Llandudno Beach Management Plan

Appraisal of Options for the future management of Llandudno's Beaches

Conwy County Borough Council

Project Number: 60525387

3rd August 2017

Quality information

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Executive Summary

Introduction

To provide forward looking planning of the beaches of Llandudno, Conwy County Borough Council (CCBC) commissioned AECOM to prepare a Beach Management Plan (BMP) to cover both the North Shore and West Shore beach areas in Llandudno.

The objectives of this Beach Management Plan (BMP) are to:

- Identify stakeholders and their desired requirements for the management of the beaches;
- Explain constraints on the selection of a management solution; and
- Assess potential beach management solutions against a range of criteria.

Approach

Management options for each shore have been developed by CCBC with inputs from the Llandudno Coastal Forum (LCF) prior to the commencement of the project. These options have been supplemented with additional options that address the key issues of flood protection, wind-blown sand and amenity value of the beaches. Each option has been appraised based on a set of agreed criteria and short-list of options selected.

The assessment has taken into consideration the updated Conwy Tidal Flood Risk Assessment, previously completed condition assessments and comments provided by CCBC during consultation events.

North Shore

The long-list of options for the North Shore is shown in the table below (see main text for explanation of notes relating to capital costs). The summary table of the assessment of the options and the short-listed options are also provided. Finally the drawings of the short-listed options are presented.

Long-list of Options for the North Shore

Option	Description	Capital costs
'Do nothing' and 'Do minimum'	'Do nothing' means to allow the defences to deteriorate and not undertake any maintenance. This is not considered acceptable or viable and is not considered any further. 'Do minimum' would mean undertaking the minimum maintenance to maintain the health and safety of people using the beach areas. This option is considered as a baseline for comparison.	£0
Option 1: Detached breakwaters and groynes.	Option 1a: Surface piercing or emergent breakwaters and Option 1b: Submerged breakwaters Both are in combination with rock groynes, the removal of some of the existing shingle and replacement with sand.	Option 1A : £26m to 32m Option 1B: £19m to

		23m
Option 2: Fishtail rock groynes	Option 2a: Fishtail groynes and Option 2b: Larger fishtail groynes/ breakwaters. Both options include additional rock groynes, the removal of some of the existing shingle and replacement with sand.	Option 2A: £14m to 17m Option 2B £13.5m to 17m
Option 3: Traditional Timber Groynes.	Removal of the shingle and cobbles from MU3, re-nourishing with sand and installing a number of timber groynes, possibly with a breakwater to protect MU1.	£11 to 13.5m
Option 4: Beach Nourishment	Option 4A: A single capital re-nourishment of the beach with sand of sufficient quantity to last 20 years. Option 4B: An initial capital re-nourishment and periodic maintenance recharge of the sand. Existing shingle will be removed from the upper beach and sand will be placed on the beach. No control structures are proposed along the frontage.	Option 4A: £10.5m to 13m Option 4B: £9.5m to 12m
Option 5: Beach Nourishment at Children's Corner	Shingle in MU2 will be removed and sand will be placed on the beach with maintenance required periodically. No additional control structures are proposed along the frontage.	£0.5 to 1m
Option 6: Wave return wall for Paddling Pool	A wave return wall will be added to the crest of the paddling pool revetment.	£20-100k[4]
Option 7: Wave return wall along the promenade	A wave return wall would be constructed along the promenade to increase the standard of protection.	£0.3 to 1m[4]

Assessment of the North Shore options

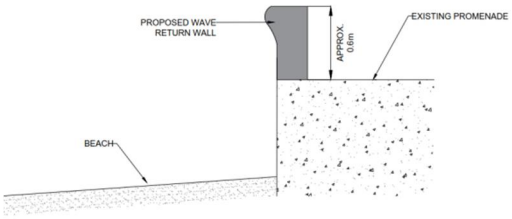
Criteria / Options	Amenity		Environment				Technical				Economic		
	Recreational use	Access	Permissions, consents and licences	Archaeology and cultural heritage	Landscape	Ecological designations	Functionality - Flood and coastal erosion risk management	Constructability	Durability	Impact on coastal processes	Capital cost	Maintenance cost	External funding potential
0: Do minimum								N/A			£0	£0 to £50k	N/A
1A: Detached Breakwaters											£26m to £32m	£0 to £600k	Low
1B: Submerged											£19m to	£0 to	Low

