GRAVEL BEACH RENOURISHMENT: AMBERLEY BEACH, CANTERBURY, NEW ZEALAND

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Abstract: Amberley Beach is a small settlement located behind a low mixed sand and gravel beach ridge at the northern end of Pegasus Bay, Canterbury. Over the last fifty years the beach changed from accretionary to erosional due to a lack of gravel sized sediment supply. Sediment losses and ridge height reductions resulted in the settlement being inundated and evacuated during a coastal storm in 1992. As a result the local community constructed a beach renourishment along 250 m of the settlement beach frontage. The purpose of this renourishment was to raise the elevation of the beach and reduce the threat of erosion to property. This measure has worked well and prevented any further inundation of this part of the settlement. However, continued erosion and lowering of the beach ridge height along the remainder of the settlement's coastal frontage resulted in the community in 2002 lobbying the District Council to undertake further coastal protection works. Following consultation on the possible options and funding issues it was decided by the community that the best solution was to undertake a further renourishment. The design involved importing of 8,000 m^3 of gravels to raise the beach crest elevation by up to 1 m over a 1.1 km length of beach in front of the settlement. A local gravel extraction company made available to the community the required material at a subsidised rate. Resource consent, required under the Regional Coastal Environment Plan, were lodged in 2002 and granted in early 2003. The construction of the renourishment is scheduled for July 2003, followed by re-vegetation by the community.

Keywords: Gravel, Renourishment, Amberley, Canterbury,

INTRODUCTION

Amberley Beach Settlement is a small coastal community located at the northern end of Pegasus Bay, between the mouths of the Kowai and Waipara Rivers, North Canterbury (Figure 1). The settlement comprises of a mixture of holiday baches and permanent residences, with total assets valued at a minimum of $8.4 million. The dwellings, along with public roads and a golf course located 1 km north of the settlement are located immediately behind the beach ridge on a low lying coastal plain comprised of former beach ridges and swales, which was laid down in the last 6500 years. The beach is narrow, being only in the order of 50 m from the landward toe to the msl contour, and the ridge elevation is low, being only 4-5m above msl.

The beach is an open, high energy coast composed of mixed sand and gravel sediments, being classified as *sandy Gravel* with mean grain size of 2 mm in the swash zone and 5.5 mm on the upper foreshore. While this sediment size is not typical of Pegasus Bay, which is predominantly comprised of sand beaches, it is typical of beaches found along much of the Canterbury coast. The contemporary source of gravel on these beaches is from local gravel bearing rivers, however much of the beach deposit is considered to be relic deposits from a period of higher fluvial activity. Current gravel input from the nearby Waipara River is considered to be only in the order of 14,000 m^3/yr (Hicks, 1998).

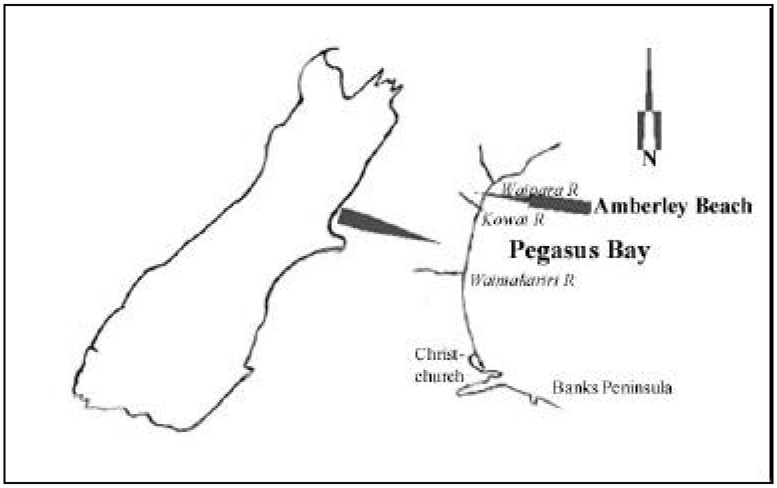

Figure 1. Location of Amberley Beach

The beach environment is used for a variety of recreational activities including walking, jogging, fishing, swimming, and 'off-roading' by motorbikes and four wheel drive vehicles. A public carpark is located on the beach ridge and backshore at the south end of Chamberlain Ave. This carpark is 125m long and comprised of compacted clay fill placed over the beach material. At the northern end of the settlement is a small coastal lagoon, which is drained by twin pipe culverts through the beach. However, due to the nature of the beach, these culverts are often blocked and require manual clearance on a 3-5 year basis to alleviate potential flooding.

