NEARSHORE NOURISHMENT IMPLEMENTATION, MONITORING & MODEL STUDIES OF 1.5M^3 AT KIRRA BEACH

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1.0 INTRODUCTION

Whilst the Gold Coast beaches are generally in long term equilibrium, the southern Gold Coast beaches have suffered serious erosion (approximately 7M m^3) since construction in 1962-1964 of the Tweed River training walls, to the south (updrift) of the Gold Coast (Fig. 1).

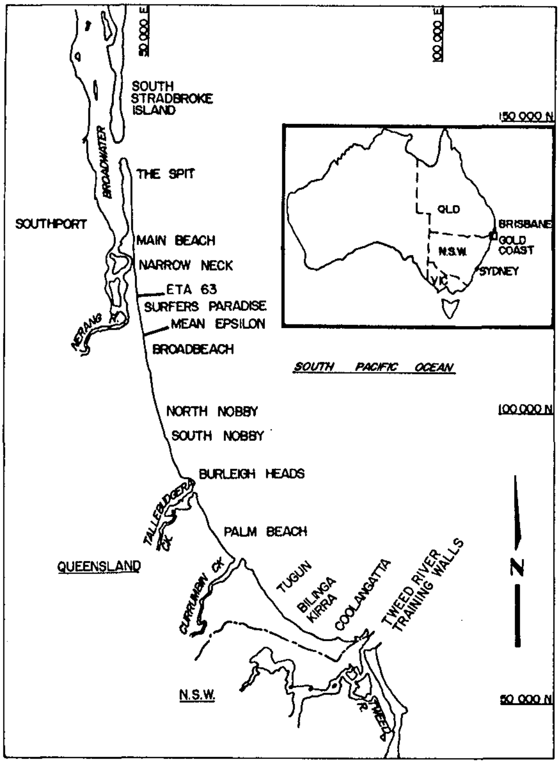

Figure 1.

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Erosion first became evident in the late 1960's and since this time, various restoration works have been implemented:-

1972 Kirra Point groyne to stabilise Coolangatta beach.

1974 Kirra Beach nourished (0.8M m^3) and Miles Street groyne constructed to entrap a beach at South Kirra Surf Life Saving Club.

1983 Investigation into sand transport around Tweed River walls/delta commenced and various options considered due to further erosion as 1974 nourishment was inadequate to cope with ongoing erosion.

1985 A 300m section at North Kirra Surf Life Saving Club nourished (0.315M m^3) and stabilised by a sand-filled groyne.

The 1985 works (Ref. Jackson 1985) were implemented as an interim measure to restore the eroded public beach at the North Kirra Surf Life Saving Club whilst investigations into the sand transport and losses were continued. This nourishment utilised the offshore sand reserves and the work included nearshore and deposition at North Kirra as well as other Gold Coast beaches to evaluate the behaviour of nearshore nourishment (approximately 50% of the cost of pumping onshore). Observation of the natural storm bars which form approximately 500m offshore in 6-8m water depth showed that these natural bars dissipate the storm wave energy and in subsequent milder conditions move back onshore (Ref. Boczar-Karakiewicz & Jackson 1990). The nearshore nourishment trials, whilst limited, indicated that as expected, sand deposited shoreward of 9m water depth generally moved shoreward.

The erosion at the unnourished sections of Kirra continued and further works were planned for winter 1988, again using the offshore sand reserves. Further sand sampling showed adequate sand of suitable quality seaward of the 20m water depth.

As it was considered that nearshore nourishment would be the likely method chosen analytical studies were undertaken by the Water Research Laboratory for the Gold Coast City Council. This was to give a qualitative assessment of the impact on coastal processes of the dredging and nearshore nourishment at various depths and to examine the applicability of the modelling techniques for predicting future nearshore nourishment behaviour and options.

2.0 MODEL STUDIES

2.1 Wave Refraction Studies

Forward ray wave refraction computer modelling techniques were employed to examine the sensitivity of the shoreline wave climate to offshore dredging. The criterion for assessing the impact on the shoreline wave climate was the change in calculated refraction coefficients and wave angles from the initial bathymetric conditions to the post-nourishment condition.

