Harbour and Coastal

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WOODBROOK LANDFILL
COAST PROTECTION

APPENDIX J – COASTAL PROCESSES MODELLING REPORT

FOR

DÚN LAOGHAIRE-RATHDOWN COUNTY COUNCIL

dlr
Comhairle Contae County Council

DOCUMENT CONTROL SHEET

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This Document Comprises of:	**DCS**	**TOC**	**Text**	**Tables**	**Figures**	**Appendices**
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Introduction

The purpose of numerical modelling of coastal processes in relation to the proposed works at Woodbrook would be to assist in assessing potential impacts of the proposed works on coastal processes. The concern would be that the works might have a significant adverse impact on coastal sediment transport processes and cause increased rates of erosion or accretion either in the vicinity of the works or away from the works.

The concerns relate to what happens during average conditions and what happens during storms.

In addition the modelling provides input data to the detailed design of the proposed works: in terms of rock armour size, crest elevation and toe level.

The modelling examined wave climate data from the M2 buoy to establish yearly average conditions. Extreme conditions were obtained from the Irish Coast Protection Strategy Study.

The modelling

- Estimates changes in wave height for extreme conditions as waves propagate shorewards;
- Yearly average longshore sediment transport ;
- Cross shore transport and profile changes during storm events;
- Beach plan changes in the long and short term.

Input Conditions

- Offshore waves from the M2 wave buoy located off Dublin Bay
- Joint Probability of Waves and Water Levels for an extreme event from ICPSS East Coast Technical Report. Three scenarios (wave height, water level) were used for a number of extreme events.

Sediment Transport Modelling

The sediment transport modelling was undertaken using DHI LITPACK – Sediment Transport and Littoral Processes forced by wave action. The modelling of wave propagation from offshore to nearshore was undertaken using spectral wave modelling software DHI MIKE21 SW. The MIKE21 SW model was used to determine the nearshore conditions at Woodbrook which were subsequently used as inputs into the litpack software. LITPACK was then used to simulate a number of wave/current situations for the determination of the net/gross littoral transport for the coastline. It was also used examine the effects of coastal protection solutions on the coastline and to indicate long-term coastline evolution.

The approach to creating extreme input conditions was based on the Inshore Joint Exceedance Curve for the NE Sector produced by the ICPSS, see Figure 1 below. The M2 wave buoy location was the model domain input boundary. Wave conditions for 3 Scenario Water Levels for 1 year, 10 year and 50 yr storm return periods were selected, Table 1. For the yearly evolution simulations a synthetic year long time series of hourly wave data was used.

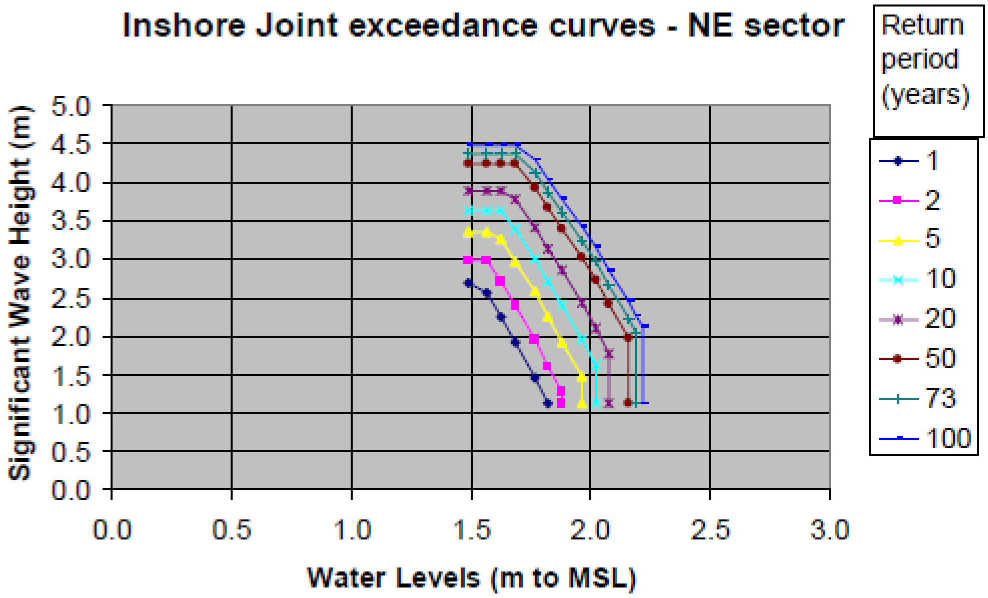

Figure 1 Inshore Joint Exceedance Curves for the North East

Table 1 Input Wave Conditions Extreme Events

Tr=1	**Scenario_1**	**Scenario_2**	**Scenario_3**
Hs (m)	2.75	2	1.1
T (s)	6.1	5.41	4.58
L (m)	58.08	45.68	32.74
Water level (m -MWL)	1.5	1.65	1.75
Tr=10	**Scenario_1**	**Scenario_2**	**Scenario_3**
Hs (m)	3.65	2.75	1.1
T (s)	7.45	6.1	4.58
L (m)	86.9	58.08	32.74
Water level (m -MWL)	1.5	1.8	2.05
Tr=50	**Scenario_1**	**Scenario_2**	**Scenario_3**

Hs (m)	4.75	3	1.1
T (s)	8.51	6.5	4.58
L (m)	113.09	65.94	32.74
Water level (m - WML)	1.5	1.9	2.2

Tr Joint event return period

Hs Input significant wave height

T Input wave period

L Deep water wave period for wave of period T.