Issues

During a coastal storm in August 1992 large volumes of seawater overtopped the beach ridge at the Amberley Beach Settlement resulting in several houses being inundated and the settlement being evacuated by Civil Defence. This was the first time that beach overtopping and inundation had been recorded at this location, which had been considered to be a state of long-term accretion and not prone to coastal hazards. Investigations following the August 1992 storm event revealed that the beach had possibility reverted to a long-term erosional state with associated beach volume losses and assumed reductions in beach ridge elevations. The effects of two previous storms in April and May were also considered to have significantly weakened the beach state prior to the August storm.

Public concern over the inundation resulted in a number of public meetings on the cause and possible solution to the problem. As a result the community decided in early 1993 to undertake a small-scale renourishment of 250 m of beach and to fence the beach to exclude vehicle access. While these measures appeared to be successful with no further inundation occurring at this location, the remainder of the settlement's beach frontage continued to suffer erosion, particular in storms during 2001 and 2002, the most recent of which also resulted in some beach overtopping. While no houses were inundated, there was damage to roading and loss beach vegetation. The existing renourishment also suffered erosion, and was in need of injections of additional sediment to retain its ability to provide adequate protection from inundation. Again there was concern from residents at the coastal hazards facing the settlement, resulting in renewed calls for coastal protection works to prevent both erosion and inundation.

SHORELINE CHANGES

Worthington (1991) reported that Amberley Beach accreted 41 m from 1862 to 1988 at an average rate of 0.32 m/yr. However, a break down of this 126 year period as part of the investigations for the initial 1993 renourishment indicated that the rate of shoreline advance had slowed down since at least 1950, and that the beach had possibility reverted to an erosional phase since the late 1960's. These trends are shown in Table 1.

Table 1. Amberley Beach Shoreline Movements: 1862-1988

Period	Years	Net Change (m)	Change Rate (m/yr)
1862-1950	88	+40.6	+0.46
1950-1968	18	+3.5	+0.19
1968-1988	20	-3.9	-0.20

A similar trend of decreasing accretion rates since the 1950's was also found at Leithfield and Waikuku Beach settlements nearer to the centre of Pegasus Bay, however these beaches had not converted to erosional in the 1970's and 1980's.

Changes in shoreline position determined from annual beach profile surveys since 1991 show that Amberley Beach has continued to erode over the last decade, with the rate of retreat being in the order of –1.0 m/yr, a five fold increase in the rate of retreat from the previous 20 year period. The beach profile data also revealed that beach volumes have decreased over the last 10 years, with the average rate of loss above msl at the Golf Club being –6.5 m^3/m/yr, and a total loss of 35% of the initial 1991 survey volume. Beach profile surveys following the 2002 storms showed that beach ridge elevations along the un-nourished part of the settlement beach were only an average of 4.2 m above msl, and at the northern end were generally less than 4 m above msl. Based on past experience and run-up modelling these elevations were considered inadequate to provide protection against future wave overtopping and inundation of the settlement.

The future prognosis for Amberley Beach is that it will continue to retreat and that storm events are likely to become more damaging as sediment volumes decrease. Long-term accelerated sea level rise associated with global climatic warming is also likely to further increase the erosion rate, with the estimated additional increase over the next 50 years being in the order of -0.4 m/yr, resulting in net erosion rates of up to -1.5 m/yr. This compares well with the results of Hicks (1993), who from shoreline modelling of a combination of the possible climate change scenarios predicted a shoreline retreat of around 70 m at Amberley Beach by the year 2040.