Detached Breakwaters											£23m	£600k	
2A: Fishtail Groynes											£14m to £17m	£0 to £440k	Low
2B: Onshore Fishtail Groynes											£13.5m to £17m	£0 to £440k	Low
3: Timber Groynes											£11m to £13.5m	£600k	Medium
4A: Beach Nourishment (Capital and Maintenance)											£10.5m to £13m	£100k to £1.2m	Medium
4B: Beach Nourishment (Capital only)											£9.5m to £12m	£100k to £1.2m	Medium
5: Beach Nourishment at Children's Corner											£0.5m to £1m	£10k to £100k	Medium
6: Wave return wall for Paddling Pool											£20k to £100k	£0 to £10k	Medium
7: Wave return wall for promenade											£0.3m to £1m	£0 to £10k	High

Short-listed options for the North Shore

Option	Notes
7:Wave return wall for promenade	The long-term flood protection for the frontage is most likely to be most cost-effectively provided through the enhancement of the existing defences using a wave return wall along the front of the promenade. This will have the added benefit of limiting the frequency and amount of beach material being deposited on the promenade.
6: Wave return wall for Paddling Pool	This option is considered to be highly beneficial in preventing both potential flood waters and limiting damage due to beach material being thrown onto the paddling pool surface and surrounds.
5: Beach Nourishment at Children's Corner	Similarly to Option 2 this option is considered potentially viable without additional structures and with minimal sand re-nourishment. However additional sources of funding may be required to make this economically viable.
Option 2: Fishtail groynes	This option has been carried forward to the short-list on the basis that although Options 6 and 7 will probably provide the most cost-effective solution with respect to flood protection funding arrangements. Other sources of funding may become available (such as grants from other bodies or from local businesses) if a larger sandy beach area were to become part of the project.

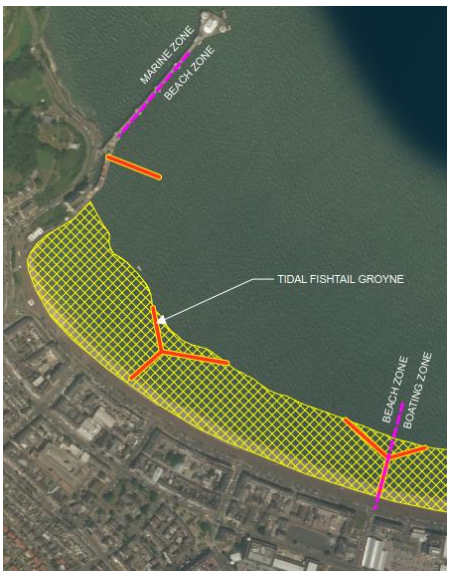
Option 7: Wave return wall along the promenade



Option 6: Wave return wall for Paddling Pool

Option 5: Beach Nourishment Children's Corner

Option 2: Fishtail rock groynes



West Shore

The long-list of options for the West Shore is shown in the table below (see main text for explanation of notes relating to capital costs). The summary table of the assessment of the options and the short-listed options are also provided. Finally the drawings of the short-listed options are presented.

Long-list of Options for the West Shore

Option	Description	Capital cost
'Do nothing' and 'Do minimum'	'Do nothing' means to allow the defences to deteriorate and not undertake any maintenance. This is not considered acceptable or viable and is not considered any further. 'Do minimum' would mean undertaking the minimum maintenance to maintain the health and safety of people using the beach areas. This option is considered as a baseline for comparison.	£0

