at a distance of 3.2km from the northern boundary, by outflow from Shoalwater Creak and an unnamed rocky headland (Figure 1).

The mouth of Mulambin Creek was closed by a causeway in September 24, 1939 (The Morning Bulletin, 1939). Concurrently with closure of the mouth by the causeway the bridge on the northern end of the causeway was cleared to take the flow as tides approach the neap conditions. The invert of the floor of the waterway under the bridge is such that only 3.7m LWD tides will flow through the bridge. This condition has caused the Causeway Lake to have a limited amplitude tide of up to only 0.9m, compared with a 5.0m possible amplitude on the sea side of the causeway.

Following construction of the causeway and bridge, there were serious changes to the hydraulic behaviour of the estuary and, in particular, flow volumes in the estuary were greatly reduced. The original river mouth cross–section became quite unstable. A large accretion of sand has since occurred in front of the causeway and Mulambin creek has been forced to flow south from the bridge parallel to Kinka Beach. Uncontrolled flow from the creek in conjunction with wave action has caused serious erosion to the beach and dunes during the past 50 years.

The University College of Central Queensland (previously Capricornia Institute) undertook investigations to remove the risk of further erosion in the area (Grigg et al.,1989). The results of that investigations were first summarized at the 2nd Coastal Zone Management Workshop in Lismore (Piorewicz, 1988). Further details were presented during the 9th Australasian Conference on Coastal and Ocean Engineering in Adelaide (Grigg et al., 1989). In the meantime the solution recommended from the study was implemented in a simplified form. The new channel stability and beach profiles arising from the solution strategy, have been monitored for the last two years. The outcome of that monitoring are presented in this paper.

2. HISTORY OF CHANGES

According to information in The Morning Bulletin (Nov.21, 1939), before construction of the causeway the spring tidal prism was about 1.6 mil cum (350 mil gallons). Examinations of aerial photographs, and site inspections have revealed that the following changes have occurred since construction of this causeway:

(a) The outlet of the Mulambin Creek has moved progressively towards the south, and a sand spit has formed offshore;

(b) Major siltation has occurred in the man–made causeway lake;

(c) Substantial erosion of the coastal dune system along Kinka Beach has occurred.

Between 1982 and 1985 Main Roads constructed 700m of temporary rubble seawall to protect the Yeppoon – Emu Park road. Major erosion of the dunes at the northern end of this wall has occurred since its initial construction. By the beginning of 1988, virtually no dunal protection for road and adjacent houses against tidal surge or cyclone remained .

Detailed analysis of these conditions revealed the following results:

(a) In the period of 1961 – 1988 dunal erosion along Kinka Beach exceeded 50m;

(b) In the years since the causeway was build approximately 1.1 mil cum of sand has accreted in the sand spit in front of the original mouth of the Creek;

(c) The spring tidal prism entering the Causeway Lake was of the order of 0.6 mil cum of which only 0.3 mil cum of water could leave the lake during the next ebb tide (local tide in the area can be characterized as a mixed, semidiurnal form). Thus the effective tidal prism used in a stabilization analysis is 0.3 mil cum.

(d) Longshore sediment transport for Shoal Bay is northward and is of the order of 13,500 cum/year (gross) and 12,100 cum/year net.

The critical situation of Kinka Beach and a required modification of the existing timber bridge demanded a quick and effective solution to the erosion problem. The solution was not permitted to increase flooding of private property, or to reduce the aesthetic amenity of the area. Several options, including traditional engineering "hard" construction were analyzed. Finally a "soft" solution which is compatible with environmental conditions was recommended. This "soft" solution involves a new dredged channel and tidal lagoon as shown in Figure 2.

3. 'SOFT' SOLUTION

The solution was based on two hypotheses:

(a) Stability of the inlet channel as suggested by Bruun (1978): Bruun postulates that the dynamic stability of an estuary (or river mouth) depends on the relationship between spring tidal prism, P in cum, and the yearly gross longshore transport, M in cum/y, passing the entrance. A stability index P/M in excess of 150 is required for a stable entrance, whereas an entrance with an index of less than 20 would be blocked by siltation.

The Bruun's index for the original estuary before construction of the causeway was approximately:

$$P/M = 1{,}600{,}000/13{,}500 = 118$$

and overall stability of the entrance could be defined as satisfactory with pronounced offshore bar formation.

After causeway construction the index was reduced to approximately:

$$P/M = 300{,}000/13{,}500 = 20$$

in which case an "overflow channel" rather than permanent inlet will developed.

(b) Stability of the beach suggested by Silvester (1974), Silvester et al. (1972) or Hsu et al. (1989). When waves approach a coast at an angle, the stable beach assumes a distinctive asymmetrical shape which is characterized by a crenulate shaped bay. It is commonly accepted that the formation of a crenulate shaped bay on a sedimentary coastline under oblique attack of persistent swell is the most stable beach generated by nature (Silvester 1974). As Kinka Beach has a natural tendency to crenulate, stabilization could theoretically be achieved by construction of a headland type structure near the outlet from the Causeway Lake.

On the basis of these two hypotheses a "soft" solution involving the dredging of a new channel and simultaneous extension of the natural dune system in the form of a sand dam to create a tidal lagoon with a capacity sufficient to increase the Bruun index to at least 75 for the initial stages was proposed. This solution is shown in Figure 2. Further improvement of the stability of that region could then be expected within a reasonable time period. The proposed solution was accepted as a temporary measure. The following site work has been performed as part of the implementation of the solution strategy:

- May 18 1988 the new channel opened and the old channel blocked by sand dam;

At that time the dam was only 200m long and no proper tidal lagoon was created.

- November 12 1989 the sand dam was extended up to the new channel and protected against wind erosion.