The 1993 Renourishment

The majority inundation in the August 1992 storm occurred on the south side of the beachfront carpark. In this area the storm resulted in ridge crest retreat of 5 m, volume losses above msl of 13 m^3/m (11% of pre storm total), and post storm ridge elevations were only 4-4.5 m above msl. The resulting renourishment involved placing 4,800 m3 of gravel, obtained from a nearby pit, as a crest cap on the back of the post storm ridge crest over a 250 m to raise the ridge height to 5 m above msl. This renourishment was a private work, with the material being supplied, transported and placed on the beach free of charge by a local contractor, and post renourishment planting being undertaken by the residents. No resource consents were required under the Resource Management Act (RMA, 1991) as the placement of all material was above MHWS, and the Canterbury Regional Coastal Environment Plan (RCEP) had not been notified at this time.

The placement of the renourishment material behind the existing crest was considered to be more effective at retaining sediment than placement on the crest, as the new material would only be worked during storm events, and hence would require less initial maintenance. As a result, the position of the beach crest was relocated from 1-6m landward of its post storm position. In association with this, the back-slope of the renourished beach was re-graded to a stable slope of 1:8. The pre and post renourishment profiles are shown in Figure 2 along with profiles from an un-nourished site at the Golf Club. A comparison between the two sites shows the success of the renourishment at slowing down the crest retreat, however the ongoing retreat of the lower foreshore and need for the additional of further material is also clearly evident.

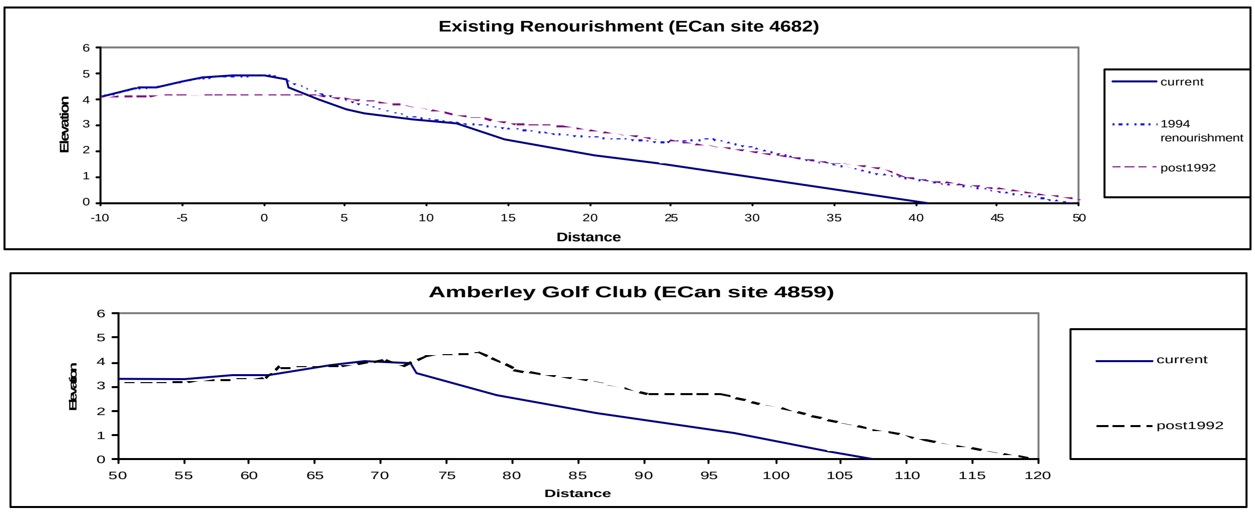

Figure 2: Comparison of profiles at 1993 renourishment and Un-nourished beach

POSSIBLE SOLUTIONS

The possible solutions to deal with the threat of erosion and inundation at Amberley had to meet the following criteria:

- Meet the perceptions of the beach settlement community in providing adequate protection. The do-nothing option was not considered a legitimate option by the beach settlement community.
- Meet the requirements of the RMA, the New Zealand Coastal Policy Statements (NZCPS), and the RCEP to avoid, remedy, or mitigate any adverse effects of the proposed protection option.
- Be affordable to the local beach community as the Hurunui District Council (HDC) had deemed that general council rates or reserves could not be used to fund protection works which were only of local benefit, and regional or central government subsidies for coastal protection works are not available. A council controlled discretionary fund for use in the Beach Settlement, which dated from when the settlement was free-holded, was available to fund the works. This fund totaled around $70,000.