Eight sections were modelled along the coastline of the study site, named P1 to P8 from South to North, see Figure 2. The proposed works are located at the landward end of P3.

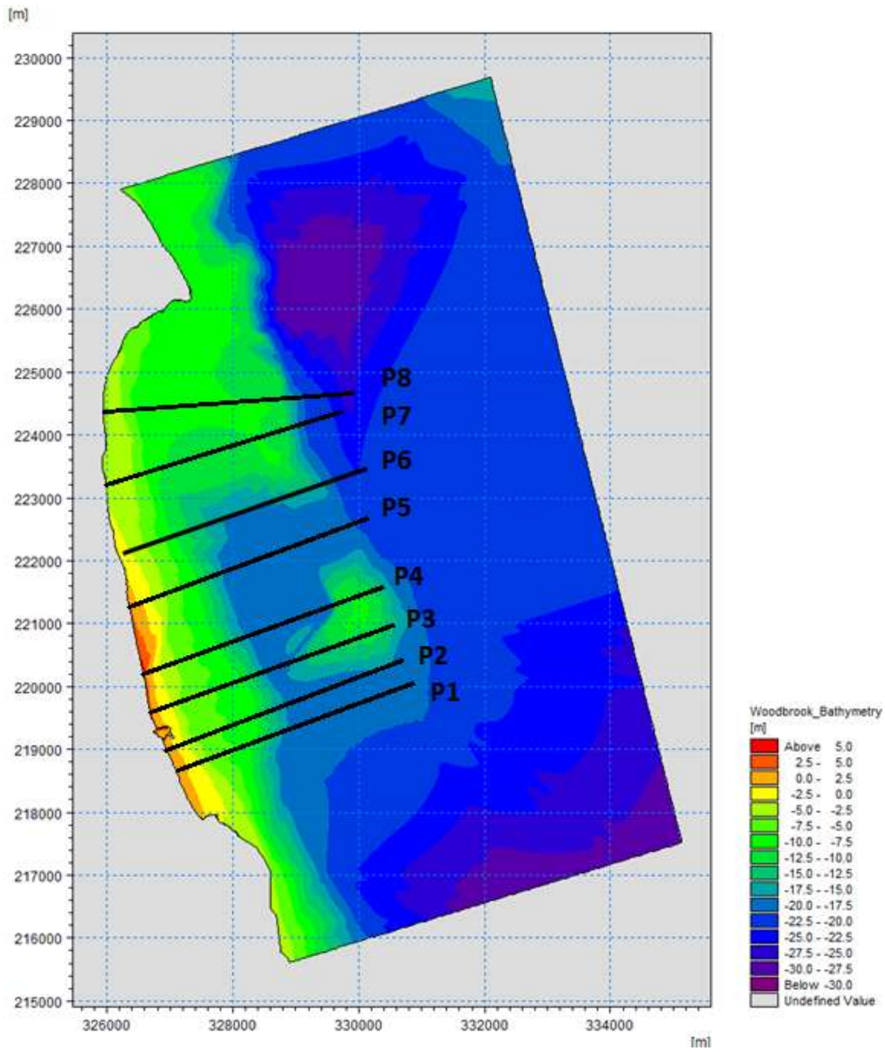

Figure 2 Profiles Modelled in Domain

Extreme Inshore Wave Conditions

The propagation of extreme waves through the domain towards the study site was also of interest. To this end the significant wave height was modelling for the various scenarios in the 1 in 50 year storm. Table 2 below gives the nearshore wave heights as they propagate towards the shore along profile P 3 for the 50 year condition for the three scenarios examined.

Table 2 Wave Conditions for 50year Return Period

Scenario 1		Scenario 2		Scenario 3	
Distance	Hs	Distance	Hs	Distance	Hs
50m	2.05	50m	1.91	50m	1.41
100m	2.19	100m	2.03	100m	1.43
150m	2.31	150m	2.11	150m	1.44
200m	2.34	200m	2.20	200m	1.45

Cross-shore Transport

The cross shore profile response to storms events was modelled to assess the response of both the existing coast and the proposed shoreline with a revetment. To understand the existing behaviour of the system, the 3 scenarios for each of the 1, 10 and 50 year return periods as per Table 1 were simulated.

The results of the above analysis at profile P3 are shown below, in Figures 3, 4 &5. The 50 year return period event response was also simulated for a shoreline with revetment Figure 6. The model shows that significant (1.5m vertical drop) erosion may occur at the toe of the revetment. Note that the model takes as input only the distance of the first non-erodible point in the profile (i.e. the revetment toe). Everything beyond that point is considered non-erodible too.

However, it should also be noted that significant erosion may occur for the present profile during storms.