To improve Bruun's index to at least 75, to achieve reasonable stability of the new channel, the recommended area of tidal lagoon should be 12.5ha. This value of 12.5ha is derived from the following calculations:

- The longshore transport is reduced to around 4,000 cum/y by construction of the sand dam;
- The required tidal prism should be not less than 300,000 cum (P = 75 x 4,000);
- In the case of a bridge sill at a existing level 3.7m LWD and with an average bottom level of the tidal lagoon of 1.3m LWD the Bruun's index of at least 75 will be fulfilled for more than 50% of time if area of lagoon is 12.5ha (300,000/2.4). Any flood level above 3.7m will improve the index because of extra volume of water will be accumulate in Causeway Lake.

It should be noted that before a tidal lagoon was created the tidal prism in the lake was limited by sill and width of the bridge and only 20% of the flood tide had a significant meaning for the total prism volume in the lake. A sand spit had developed in the area following construction of the causeway.

Available aerial photos were analyzed for the period since 1961. The photographs indicated a stable shape for the Mulambin Beach, north of the Causeway Lake. That area has a limited sand supply and therefore can be considered as statically stable. The shape of this beach developed under a predominant swell from east direction as shown in Figure 3. The last aerial photos take in November 1989 show the same stable shape of the Mulambin Beach. The same swell direction has therefore been assumed for the nearby Kinka Beach. The expected shape of the Kinka Beach occurring after creation of the lagoon is shown on Figure 4. The changes to the beach line have been predicted based on Silvester's method (Hsu et al., 1989) at a low volume of longshore sediment transport. This theoretical shape of the statically stable Kinka Beach is highly probable. As the time factor involved in developing a stable beach is difficult to predict. The only way to verify the solution is regular monitoring.

4. SITE WORK AND MONITORING

Since excavation of the new channel and blockage of the old channel, monitoring was concentrated on three places:

- the cross–section of the new channel;
- the situation near the sand dam (profile 1 in Fig.4.);
- the situation 800m south of the sand dam near the existing rockwall (profile 2 in Figure 4.).

4.1 Site Work

The sand dam was constructed using an excavator and caterpillar. Work was done during the low tide. The dam has the following characteristics:

- It is located in the area with elevations about 1.5 to 2.0m LWD;
- 6m top width at an elevation of 0.5 + H.A.T.=5.5m LWD;
- side slopes of 1:5 on lagoon side and 1:10 on sea side;

On the sea side a fence against wind erosion has also been built. This fence has had a positive action on stopping dry sand being blown by the wind.

4.2 Weather Conditions

For the period May 1988 to September 1990 mild weather conditions predominated with only one severe period of heavy rain and storms (23 – 30 March 1990). Rainfall exceeded 800mm during that period. This storm caused bridging of the sandy dam in its central part. The damage was repaired immediately following the storm. However not any erosion was observed along Kinka Beach during that storm period which could have been very serious in the situation without a dam.

4.3 Stability of the New Channel

Stability of the new channel can be considered in both the plan and in the cross–section. The channel itself was excavated on the basis of minimum earth works and has only 5m width. During the next ebb tide it enlarged itself by the action of the strong ebb current. Over its total length of around 500m, the stability in plan is acceptable although, as shown in Figure 5. the channel shows a tendency to widen. The longitudinal profile shown in Figure 6. indicates stable depth. The same could be seen with the cross–section in Figure 7. The cross–section below MSL has varied between 40 and 48m^2 for the past two years. O'Brien (1969) suggested that stability of cross–section could be related to a spring tidal prism by empirical relation:

$$A = 6.56 * 10^{-5} P$$

where A is cross–sectional area below MSL in [m^2] and P is spring tidal prism in [m^3].

In that case the cross–sectional area would require tidal prism of the order 600 to 700 ths cum. No measurement has yet been undertaken for the tidal prism, however, initial calculations suggest a value of 550 ths cum. This value confirms the stability of present new channel.

4.4 Kinka Beach Conditions

Before construction of the sand dam the beach situation was critical. Erosion of the dunes was progressing continuously and virtually no dunes remained to protect the nearby road and houses. The temporary rock wall along the beach had shown a tendency to sink into the sand and strong local erosion was observed at its northern end.

The dam and fence against wind erosion constructed along the dam and the nearest dunes have increased siltation. Over a one year period the fence, which is one metre high, was covered by sand. Significant accretion of sand has been observed along the northern part of the dam near the new entrance. Recent aerial photographs show progression of new channel towards the nearby island.

Control profile 1 shown in Figure 8. indicates progressive accumulation of sand. Profile 2 in Figure 9. indicates that, before full extension of the dam in November 1989, continuous erosion was occurring. This condition has changed recently and a continuous process of sedimentation has been obtained. All these changes have been recently analyzed quantitatively using the latest survey data. The results of this work are not yet available. However, it can already be stated that the simple solution used has had a positive influence on improving beach stability.

5. CONCLUSIONS

It is well accepted that no ideal solution exists for erosion control. The wave climate, tidal range, longshore transport are among the many variables that must be considered at each individual site. Traditional engineering approaches to stabilization 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 stabilization of the shoreline on the basis of the daily processes which are so important in shaping the beach. The concept of the existence of stable crenulate–shaped bays could be a very promising means of stabilizing a shoreline.

In the case of Kinka Beach, construction of the sand dam has created a tidal lagoon to accumulate sufficient tidal prism. At the same time the dam can be considered as a natural headland for the nearby beach. The future shape of the beach can be predicted on the basis of empirical relationships between swell direction and physical parameters of the bay. In spite of the lack of adequate theory of such bays, this method of beach stability has become more and more accepted and many artificial headlands have been built around the world (Magoon, 1978). Unfortunately, to the author's knowledge, except for Kinka Beach, there has not been any project involving this type of beach stability, considered in Australia for the last 10 years.

The cost of realizing the project, consists of the costs of new channel excavation and sand dam construction together with the fence against wind erosion, and was of the order of $100,000. This is a reasonably low price considering that the cost of a proper seawall is of the order of $3,000 per running metre and that of being nourishment about $3 per 1 cum of replacement sand. The solution also has the advantage of possible improvement by the force of Nature and environmental acceptance.