A summary of potential protection options and the issues associated with each one were presented to the beach settlement community at a public meeting.

Renourishment option

The principle of beach renourishment on gravel beaches is to use sediment of similar or slightly coarser grain size than the native material to add volume and height to the ridge crest of the beach. This technique has been used in a previous gravel beach renourishment in Canterbury (Kirk & Weaver 1985). The use of this sized material and the establishment of stable upper foreshore and backshore slopes and profile shapes will result in a slower erosion rate, and the additional height will reduce the threat of wave overtopping. The advantages of a renourishment option included that there would not be any local increases in erosion as a result of the structure through wave reflection, refraction or sediment starvation, the natural erosion of the renourishment provides material to the down drift coast, and that the end result was a beach, therefore natural character and amenity values under the RMA are satisfied.

The major disadvantage of renourishment were finding a local supply of suitable sized material so that costs were minimised, and that there would need be a regular on-going supply of additional material to offset natural losses and maintain the desired level of the protection. In this regard, the project was fortunate that Christchurch Ready Mix Ltd, a concrete firm who operate a gravel extraction pit within 1 km of Amberley Beach, offered the use of their screened tailings for use in the renourishment at cost of excavation and transport (approximately $3/m compared to commercial rates of $10/m). In 2002 the tailings stockpile included 19,000 m^3 of material in the size range 6-40 mm, and with Ready Mix holding a 35 year consent to mine the pit, there was considered to be ample material meet both the initial and on-going requirements of the renourishment.

Hard engineering options

The hard engineering options considered included a rock revetment, a concrete seawall and an artificial offshore reef. The revetment and seawall options were rejected due to the potential adverse effects of increased foreshore volume losses in front of the structure, increased erosion at the end of the structure resulting in possible outflanking of the structure, and loss of natural character and amenity values of the beach. These options were also rejected on the grounds of cost compared to the renourishment option. While an artificial offshore reef was not considered to have the same potential adverse effects, it was also considered too expensive for the local beach community.

RENOURISHMENT DESIGN CONSIDERATIONS

Once the beach settlement community decided that beach renourishment was the most cost effective and environmentally friendly protection option to pursue, various design options for the renourishment were considered. These included the following for the un-nourished part of the beach frontage:

- Increasing ridge crest elevation up to a height of 5m above msl, with foreshore slopes in the order 1:4, a 2 m crest cap, and backshore slopes in the order 1:7. All material to be placed landward of bottom the existing erosion scarp, which is generally above the 3.5 contour, hence the new crest position will be on average 4-5 m landward of the top of the existing erosion scarp. The total volume required was estimated to be around 6100 m^3 over 700 m length.

- Raising the height of the crest cap to 5.5 m above msl to offer additional protection from wave overtopping and inundation. This would have required an initial renourishment input of around 10,700 m^3 for the 700 m length.
- Locating the renourishment 5 m further seaward such that the crest cap position was the same as the top of the existing erosion scarp. This would have required an initial renourishment input of around 10,000 m^3 for the 700 m length, and a higher on-going maintenance requirement.

For cost reasons the community chose the first design option. Representative profiles of this option compared to be existing beach are shown in Figure 3.