In general, the study demonstrated that dredging in areas seaward of the 20m depth contour is not likely to have any significant effect on shoreline conditions. This was not a totally unexpected result as both the dredged area and the nourishment bar approximately follow the bottom contours.

Typical results for waves approaching from the dominant wave direction are shown in Figure 2.1. Three dredging and placement options were considered and the results expressed in terms of the average change in refraction coefficient K_R and the change in wave angle for sections of coast in the study area. The results showed changes in the wave climate, although these were generally within the order of accuracy of the technique. The study showed that dredging in depths greater than 20m would have negligible effect on the shoreline wave climate. This result was expected as the dredging operation was contour parallel. Placement of material on the nourishment bar resulted in some significant localised changes, but these were more a function of the irregularity in the schematised disposal pattern introduced by the model formulation.

2.2 Sediment Transport Predictions

The monitoring of a previous small scale nourishment at Kirra in 1985 indicated that although there was a rapid smoothing of the individual dump mounds, the deeper sections (to R.L. -10m) of the bar were slow to respond to gross sediment transport forces. The purpose of this study was to attempt to predict the rate of migration shoreward of a nourished bar as a whole in various conditions using a coastal sediment transport model.

The criteria for selection of a model was that it should be cost effective, user friendly and have been originally developed as an interpretive tool. The model chosen was that developed by Perlin and Dean (1983) and subsequently updated by Scheffner and Rosati (1987). This is a shoreline evolution model in which the beach profile is schematised into N contour levels. There are a number of severe limitations, but nevertheless it can assist in assessing sediment transport in some locations.

offshore bars to be modelled correctly. Furthermore, the profile must be schematised to a limited number of stepped changes, for computational reasons.

Profiles of a different shape can be modelled by inputting horizontal contour adjustment distances which represent the difference between the equilibrium profile and the actual profile. Dumped dredge material can only be modelled correctly if the seabed continues to slope down in the offshore direction. An additional limitation is that the model boundaries are fixed; that is, there can be no allowance for longshore transport into or out of the area modelled. The onshore-offshore transport rate is proportional to the bed steepness relative to the equilibrium profile steepness and hence is sensitive to the method of placement of the nourishment.

2.2.1 Schematic Models of Kirra

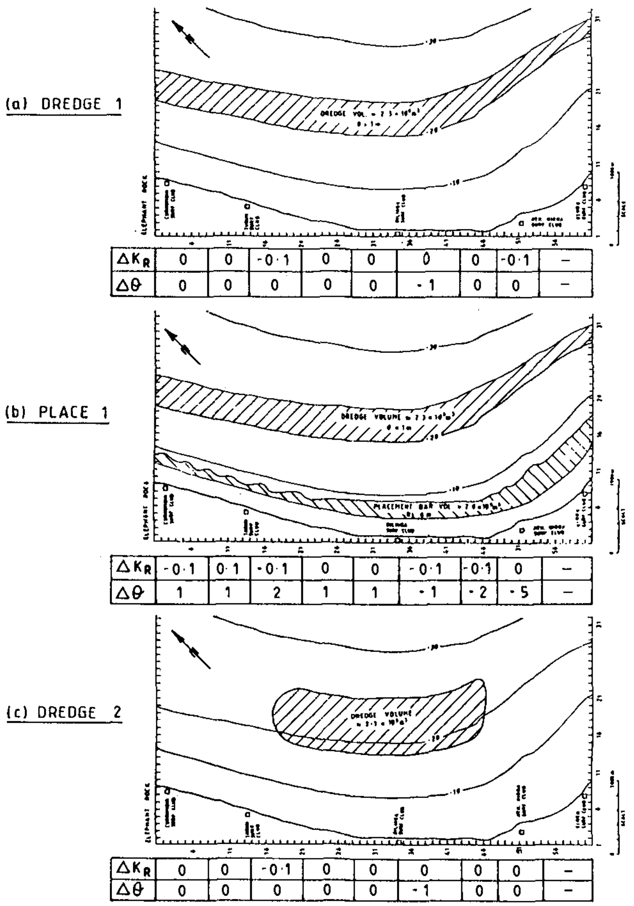
A preliminary assessment of whether this model could be used to predict the response of Kirra beach to dumping of dredged material offshore has been carried out. This was done using schematic beach profiles referred to an equilibrium profile chosen to represent the typical pre-nourished Kirra beach profile as shown in Figure 2.2. Three idealised cases have been examined in this preliminary assessment. They are:

1) Equilibrium beach profiles with dredge material dumped in a V-shaped mound, in 5 to 11m water depth.