It is well known in coastal engineering that projects connected with beach stability are usually realized without the satisfaction prior knowledge of 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 continuous development in theoretical studies will allow for more rational criteria for design and construction of features to stabilize coastlines. The monitoring of Kinka Beach is continuing.

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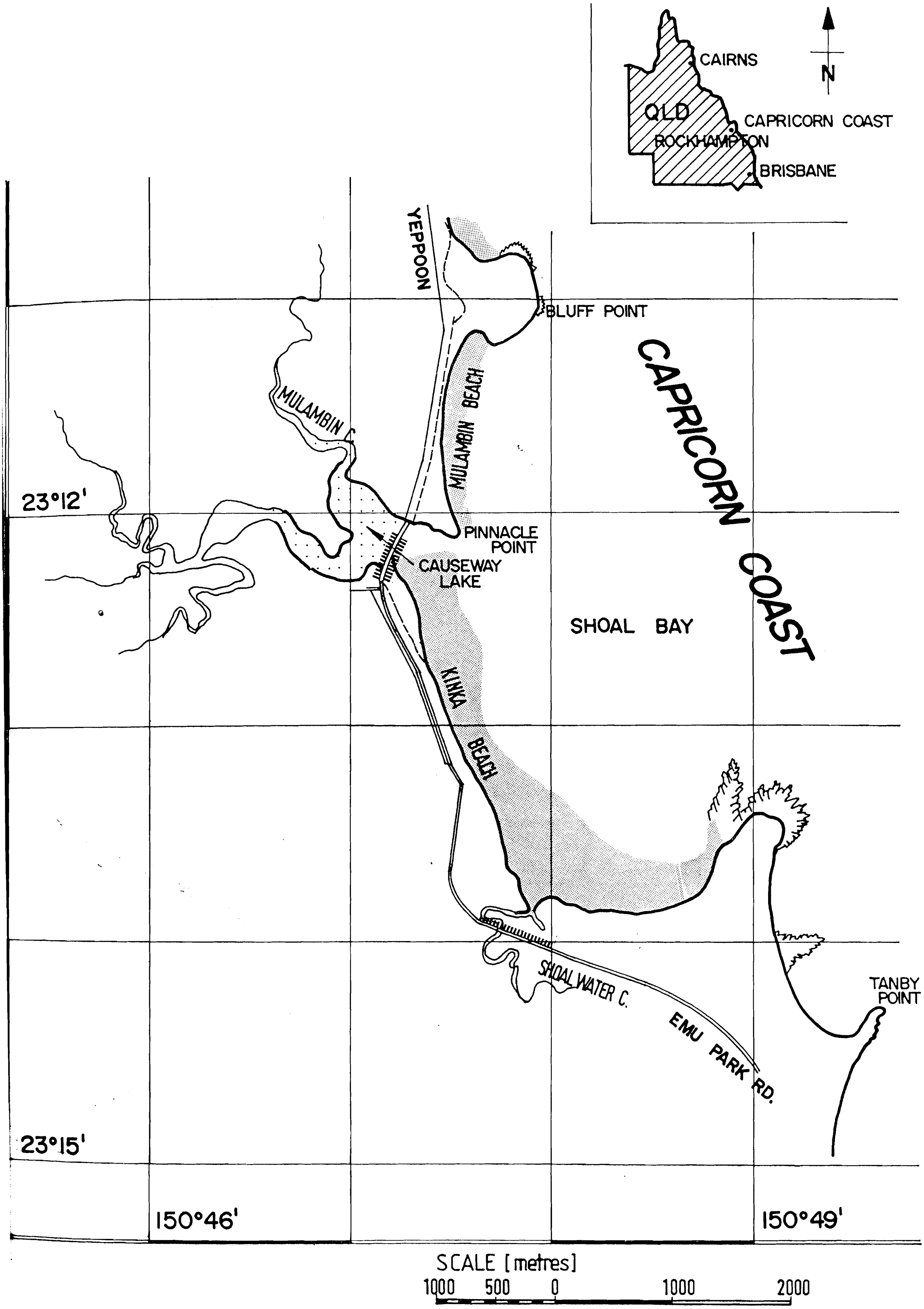