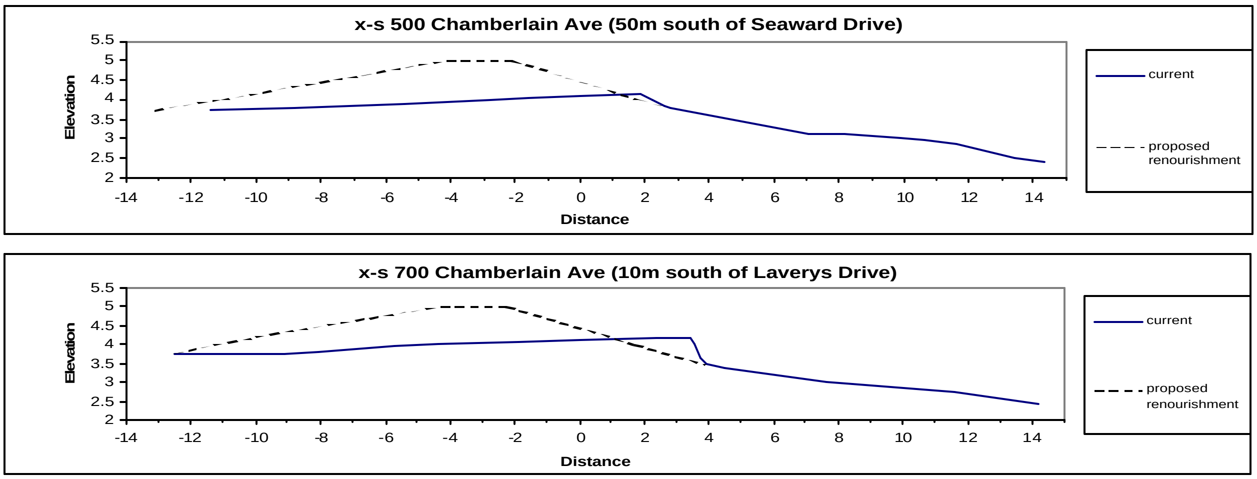

Figure3: Proposed renourishment design compared to existing un-nourished beach

For the maintenance of the existing renourishment, which as shown by the profile in Figure 2 has retained its original elevation, it was decided that all additional material be placed to re-establish the original 1:4 upper foreshore slope and not to disturb the existing established vegetation located on the crest cap and backshore. This would involve the placement of around 600 m^3 of material over a 250 m length, with all material be placed above the 3 m contour, hence only being acted on by wave run-up in storm events. As for the un-nourished part of the beach, the alternative design of increasing the crest elevation to 5.5 m was not considered justified.

For the carpark section, the compacted nature of the material presents a largely impermeable barrier to wave run-up, resulting in less dissipation and more reflection of wave energy back on to the foreshore, hence increased foreshore erosion and scour of the toe of the car park. The erosion of this fine sized material from the car park and placement on the foreshore further compounds the problem by filling the pore spaces in the beach, therefore reducing permeability, resulting in increased run-up and frequency of wave attack on the car park. It was considered that the best way to address the issues at this stretch of beach is to first remove the fill material from the front of carpark and replace with imported beach gravels to form an appropriate beach profile. This would involve the removal of around 700 m^3 of fill material and the replacement with around 900 m^3 of imported gravels to form beach profiles with 1:4 front slope, 2 m wide crest cap at an elevation of 5 m AMSL, and a back slope of 1:8 down to the 4 m contour. This profile will result in the front of the new crest cap being located an average of 2.4 m landward of the existing scarp top as surveyed in August 2002 with an average gravel depth of 1 m at this location. The placement of all material would be above the 3 m contour and new material would only extend an average of 2.6 m and a maximum of 5 m seaward of the bottom of the existing scarp. Representative profiles of this design compared to be existing carpark profiles are shown in Figure 4. As with the other sections of the beach, the alternative design of increasing the crest elevation to 5.5 m was not considered justified. A small car park is to be re-established landward of the beach profile.