2) Equilibrium beach profiles with material added uniformly along the shore to simulate as closely as possible an offshore bar in 3 to 7m water depth.

3) Equilibrium beach profiles with material added uniformly along the shore to simulate as closely as possible an offshore bar in 3 to 7m water depth and dredge dumped material in 6 to 10m water depth.

The equilibrium profile used a Dean coefficient, A, of 0.15 and a grain size of 0.2mm. The beach slope was set to 0.05 up to a berm level of 3m. The computational grid consisted of up to 39 alongshore grid cells at 50m spacing.



(a) DREDGE 1

ΔK_R	0	0	-0·1	0	0	0	0	-0·1	–
$\Delta\theta$	0	0	0	0	0	-1	0	0	–

(b) PLACE 1

ΔK_R	-0·1	0·1	-0·1	0	0	-0·1	-0·1	0	–
$\Delta\theta$	1	1	2	1	1	-1	-2	-5	–

(c) DREDGE 2

ΔK_R	0	0	-0·1	0	0	0	0	0	–
$\Delta\theta$	0	0	0	0	0	-1	0	0	–

NOTE $\Delta K_R = (K_{R(initial)} - K_{R(x)})$ $\Delta\theta = (\theta_{initial} - \theta_{(x)})$ (degrees)

OFFSHORE WAVE DIRECTION: S.E.
OFFSHORE WAVE PERIOD: 14 secs.

Figure 2.1 Change in Shoreline Wave Climate

The Perlin and Dean model is based on the equilibrium beach profile concept. The seabed depth is assumed to increase monotonically in the offshore direction. The relationship used is the Dean equilibrium profile given by

$$h=Ay^{2/3}$$

where n is the water depth, y is the distance offshore and A is a coefficient. This profile does not allow

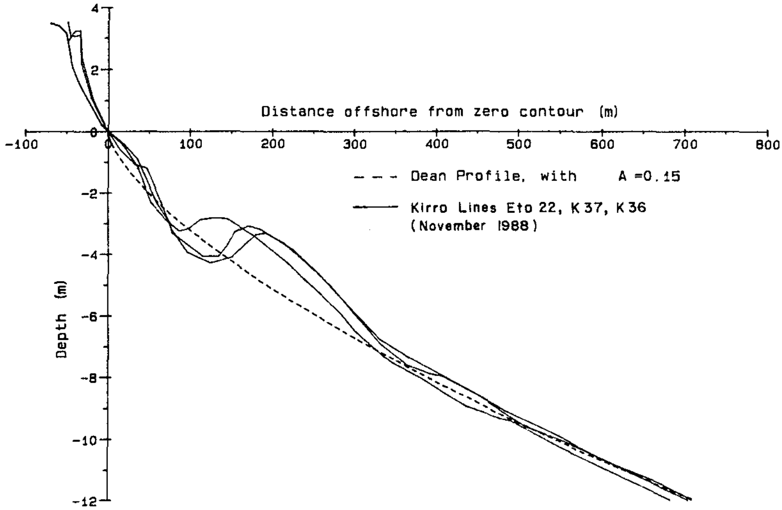


Figure 2.2 Equilibrium Profile Based on Typical Kirra Profiles

1. The rapid smoothing of the individual dredge dumps shown by the survey data was examined by simulating each dump as a V-shaped deposit. This was done by moving the R.L. -7 and R.L. -9m contours offshore as shown in Figure 2.3.