Figure 1

Kinka Beach/Causeway Lake Study Area

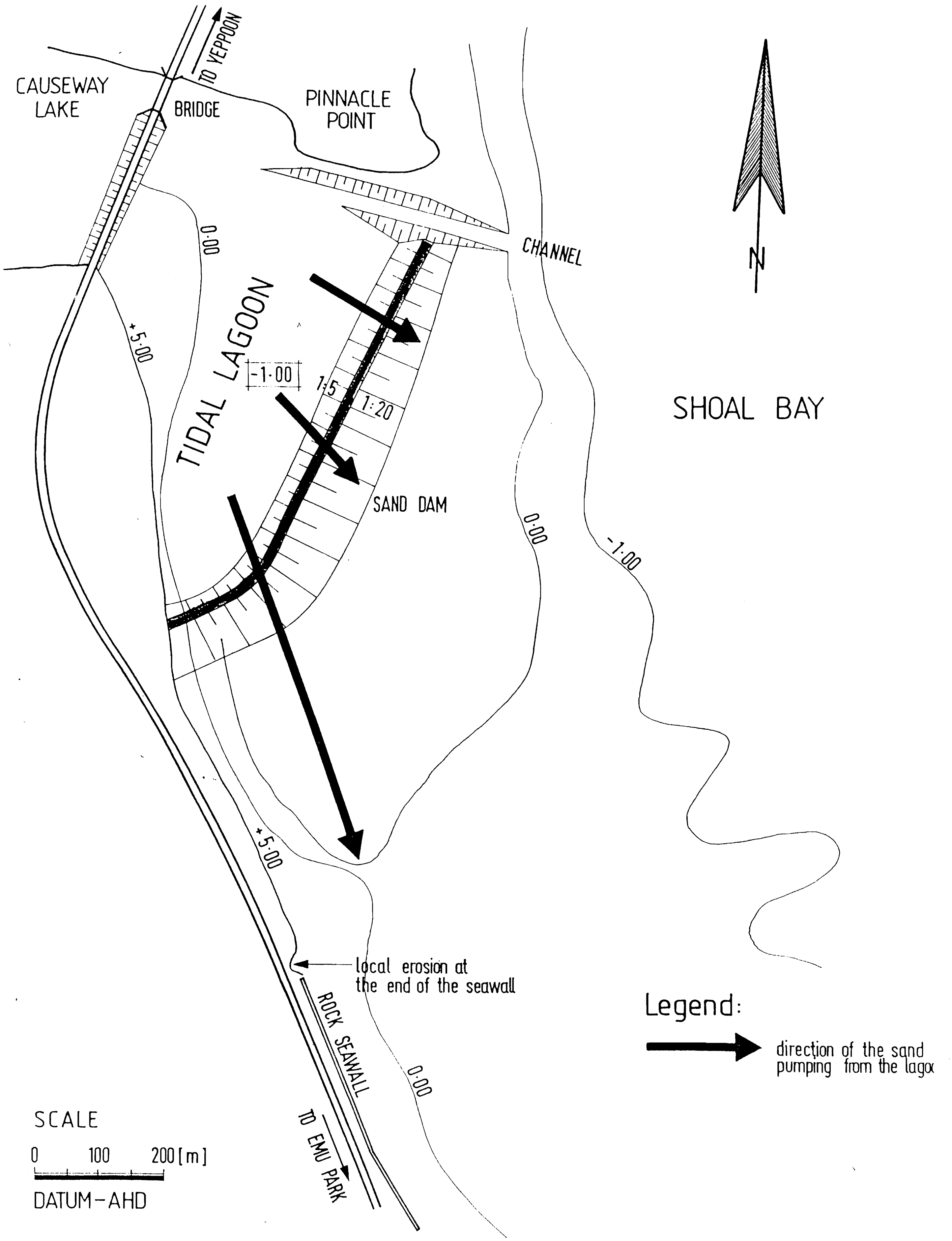

Figure 2

Proposed "Soft" Solution to Stabilize New Channel Outflow and to Improve the Condition of Kinka Beach