The modelling assumes that the beach profile consists of coarse sand with a D50 grain size of 1.3mm. In reality the beach is a mix of larger stones with some sand sized material. The larger stones can act as a shield protecting the finer material and the scour less than that indicated by modelling. The modelling indicates that it would be prudent to allow for a significant drop in beach levels at the revetment toe.

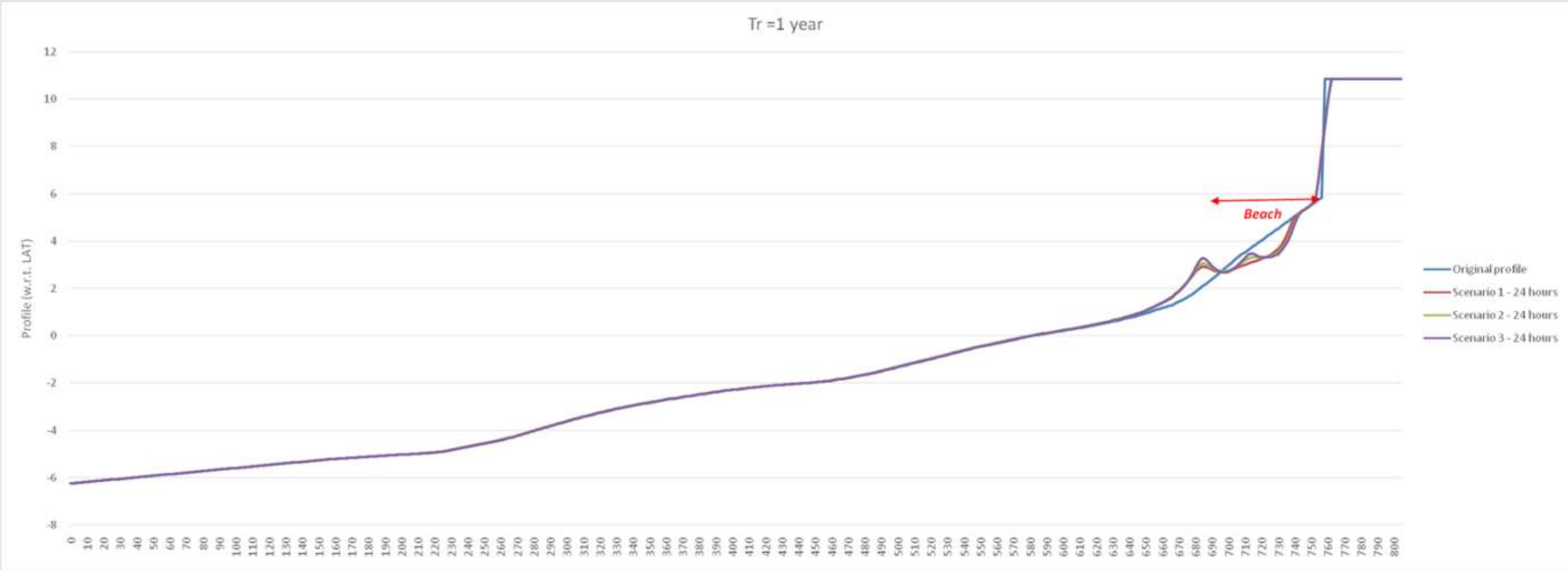

Figure 3 **1 year return period simulation for Profile P3**

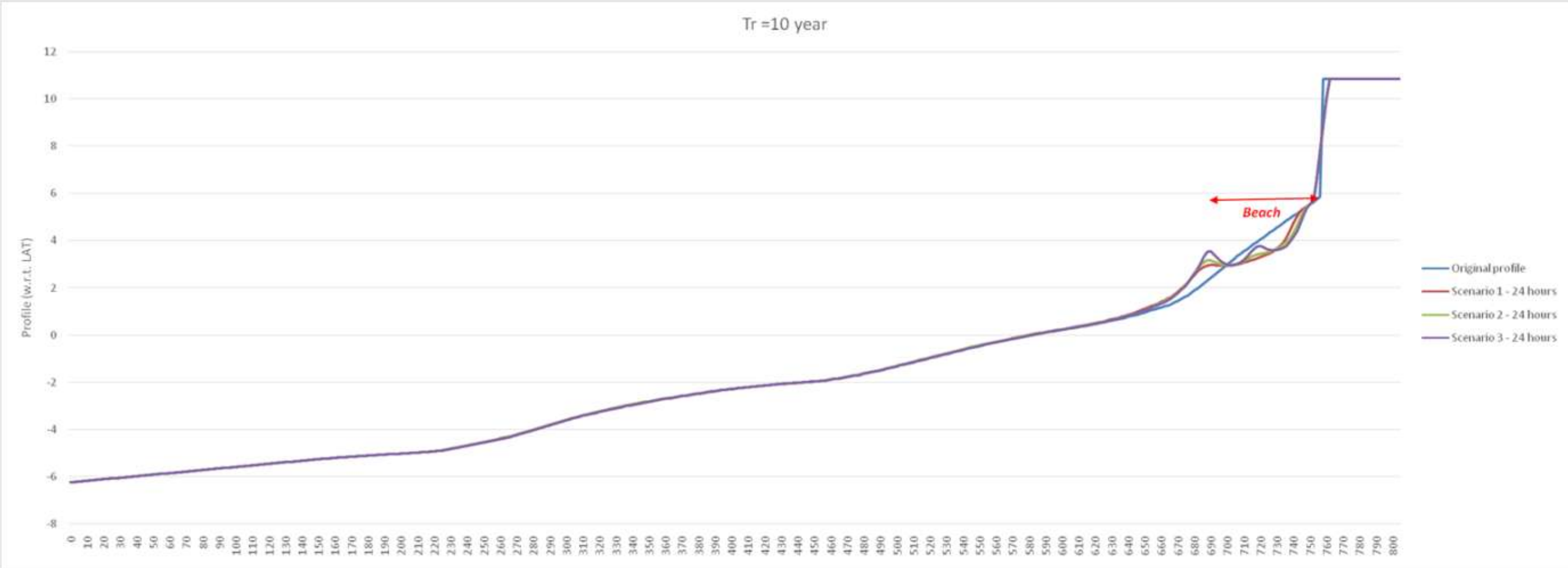

Figure 4 **10 year return period simulation for Profile P3**

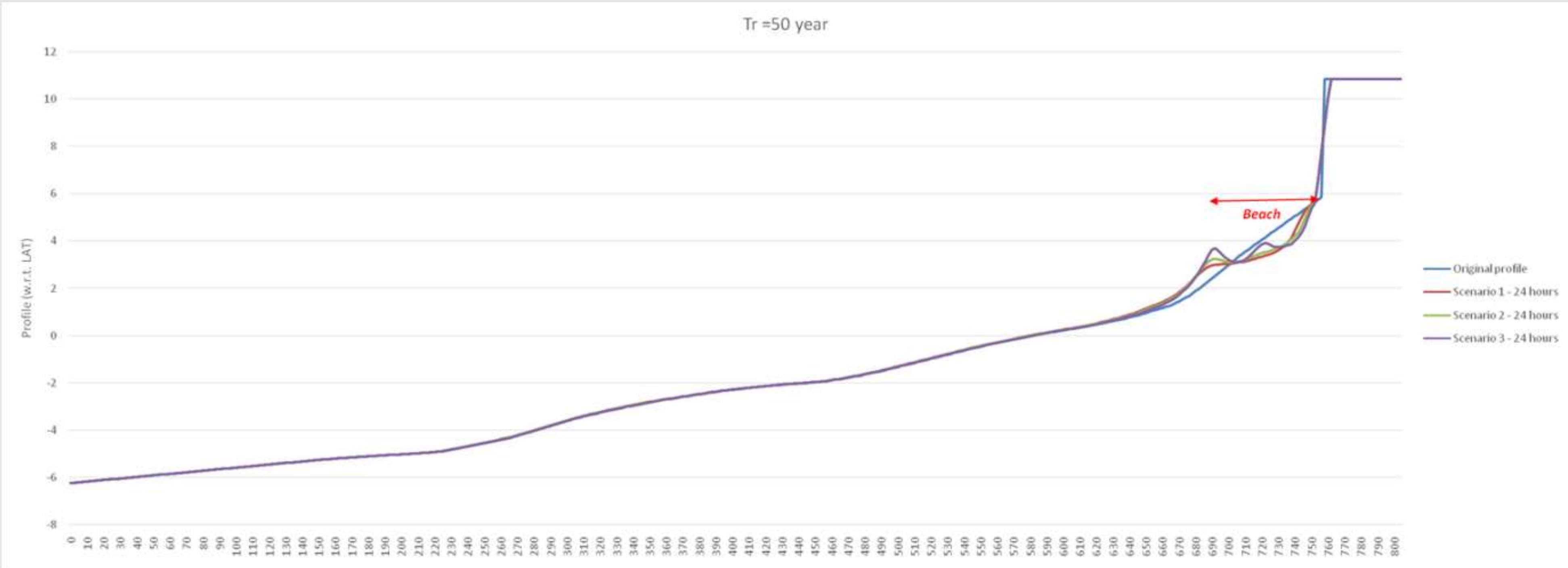

Figure 5 **50 year return period simulation for Profile P3**

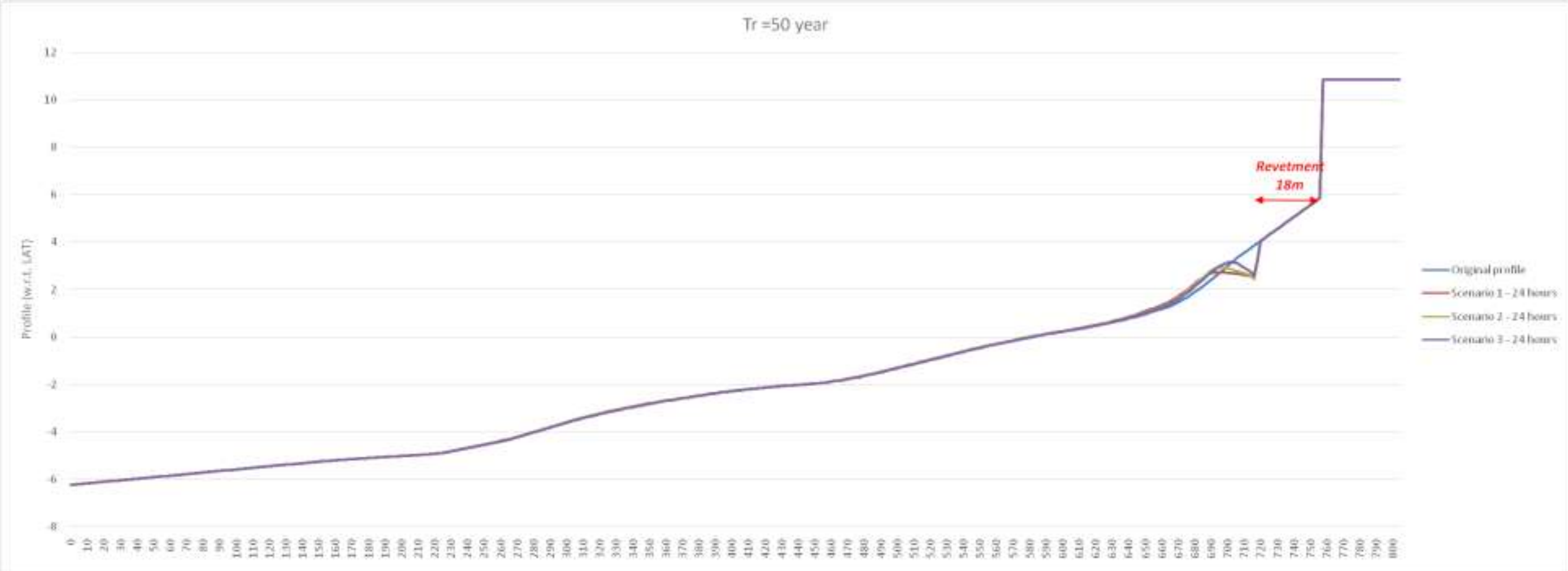

Figure 6 **50 year return period simulation for Profile P3 with revetment**

Alongshore Sediment Transport

There would be a concern that the construction of a section of hard defence on a beach may cause an increase in erosion in the down-drift direction. In order to assess this the gross total yearly alongshore sediment transport was simulated at each of the 8 profile locations using a year long time series of hourly wave data. The results of this simulation in m3 of sediment transported are provided in Figures 7 to Figure 10.