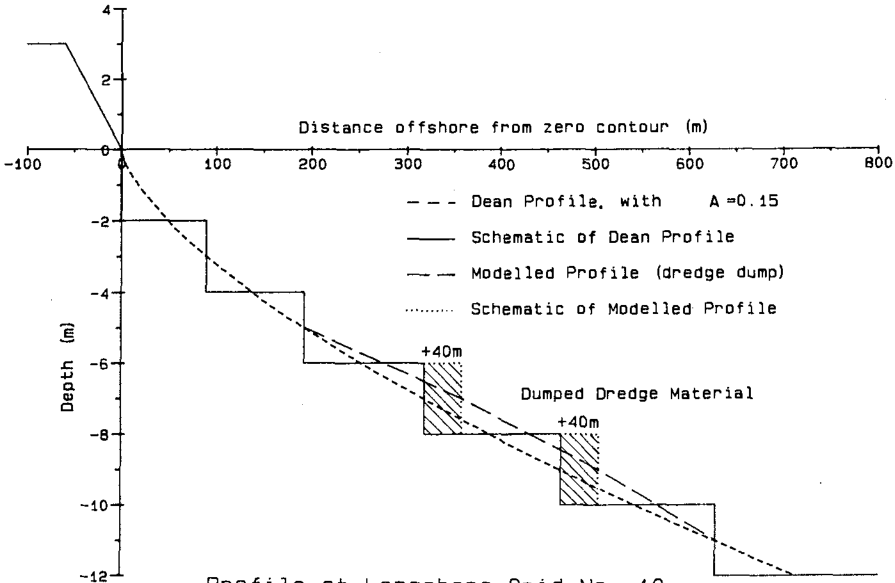


Figure 2.3 Schematic Profile of Individual Dredge Dumps

Running the model with an average annual wave climate caused the V-shaped contours to be smoothed out very rapidly even when the wave climate was mild. Figure 2.4 shows the initial and final contours for the case of a model run for one year using synthesised wave data.

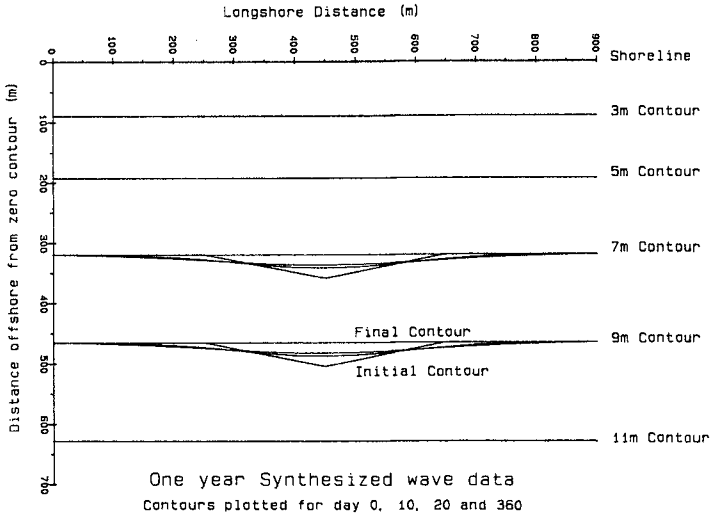


Figure 2.4 Individual Dredge Pump Response

2. Material was then added to the model to simulate as closely as possible a real offshore storm bar. Surveyed beach profile data from Kirra was used for this purpose. Since the offshore depths must increase monotonically with offshore distance, a true bar could not be modelled. However the contours between R.L. 0 to R.L. -7m were adjusted either onshore or offshore by up to 65m to schematically represent the bar.

   The model was run for a period of one year using the synthesised annual wave climate. This resulted in rapid changes to the nearshore areas, but no significant change to contours beyond R.L. -4m. There was no suggestion that with this wave climate the profile as a whole would move towards an equilibrium profile.

3. Having established that the response time was slow for this case, material was added to the storm bar profile to simulate the nourishment bar as shown in Figure 2.5. The equilibrium profile contours were adjusted onshore and offshore by up to 95m to schematise the nourished profile. The model was run using the synthesised wave data as well as specific storm data. The length of the idealised shoreline was varied to test the sensitivity of the model to the chosen grid spacing.