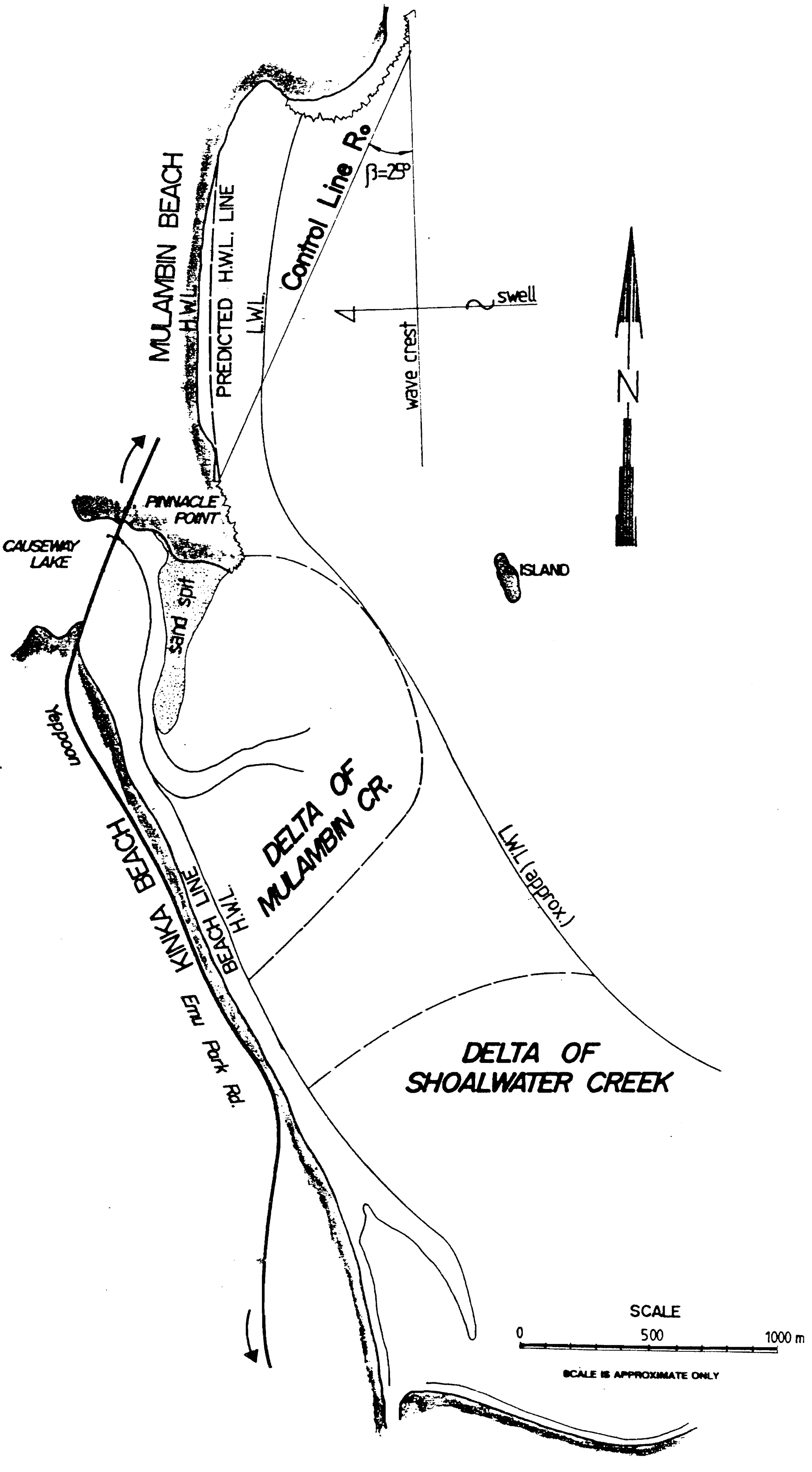

Figure 3

Shape of Mulambin Beach – 1961

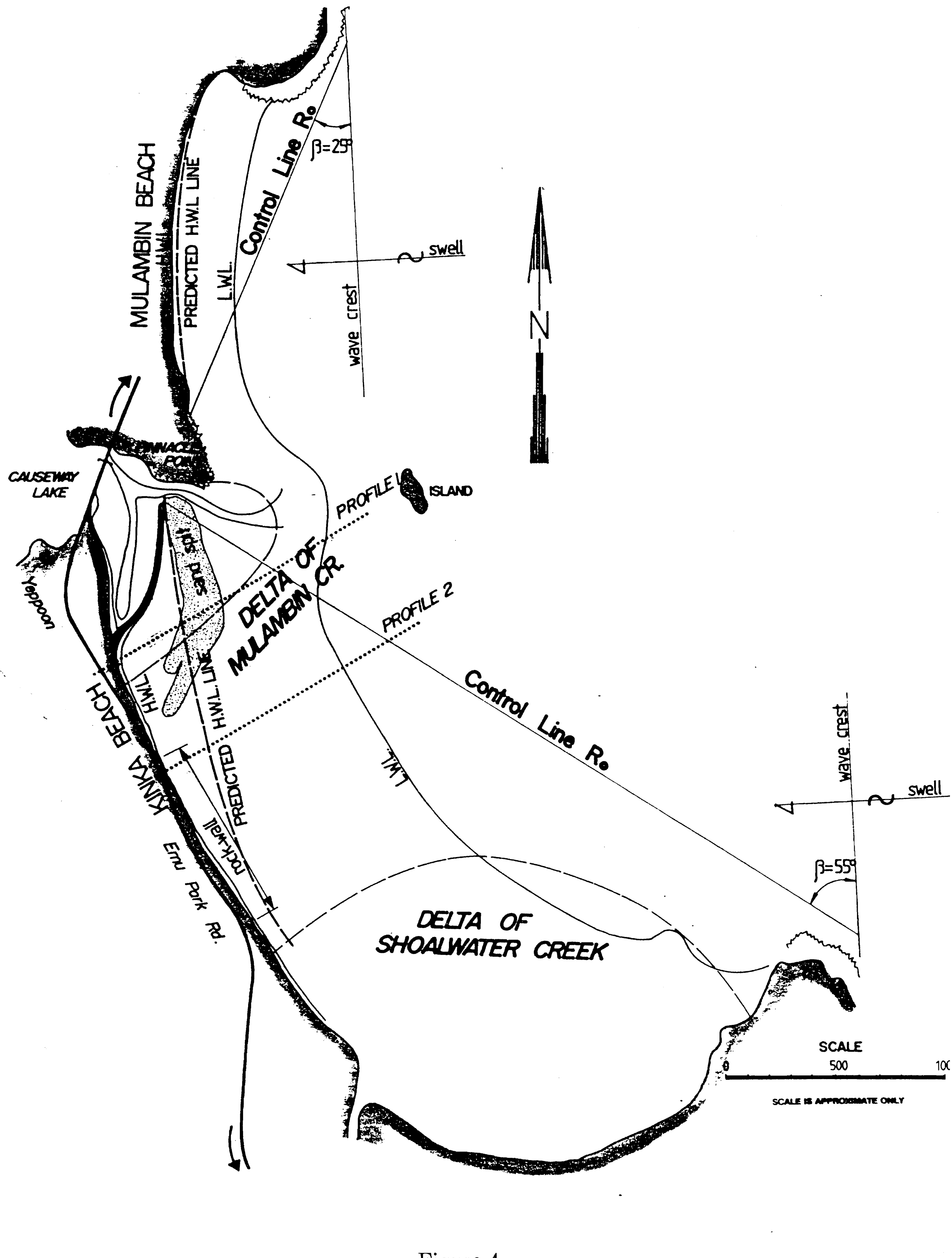

Figure 4

Shape of Mulambin Beach – 1989