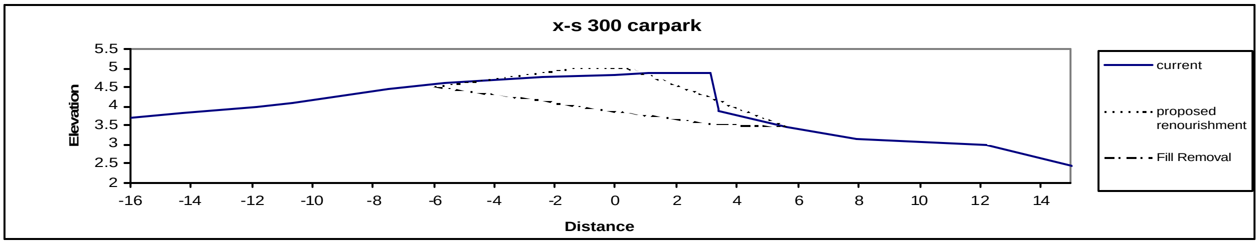

Figure 4: Renourishment design at existing beach ridge carpark

The total volume required for the preferred design was estimated to be in the order of 7,600 m^3, with the estimated costs of obtaining the necessary resource consents, placing this volume of material, the purchase of appropriate plants for re-vegetation being in the order of $50,000. Since this was less than the value of the council discretionary fund available to the beach settlement community, hence was seem to be the most desirable option by the local community.

Maintenance Requirements

Based on past erosion and future projections, the volume required to maintain the renourishment is estimated to be in the order of $1m^3$/m per year. Hence over the 1100 m length of the renourishment, annual requirements will be in the order of 1100 m^3. However, whether these losses occur in any one year will be dependent on the frequency and magnitude of coastal storms within the year. It is considered that it is not practical or economical to undertake maintenance on an annual basis, therefore it is proposed that renourishment be undertaken on a 3-5 years basis, which would involve the placement of 3500 m^3 to 6000 m^3 each time. The community decided that the funding for this on-going maintenance should come from a special rate on the properties owners of the settlement, with the amount required per property being in the order of $35-$40 a year.

RESOURCE CONSENT PROCESS

Although the renourishment was to be located above MHWS, a resource consent was required under the Canterbury RCEP as the location within a coastal hazard zone, and the activity would affect the magnitude of coastal hazards. For reasons of time and costs, the local community was very keen to that project proceed as a non-notified application, hence avoiding the need of a potentially expense and time consuming heard and potential appeals. For this to occur, the application had too satisfy the dual criteria, that all adverse effects of the proposed activity would be no more than minor, and that all potentially affected parties had given their written approval.

In assessing the potential effects, the majority were found to be positive, natural character and amenity values would not be compromised, with the only adverse effects considered to be minor and short-term during construction. A summary of the proposed renourishment was circuited to all landowners at

Amberley Beach together with forms for the Written Approval of Persons Likely to be Aversely Affected. Of the 105 rateable properties at Amberley Beach, Affected Parties forms were returned from 70. Only two returns expressed opposition to the proposal, and this was on funding issues not the need for, or design of the renourishment. Meetings were held with members of the local Runanga (who was also an adjoining landowner) and the Department of Conservation to discuss the proposal. Both of these groups supported the use and design of the renourishment, and gave their written approval to the proposal.

The consent application was lodged with the regional council (ECan) on December 2002, was considered appropriate to be treated as a non-notified application, and was duly granted in February 2003. The term of the consent was for 20 years, with the conditions mirrored those proposed in the application, being for design, construction, access, planting, monitoring and maintenance. Monitoring requirements include four beach profiles through the renourishment, to be surveyed immediately following construction and annually thereafter for the term of the consent.

CONCLUSION

The Amberley Beach renourishment is seen as a good example of what can be achieved with positive local community involvement in the decision making for coastal protection works. At the time of writing, the community eagerly await construction of the renourishment, which is planned for July 2003, followed by a community beach re-planting programme.

The 20 year term of the consent for the renourishment together with the rating arrangements for maintenance requirements, gives the current and future landowners some guarantee that the quality of protection from coastal hazards will not be compromised within this time. Following this, the community will again have to decide what level of protection they want and how they may pay for it. By this time, knowledge of climate change, sea level and their associated effects on coastline stability is likely to be considerably advanced, which may change the outcome of the decision.

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KEYWORDS
Gravel, Renourishment, Amberley, Canterbury,