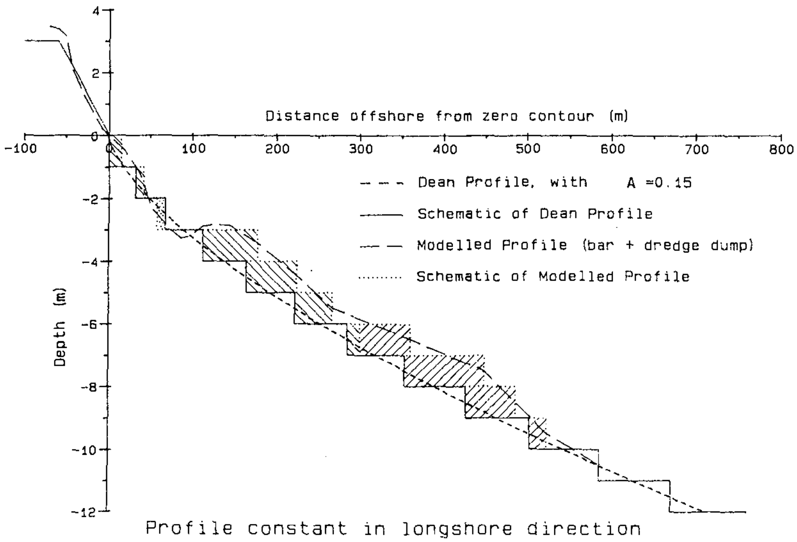


Figure 2.5 Schematic Profile of Nourished Profile

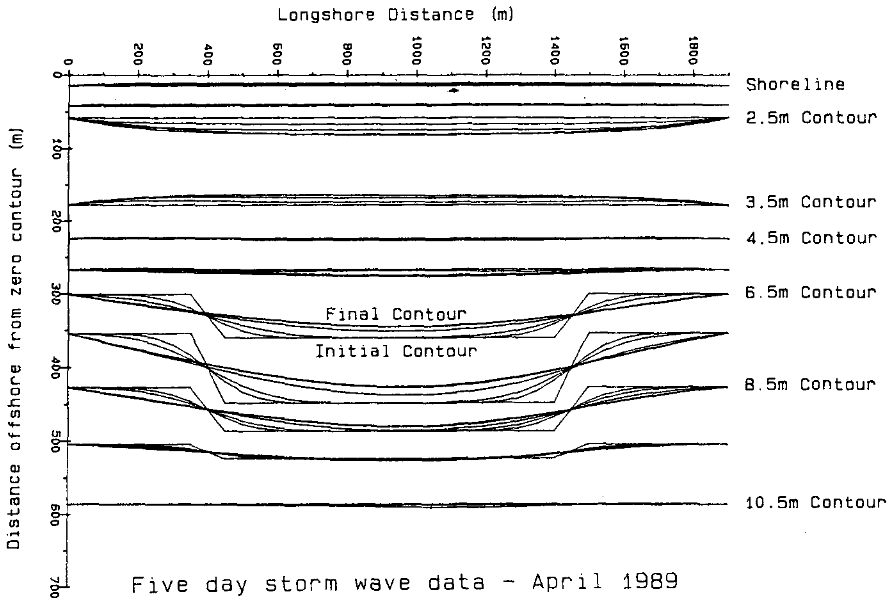


Figure 2.6 Idealised Nourished Bar Response

The results shown in Figure 2.6 were for a storm which occurred in April 1989 some five months after the nourishment. The significant wave height was 5 to 6m for two to three days with wave periods of up to 12 seconds. A section of coastline was idealised as being a straight beach, and a uniformly placed nourishment was as shown by the initial conditions given in Figure 2.6.

The results of this run showed predominantly longshore transport to the north as was expected, given the SSE wave approach direction. It was found that of the material added to represent the nourishment, less than 10% was transported out of the control area. The survey results for the whole of the beach profile suggest that around 30% of the deposition was transported out of the region during the four months between surveys.

3.0 TENDER EVALUATION

Investigations had shown the whole active profile out to approximately R.L. -10m, to be depleted in the area to be nourished. The required quantity in this area was estimated to be approximately 1.5M m^3. The tender documents specified nourishment of the whole profile from the beach to R.L. -10m as the preferred option. However, a range of options of nourishment locations was included. The tender prices were:

a) Nearshore nourishment only: $2.3M (WestHam Dredging) R.L. -6 to -10m)

b) Profile nourishment : $6.8M

c) Onshore nourishment only : $8.3M

It was decided to accept the tender of WestHam Dredging Pty. Ltd. to carry out nearshore nourishment only (Fig. 3.1).