and Predicted Future Shape of Kinka Beach

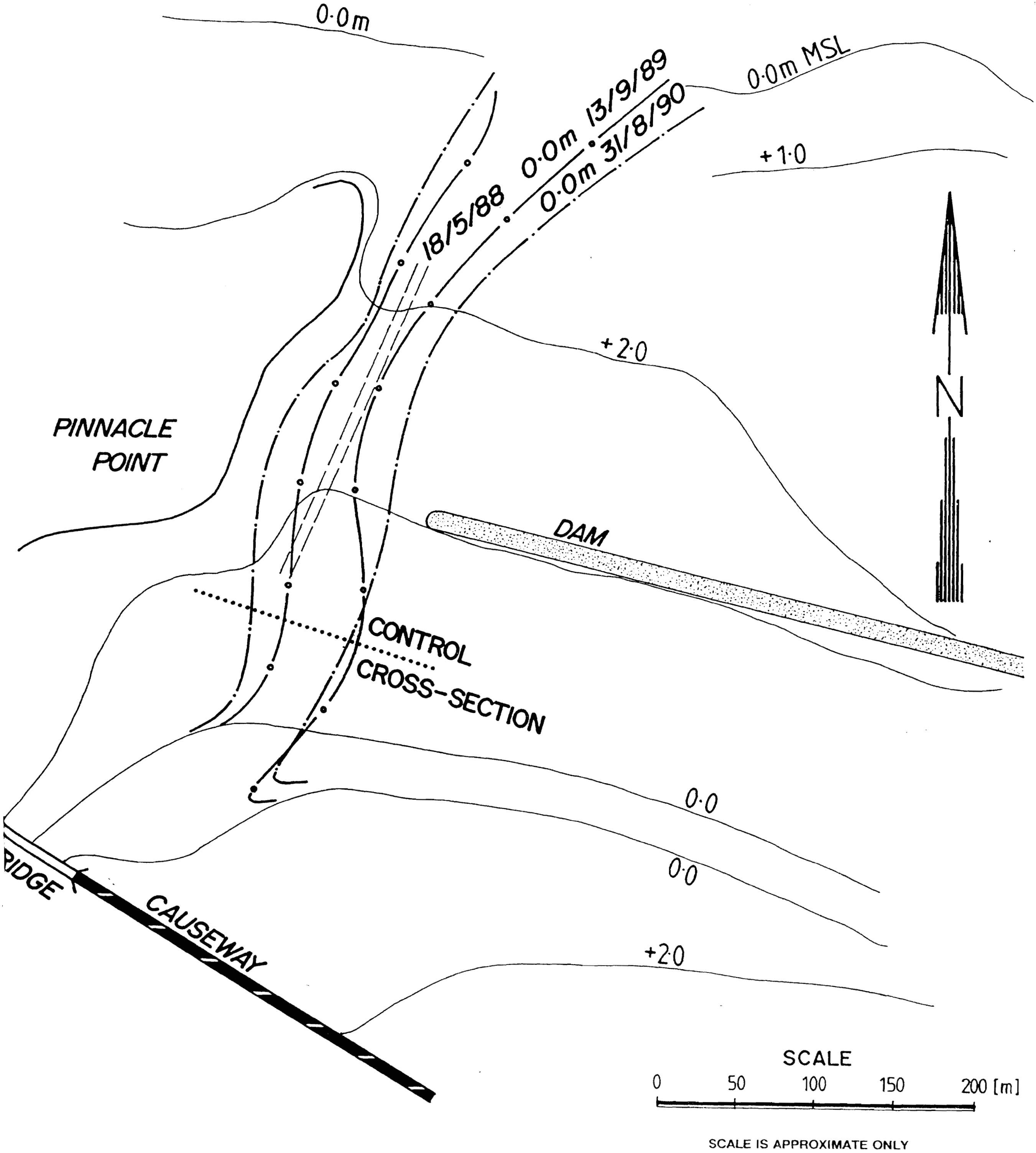

Figure 5

Stability in Plan of the New Channel

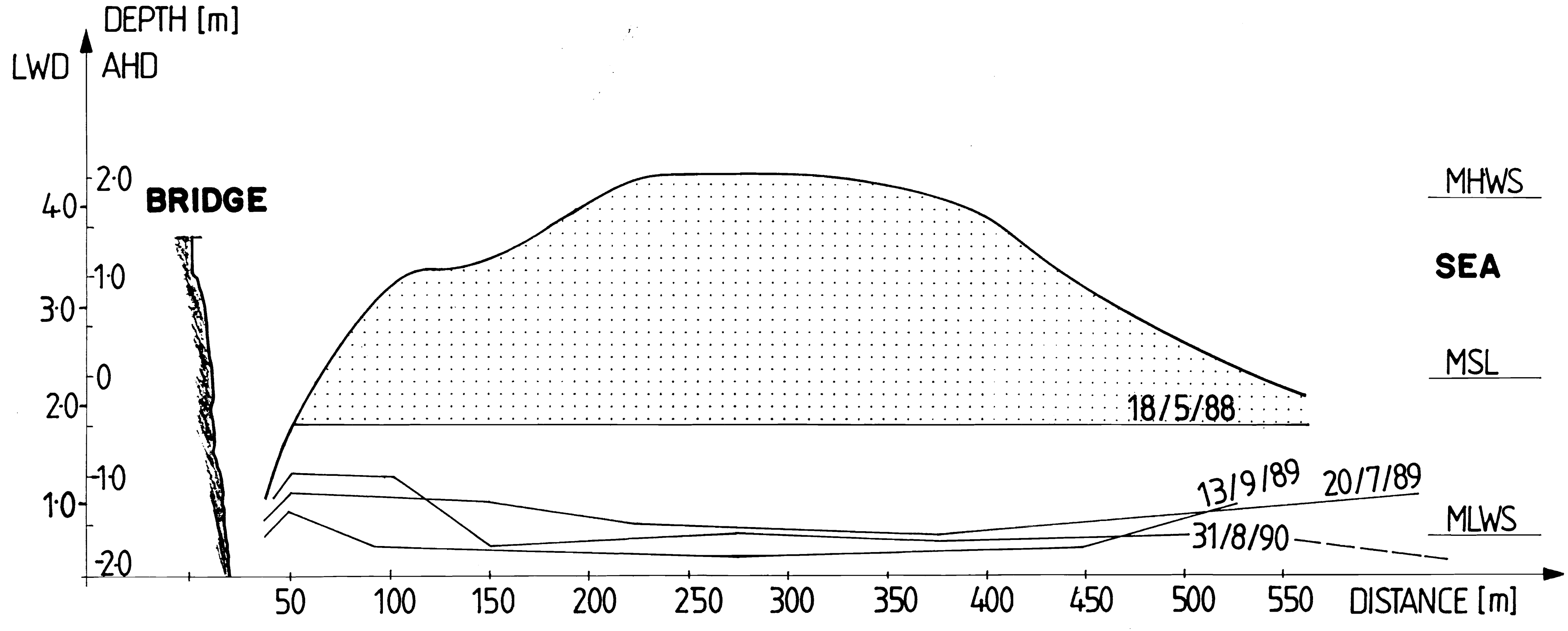