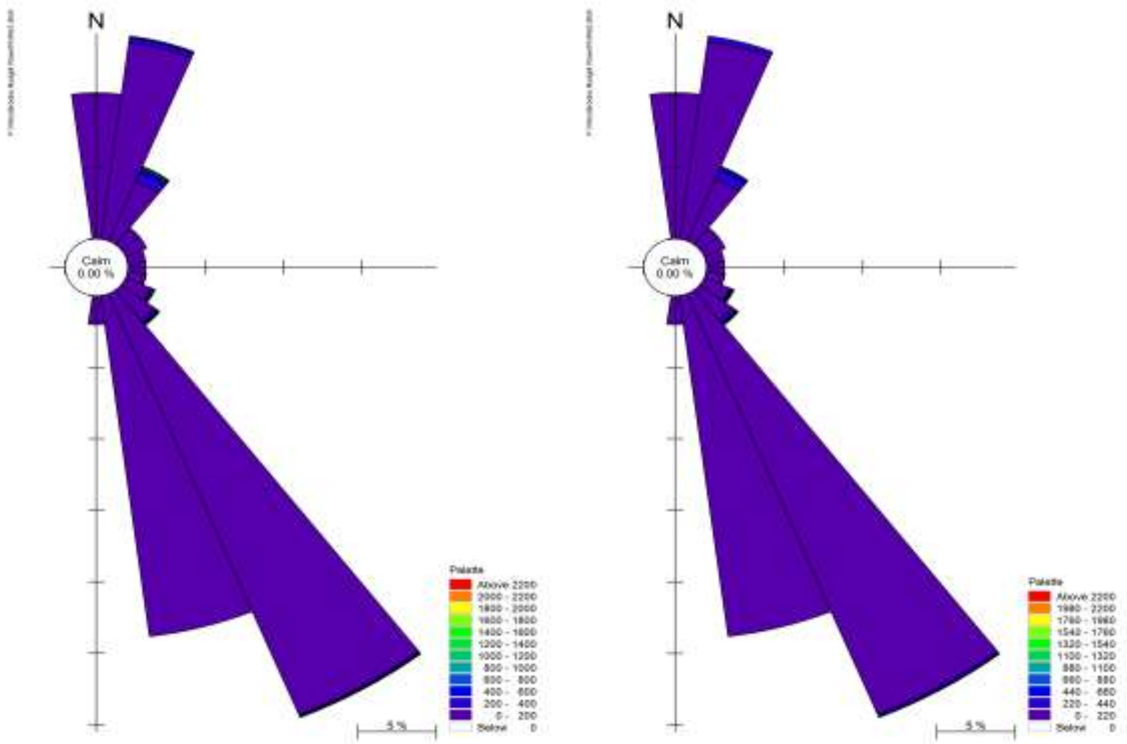

Figure 7: Total yearly transport (m3) Profile 1 and Profile 2

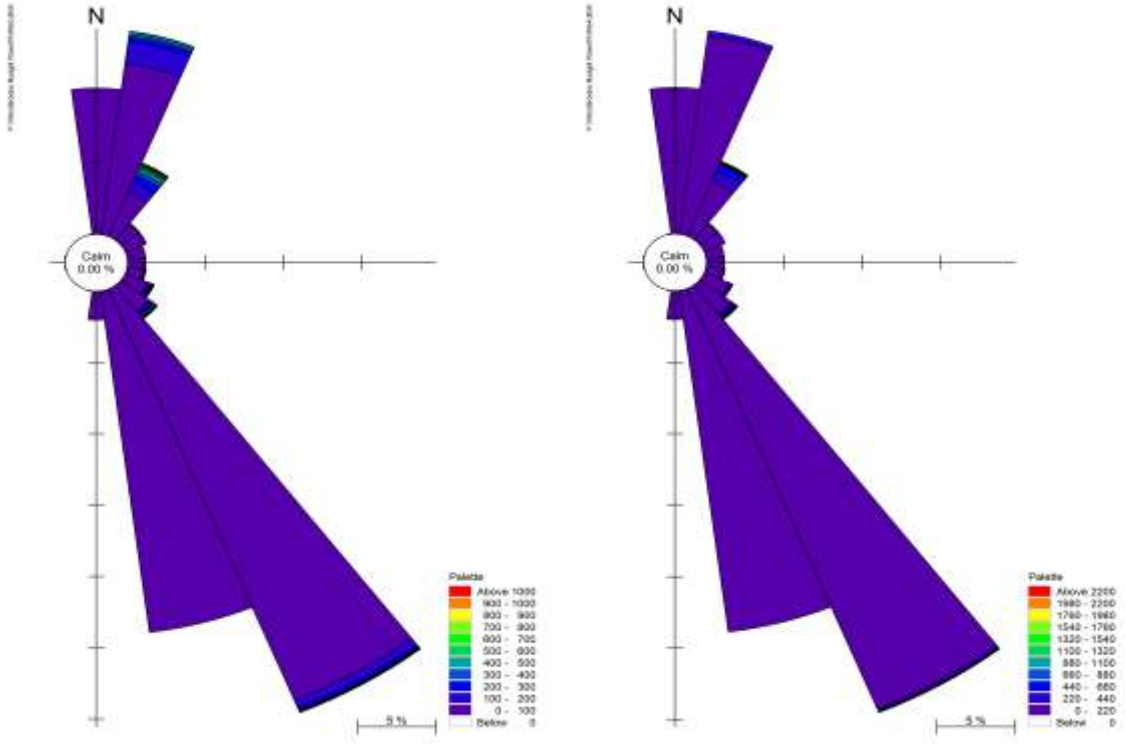

Figure8 Total yearly transport (m3) Profile 3 and Profile 4

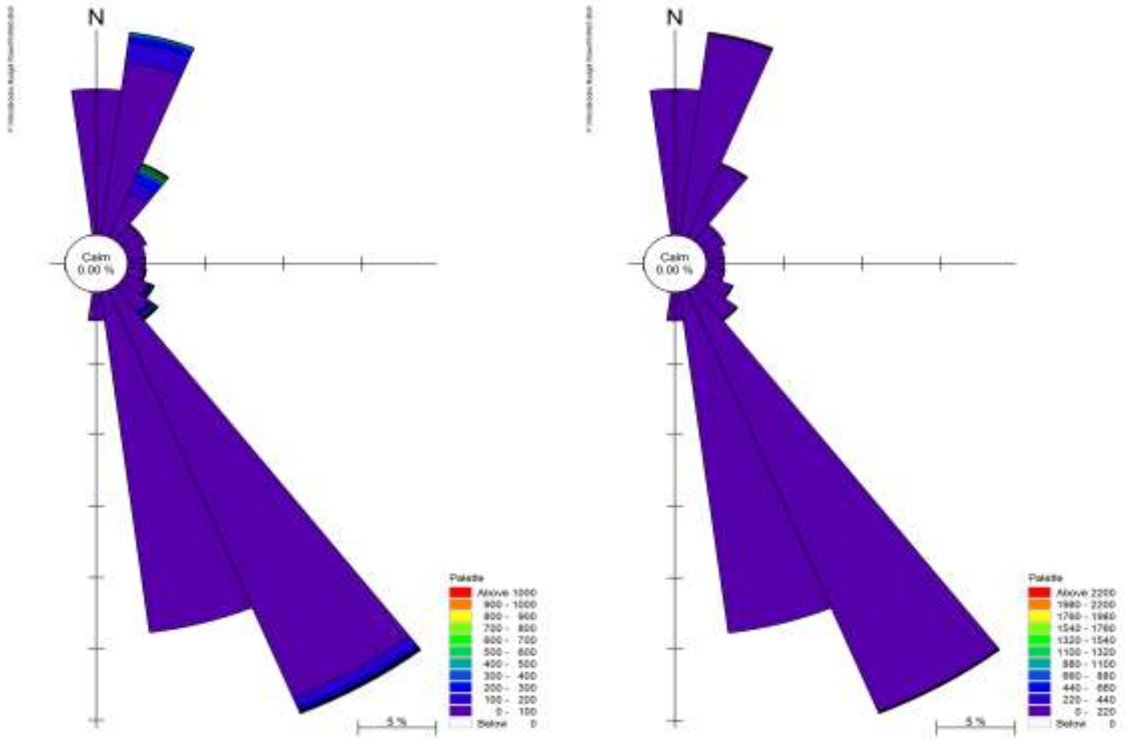

Figure9 Total yearly transport (m3) Profile 5 and Profile 6

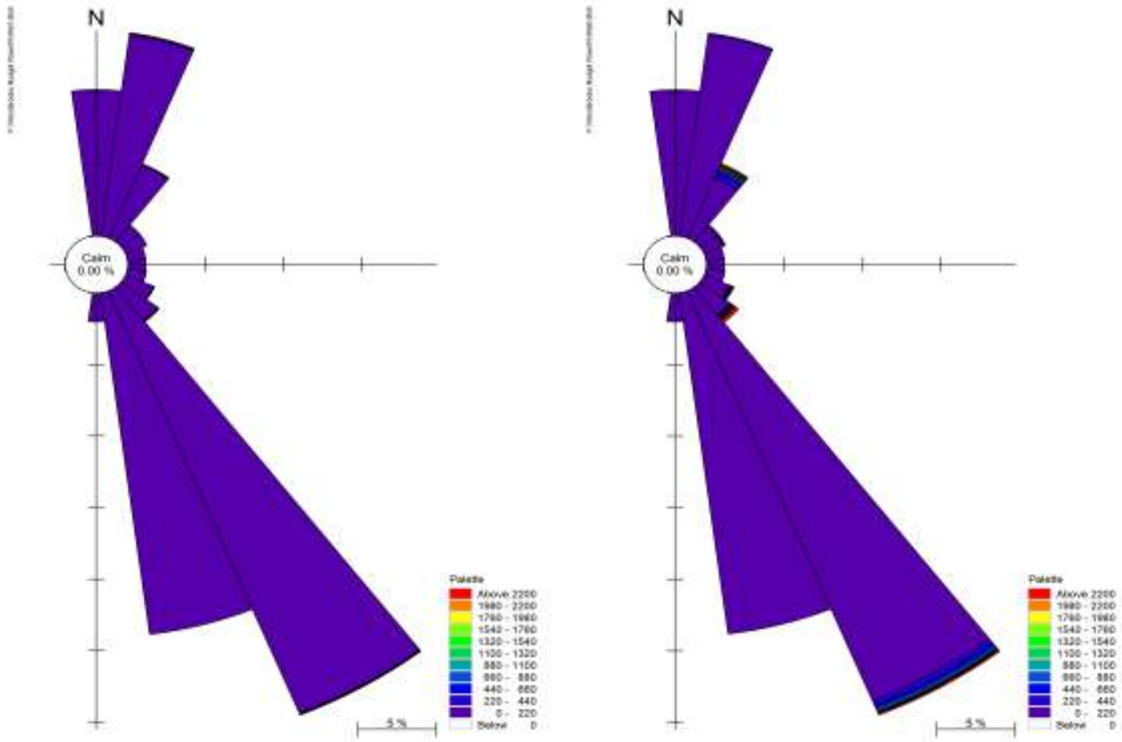

Figure 10 Total yearly transport (m3) Profile 7 and Profile 8

The yearly net transport is calculated from this output and presented in Figure 11 below. It should be noted that sediment transport through Section 7 and 8 is not reliable due to the curvature of the coast and the models inability to simulate this accurately. The simulation results for the study site profile P3 shows a net northward sediment transport of 5854m3 which is considered relatively small over a year. The modelling exercise is based on a grain size of 1.3 mm. As for the cross shore modelling there can be armouring by larger grain sizes which reduces the overall transport rates.