4.0 IMPLEMENTATION

The sand was dredged from seaward of R.L. -20 some 1,500m offshore and deposited between R.L. -6 to 10.5m using the trailing suction hopper dredge "W.H. Resolution" with bottom opening hopper gates to discharge the material. As stand-down conditions applied for H(sig) greater than 1.9m, and to evaluate the behaviour of the nourished bar, a wave rider buoy with a real time analysis system installed on both the dredge and in Council's offices.

The deposition operations involved grounding the bow of the dredge as far shoreward as possible in the deposition area (shoreward of the R.L. -10m contour) and moving shoreward as the load was dumped. This method resulted in discrete mounds being left on the seabed with a crest level of approximately R.L. -6m. In order to verify quantities and the dredging/deposition location, two Council inspectors were stationed on board the dredge.

To optimise deposition placements, the contractor carried out daily surveys over the deposition area using a 43' survey vessel, which provided updated soundings daily to the dredge. The location of each load deposited was also plotted by the Council inspectors on board to verify acceptability of each load location and to provide details of areas filled to the dredge Captain.

Council also carried out regular surveys from the beach to R.L. -12m prior to and during the project. In order to be able to distinguish between individual mounds in the deposition area, these surveys were carried out approximately shore parallel at 10m max. spacing.

Unfortunately, the works were curtailed some 4,000m^3 short of the 1.5M m^3 due to heavy sea conditions and storm conditions were experienced repeatedly for over a year afterwards (Fig. 4.1). This severely restricted accurate surveys of the post-nourishment behaviour and data available for analysis. Despite the storm wave conditions which caused considerable erosion elsewhere and accelerated erosion of the depleted area to the north (downdrift) of the nourishment, significant onshore translation and accretion at the toe of the boulder wall has been measured as a result of the increased offshore wave breaking, decay and refraction over the artificial bar zone. Accretion to form a narrow beach in front of the boulder walls occurred between storms in most of the area nourished (Fig. 4.2).

As the erosion to the north threatened private foreshore properties (the nearshore nourishment was mainly seaward of foreshore fronted by public park), considerable public pressure from the affected residents resulted, and the Queensland Government implemented a scheme to fully restore the southern Gold Coast beaches.