Figure 6
Longitudinal Profile of the New Channel

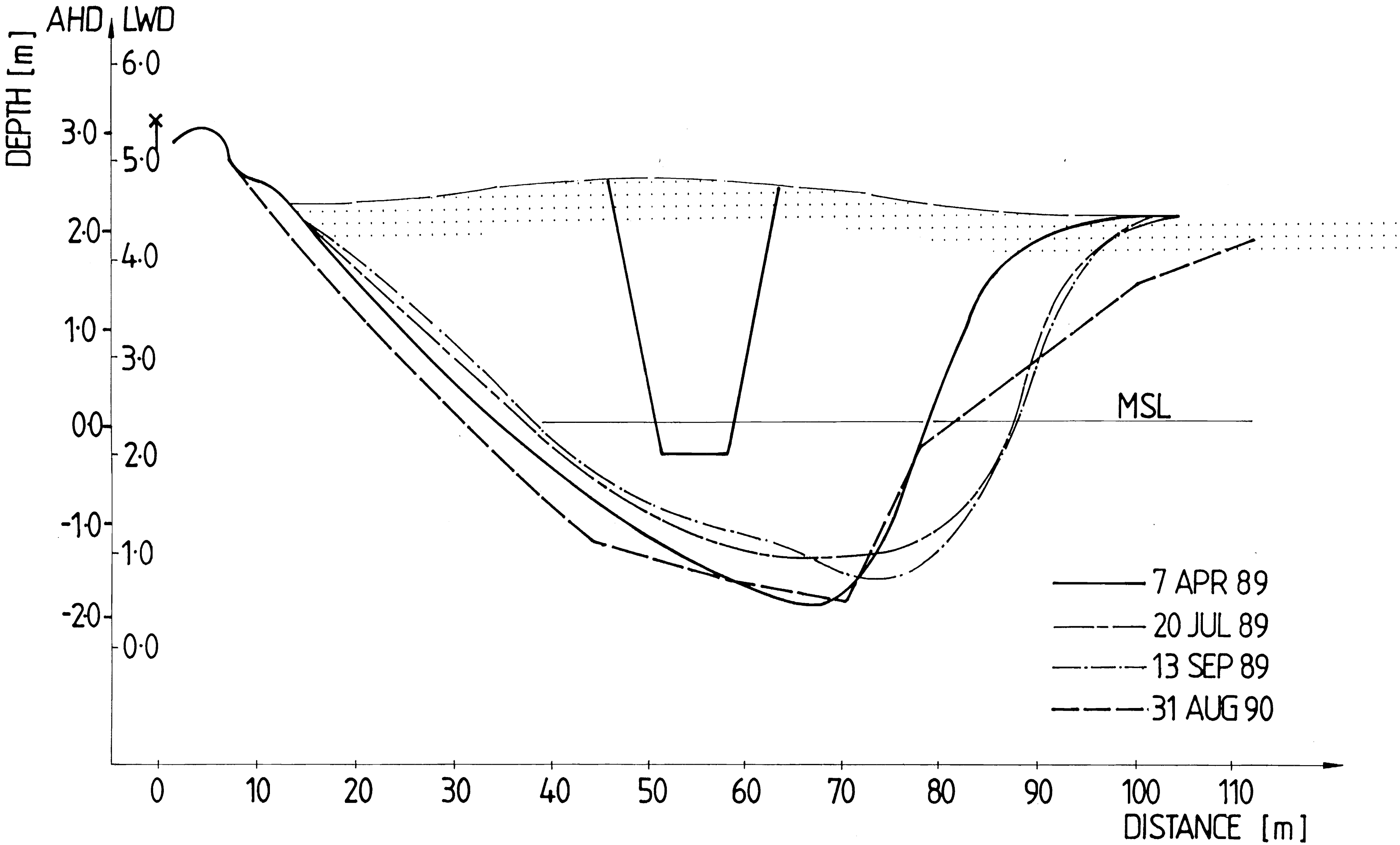

Figure 7

Changes in the Control Cross–Section of the New Channel.