Option	Description	Capital cost
Option 1: Periodic Beach Maintenance	This option assumes that the back of the beach is recharged with shingle and there is ongoing maintenance of the sand on the beach. Excess material will be removed regularly from the frontage and re-used in other areas (possibly the North Shore) where required.	£0.5m to 1.5m
Option 2: Dune Regeneration	Forming dunes at a number of locations with sand filled geotextile bags at their core. These will continue to accumulate material and grow over time, creating a barrier to windblown material. New plants will also be planted on the dunes to encourage growth of the dune.	£100k to 500k
Option 3: Concrete wall and periodic beach maintenance	A concrete wall will be constructed along the back of the beach from the Dale Road car park to the Cerrig Duon breakwater. Periodic beach maintenance will be undertaken across the entire frontage to remove excess material.	£400k to 600k
Option 4: Rock cover layer	A cover layer of 5-10kg rock will be placed over the existing beach material in order to prevent wind-blown sand. This will be backed by a retaining wall to prevent material loss.	£100k to £200k
Option 5: Sand Traps	This option involves the installation of sand traps along the West Shore. There are a number of existing sand traps in place however many of these have become inundated with material and are in a state of disrepair.	£30k to £50k
Option 6: Breakwater Removal	This option involves the removal of the three existing breakwaters which are located along the West Shore; the Gogarth breakwater, Lloyd Street breakwater and Cerrig Duon breakwater. The beach will be re-instated to a 'natural' state.	£4m to 5m
Option 7: Raised Walkway	This option involves constructing a raised timber walkway along the current cycle path route. This option will be raised above the current path level in order to avoid the accumulation of sand and material which currently obstructs the path route. It is assumed that the path will be approximately 300 mm above the existing ground level and not require a hand rail. Kerb rails will be required for wheelchair safety. The structure can be constructed from timber or recycled plastic.	£0.5m to £1.5m[5]
Option 8: Wall repairs / raising	It is proposed to undertake local repairs to the existing wall structure where it is currently in a state of disrepair. Where required, the existing wall will be raised to improve the frontage defence standard.	£1m to £2m[6]

Option	Description	Capital cost
Option 9: Combined Scheme	Combines components of Options 5, 7 and 8.	£2.4m

Assessment of the long-list of options for the West Shore

Criteria / Options	Amenity		Environment				Technical				Economic		
	Recreational use	Access	Permissions, consents and licences	Archaeology and cultural heritage	Landscape	Ecological designations	Functionality - Flood and coastal erosion risk management	Constructability	Durability	Impact on coastal processes	Capital cost	Maintenance cost	External funding potential
0: Do minimum								N/A			£0	£0 to £50k	N/A
1: Periodic Beach Maintenance											£0.5m to £1.5m	£0 to £0.5m	Low
2: Dune Regeneration											£100k to £500k	£0 to £5k	Low
3: Concrete wall and periodic beach maintenance											£400k to £600k	£300 to £400k	Medium
4: Rock cover layer											£100k to £200k	£TBD	Low
5: Sand Traps											£30k to £50k	£0 to £10k	Low
6: Breakwater Removal											£4m to £5m	£0	Low
7: Raised Walkway											£0.5m to £1.5m	£0 to £10k	Medium
8: Wall repairs / raising											£1m to £2m	£0 to £10k	Medium
9: Combined scheme											£2.4m	£0 to £20k	High

Shortlisted options for the West Shore

Option	Notes
8: Wall repairs / raising	The increase in flood protection is likely to be achieved most cost effectively through the enhancement of the existing sea defences. This could be through the replacement/raising of the existing wave return wall or the construction of a secondary defence behind the existing sea wall. It is likely that the wall will also need to be extended south across the car park.

9: Combined scheme	If possible other measures that can help to maintain beach levels and reduce the wind-blown sand issues could be incorporated into the preferred scheme. It is possible that they will provide additional flood protection benefit by maintaining beach levels; however this would require careful consideration and investigation to demonstrate. See below for why the cycleway has been included.
7: Raised Walkway/cycleway	The access to the shoreline in this area is considered to be very important and the presence of the cycleway is a key feature of that access. There is a clear need to provide a more permanent solution that is robust and will resist both loss of sand due to storm activity and excess material due to wind-blown sand. The raised walkway/cycleway is considered to be the most effective solution to providing this level of access to the shoreline.

Conclusion

This BMP has presented a range of options for the future management of the beaches of Llandudno. It has considered the two frontages in a similar manner and acknowledges that each has unique issues and objectives. The overriding consideration however that is likely to affect any option going forwards is the standard of flood protection that is presently afforded by the defences and will be required in the future under projected climate change.

The CTFRA has quantified the flood risk to Llandudno from the effects of waves, still water levels and the risk of breaching. The conclusion is that the flood risk increases significantly from the Present Day to after 100 years of climate change. This means that work will be required to improve the flood protection in the future.

A review of different options for each shore has been undertaken that has identified a short-list of options for the enhancement of each shore produced. The short-listed options are considered to be the most likely to be approved for funding. Each option will require further development and may result in variations. For example the West Shore option includes the enhancement of the existing sea wall. It may be possible to undertake this in a variety of ways, each potentially providing different amenity benefits. A further options appraisal will be required to finalise this. The retention of Option 2 on the North Shore is also an acknowledgement that whilst unlikely to be justifiable solely for flood protection, it is possible that the provision of an extended sand beach may encourage funding from additional sources such as private businesses.