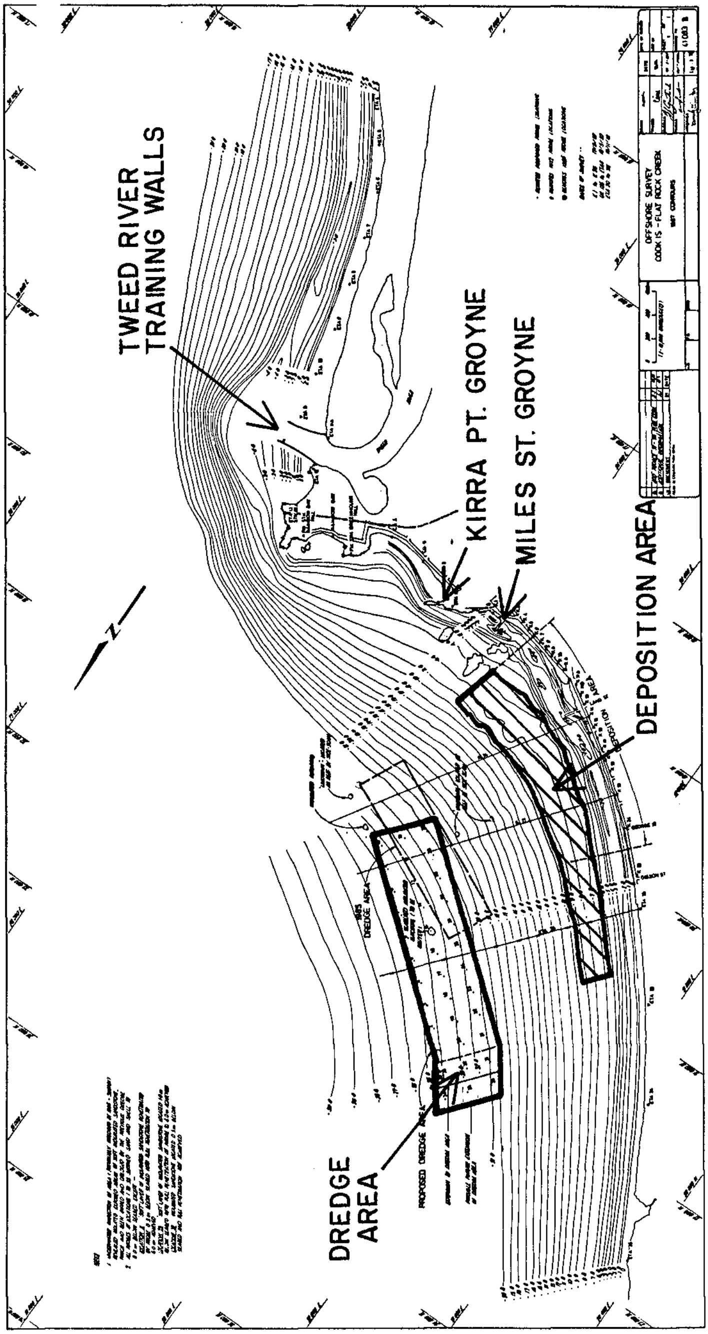


Figure 3.1 Plan of Kirra Nourishment Project (1988)