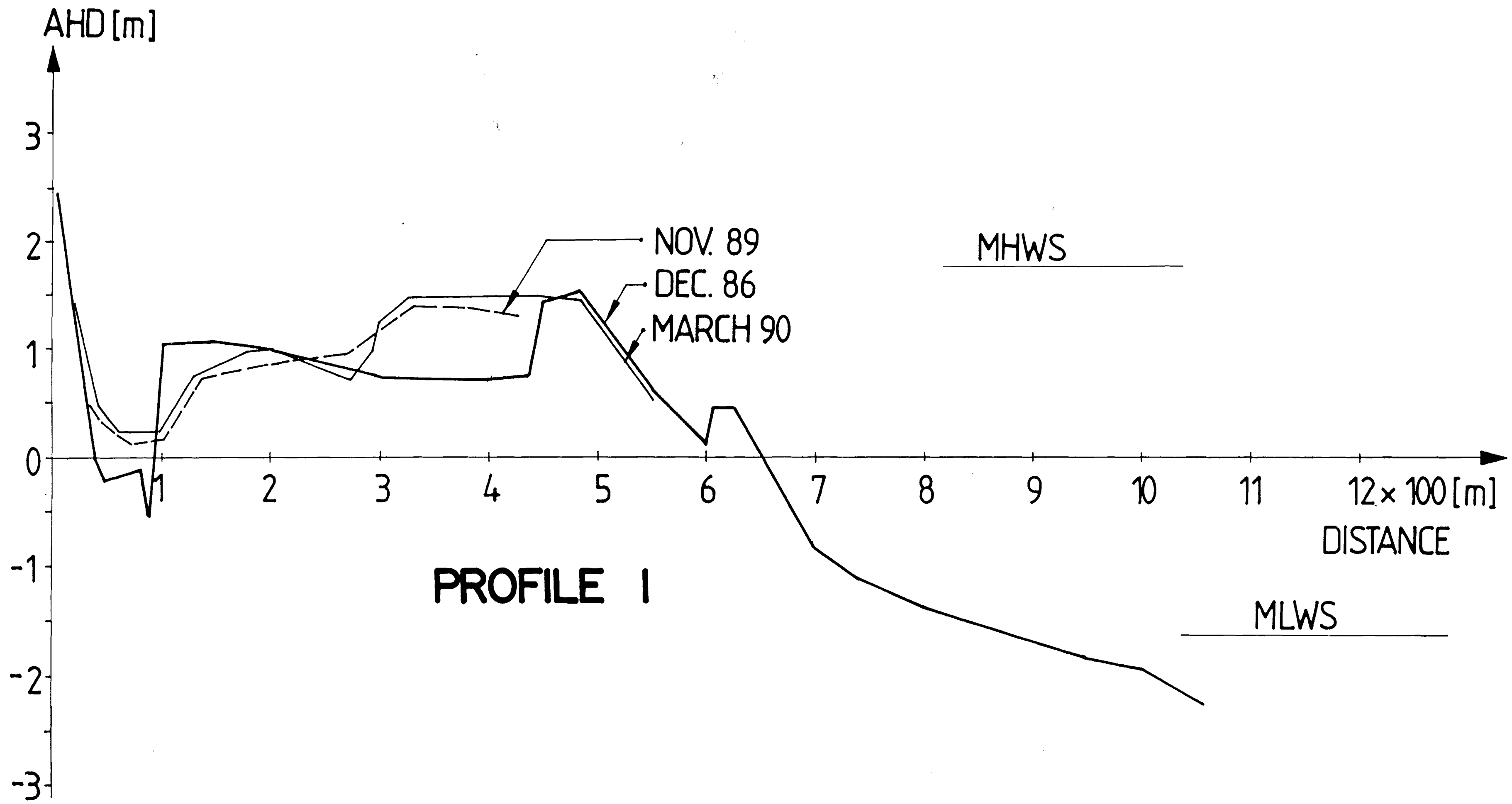

Figure 8

Changes of Kinka Beach along Profile 1

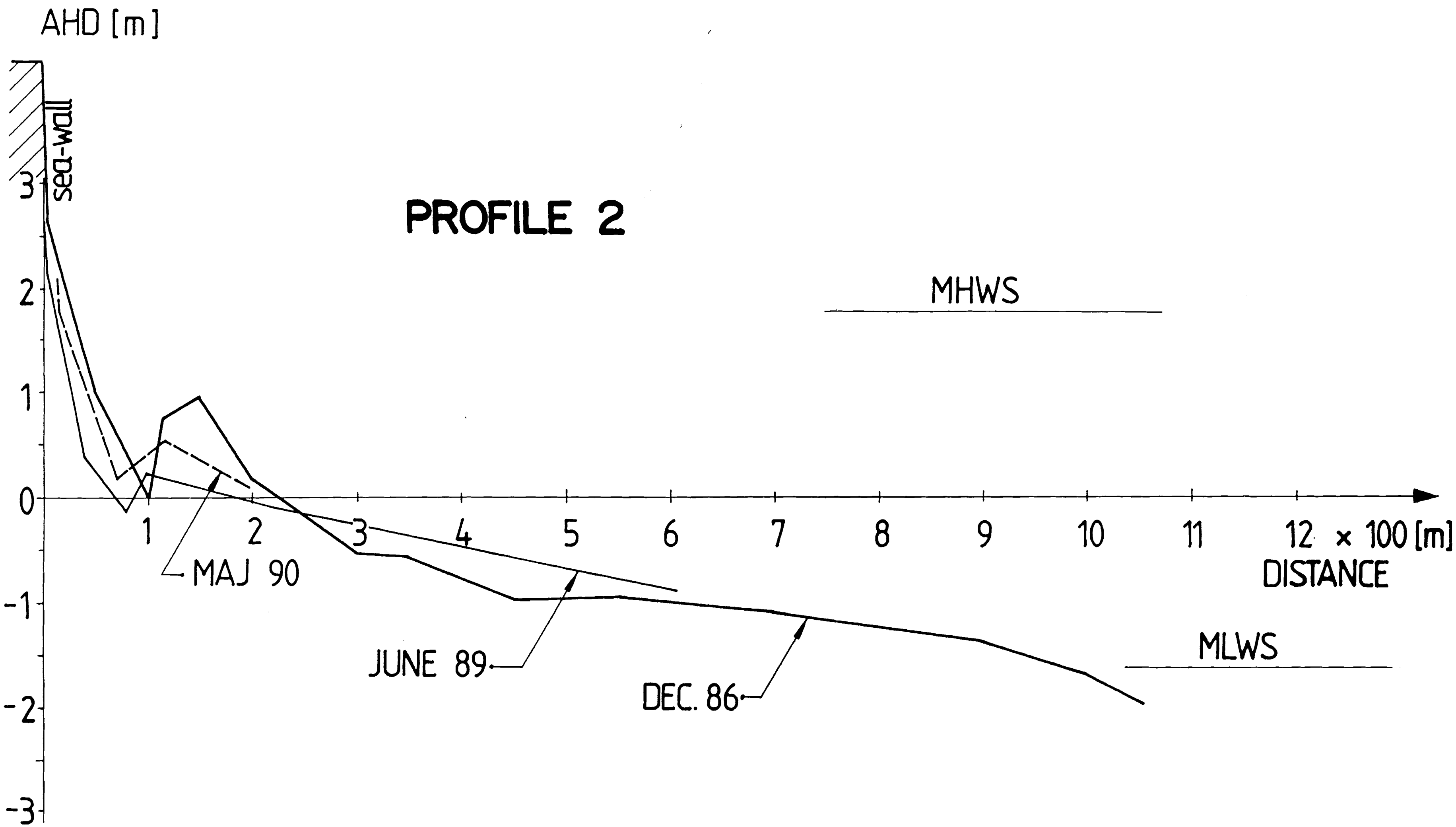

Figure 9

Changes of Kinka Beach along Profile 2