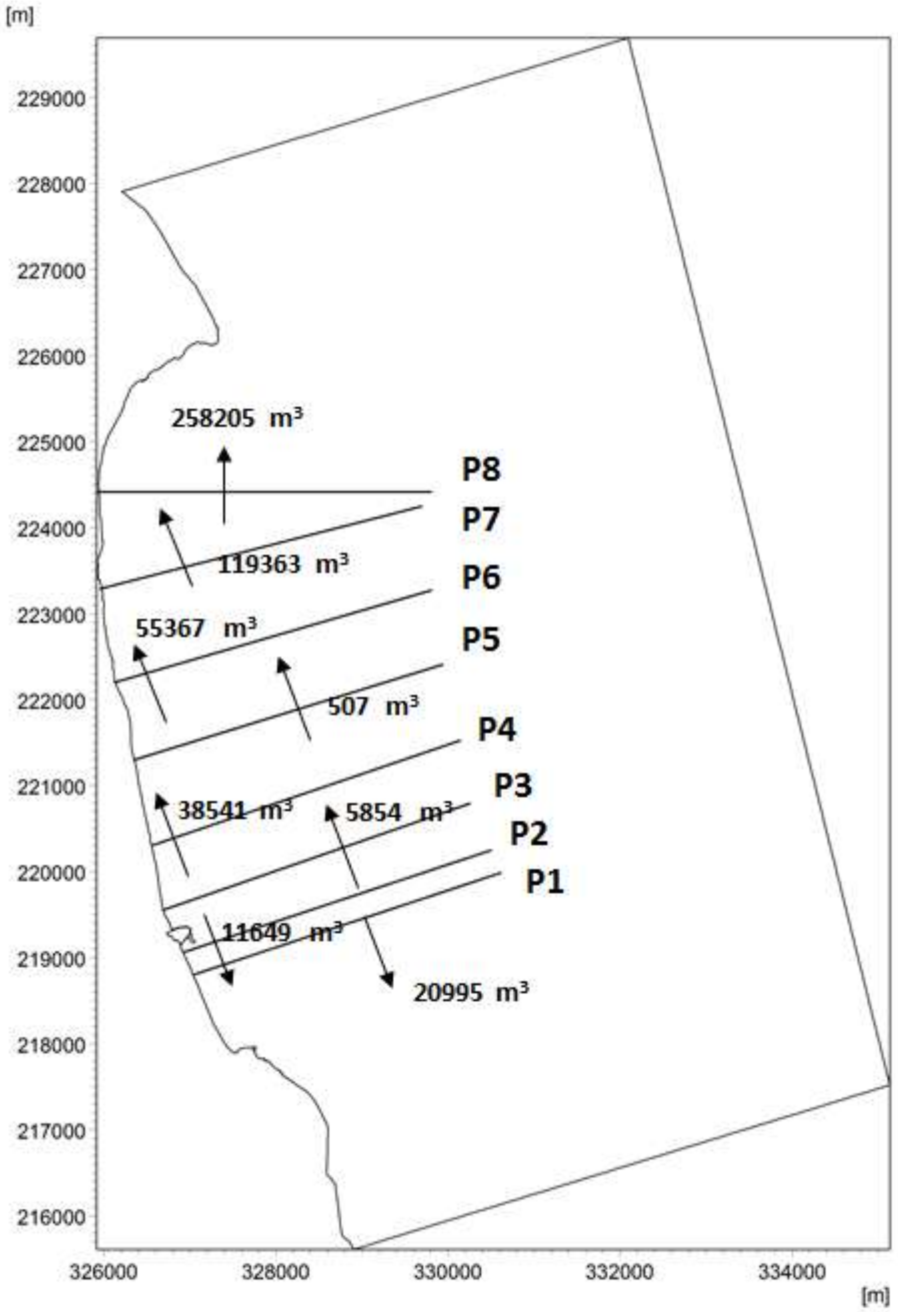

Figure 11 Yearly net transport across each entire section.

Coastal Plan Evolution

The results given in Figure 11 can be used to develop a beach plan evolution of the study site and adjacent shoreline. This is shown in Figure 12. This is based on yearly average conditions. The results indicate that over the year long simulation period that the coastline in the vicinity of the proposed works could accrete and that the coastline to the north is receding. It should be noted that this model assumes that the shoreline consists of a uniform sand sized material and would overestimate considerably the rates of erosion. The actual coastline consists of a thin layer of a broad range of sediment sizes underlain and backed by a cohesive glacial till. However, the model results should give a good indication of the tendency of different sections of cliff to erode.

While the modelling indicates that over time the section of coastline containing the proposed works may accrete, individual storms and the nature of the shoreline may cause erosion. While in the long term the beach material may accrete in the area of the proposed works, during storms, if beach material is removed, the underlying glacial till may erode and retreat. While this retreat may be at a slower rate than a sand, once it is eroded it will not rebuild like a sand beach would. To this end, a model run was undertaken of the likely longshore sediment transport rates during a 24 hour storm and the subsequent beach plan evolution during this storm. The 24 hour SE storm condition was run for the 3no 50year storm scenarios. The results of the simulation Table 3 below show the sediment drift after a 1 day event.

This storm modelling indicates that during a south easterly storm there may be erosion in the study area. In the scenario 1 case of relatively low water levels and large waves the longshore transport rate decreases between profiles 2 and 3 and increases between 3 and 4. A decrease in longshore transport results in accretion and an increase in erosion.

Figure 12 Beach Plan evolution over 1 year simulation

Table 3 Longshore Sediment Transport During Storms (nominal 50 year event)

Tr=1	Scenario_1	Scenario_2	Scenario_3		
Hs (m)	2.75	2	1.1		
T (s)	6.1	5.41	4.58	Direction that maximise the littoral sediment transport for all profiles	
L (m)	58.08	45.68	32.74		
Water level (m -MWL)	1.5	1.65	1.75		
Direction (˚N)	135	135	135		
Profile [No]	**Sediment drift [m3]**				
1	117274	16632.9	1093.29	Total sediment drift across the whole profile and for the whole 24hrs storm period.	
2	254379	23322.8	1103.17		
3	175525	27341.2	1384.4		
4	526982	78614.5	2259.62		
5	203015	26027.5	2218.64		
6	194135	70389.4	677.426		
7	59430.5	4719.3	568.44		
8	1248810.00	459716	2678.22		