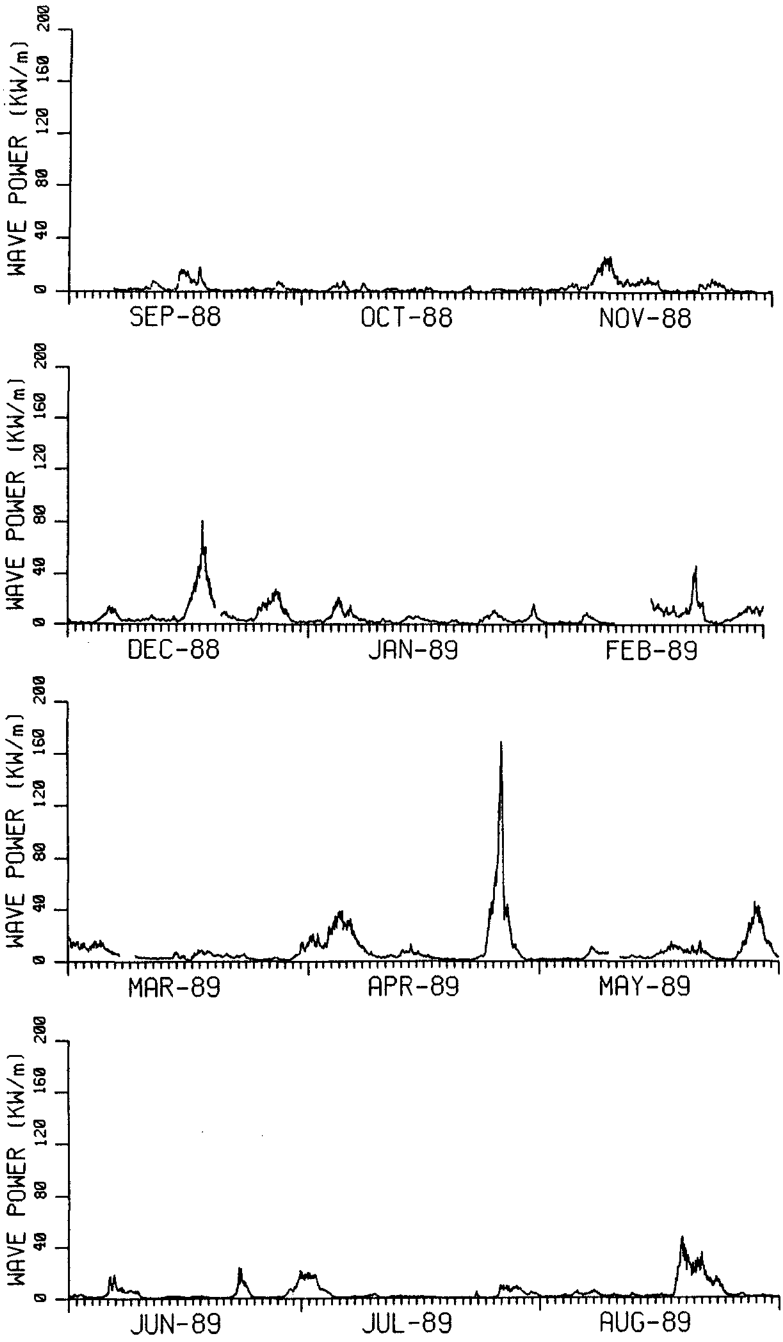


Figure 4.1 Kirra Waverider Buoy Records

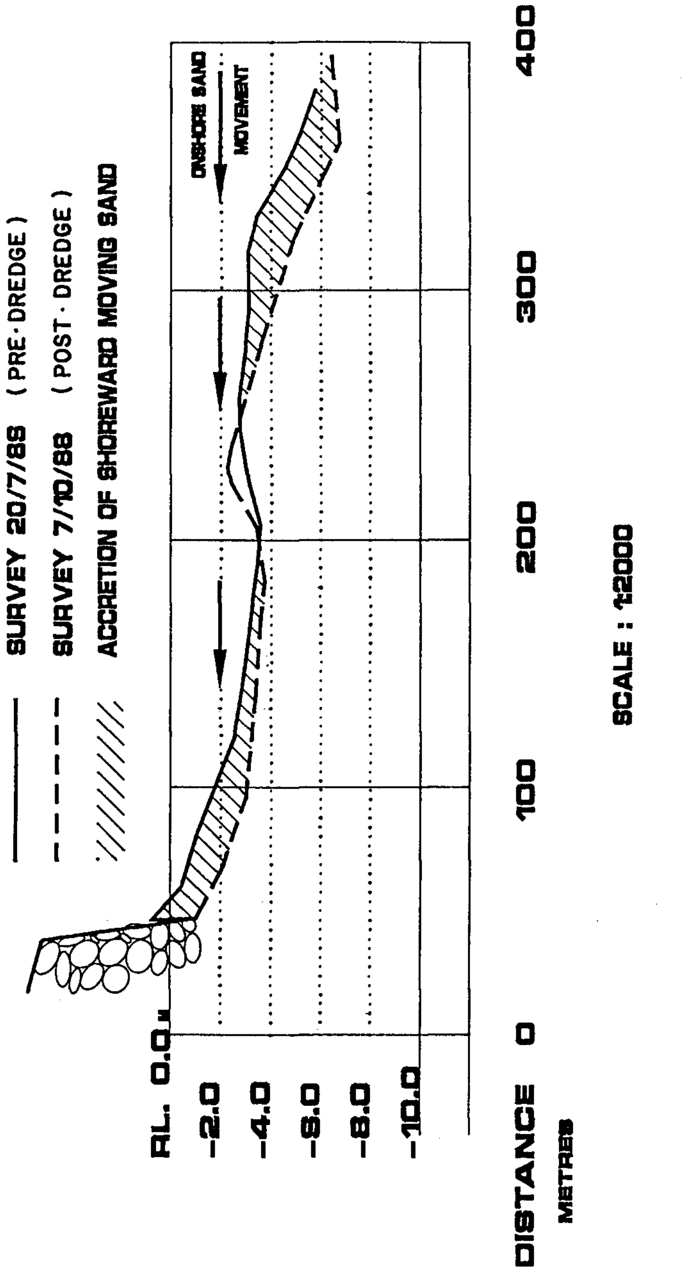


Figure 4.2 Post Nourishment Profile (Typical)

5.0 CONCLUSION

Despite adverse conditions, the works carried out in 1988 appear, as predicted by the model investigations, to have been effective in protecting the foreshore and allowing accretion of a usable beach. The adverse weather conditions and the further works of 3.6M m^3 implemented in November 1989 limited the survey data which could be collected and analysed. The results of the 1988 works are to be further analysed in conjunction with the 1989/90 works which included 400,000m^3 nearshore nourishment.

References

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