Following this assessment it is recommended that an application to the Welsh Government should be made for funding to undertake the necessary studies to build the business case for flood protection works based on this BMP.

1. Introduction

1.1 Background

To provide forward looking planning of the beaches of Llandudno, Conwy County Borough Council (CCBC) commissioned AECOM to prepare a Beach Management Plan (BMP) to cover both the North Shore and West Shore beach areas in Llandudno (Figure 1-1). The BMP aims to broadly follow the guidance set out in the CIRIA Beach Manual (CIRIA 2010) whilst also considering the specific application to Llandudno.

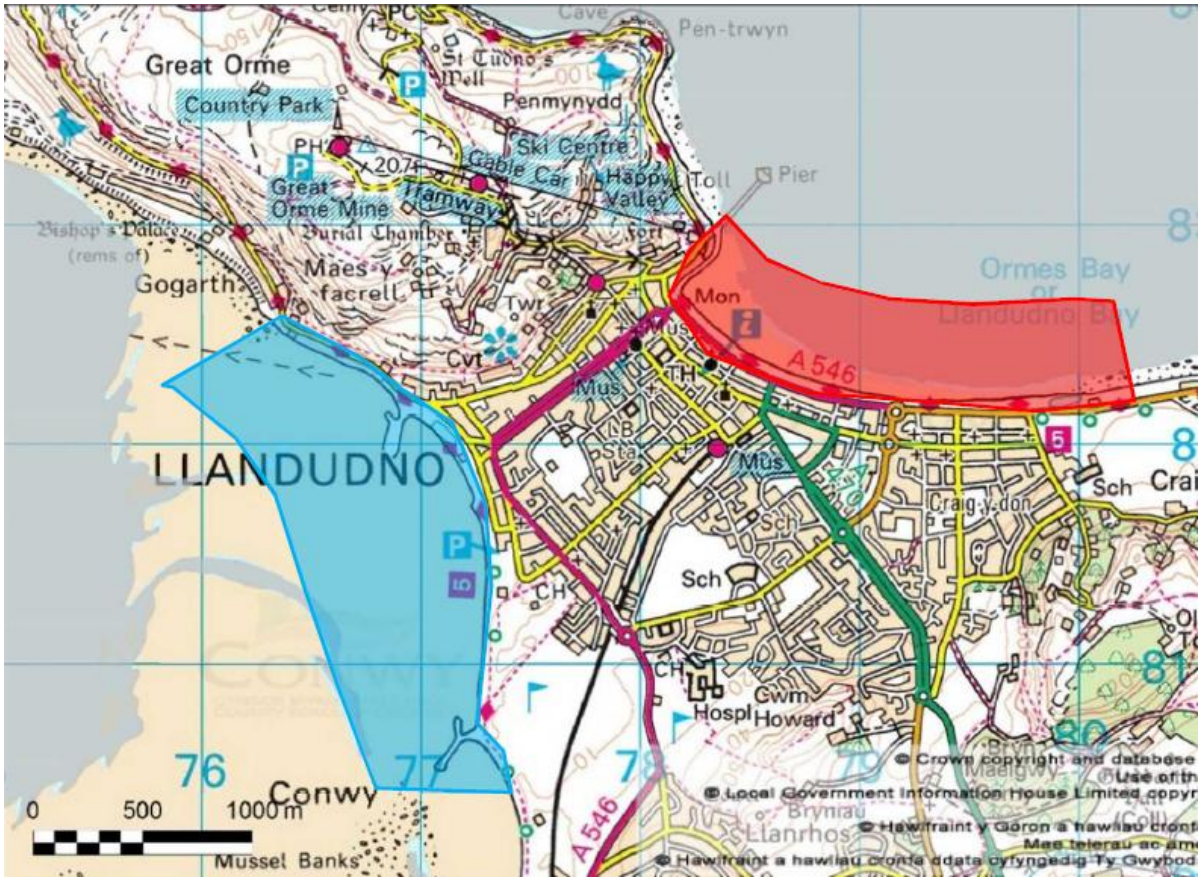


Figure 1-1: Location plan showing the North Shore (red) and West Shore (blue) (Source: Conwy County Borough Council)

Beaches act as natural buffers between the sea and the land. They are efficient dissipaters of wave energy and play a critical role in the management of flood and erosion risk to local communities. Beaches also provide significant value to the local and wider communities that live, work or visit the beaches or land behind the beaches. The beaches at Llandudno provide a wide range of benefits including coastal defence, recreational space, heritage sites and habitat and fishing grounds.

Beaches are dynamic and change in response to the natural forcing of waves and currents and the availability of sediment, the influence of coastal geological features and the influence of coastal structures such as groynes and breakwaters. Users of the beach often (but not always) desire some continuity or stability in the environment to allow their own personal use of the beach area. The continual changing nature of beaches complicates the process of beach management within the context of meeting the (often conflicting) desires of different stakeholders.

The Welsh Government advocates management of beaches to provide a flood and coastal defence function and funding is available for changes to beaches to facilitate the protection of coastal communities and built assets from the risk of coastal flooding or erosion. Allied with this is a requirement to consider the wider benefits that beaches provide in delivering goals for the well-being of communities with consideration given to funding projects that may provide other benefits.

The emergency works conducted after the winter storms of 2013/14 (Figure 1-2) resulted in 30, 000 m^3 of shingle being placed on the North Shore over a five week period (Figure 1-3). The Llandudno Coastal Forum (LCF) was established in response to the public concerns surrounding the large scale shingle replenishment. The LCF, in conjunction with CCBC, canvassed local opinion regarding future defence requirements which provided the stimulus for the development of this Beach Management Plan. Nearly 3 000 people took part in this consultation process which highlighted the desire locally for public feedback to be incorporated into any future plans. The LCF identified a number of concept options for the management of the frontage and developed further by CCBC. These concept options have been considered as part of this BMP study.

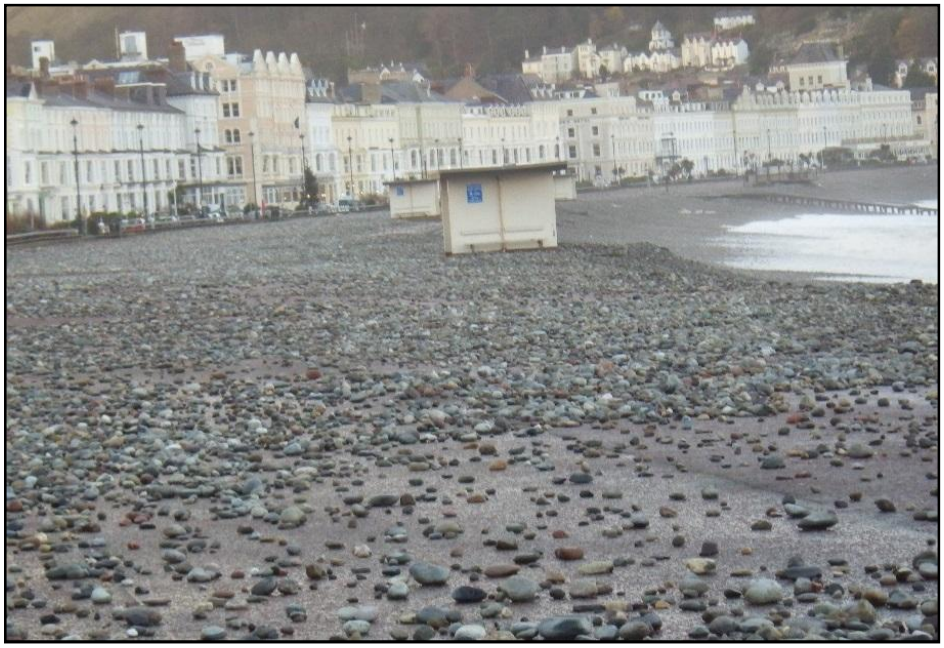


Figure 1-2. View along the North Shore (facing west) following 2013/14 storm events (CCBC, 2016)

Figure 1-3. View of the North Shore (facing east) following the beach replenishment works in 2014 (CCBC, 2016)

An initial long list of options was presented by CCBC to the public on the 17th November 2016 in order to gather feedback for further options development. A further site walkover and discussion was undertaken on the 15th December 2016 with representatives of the LCF in order to progress development of these and other potential options. These meetings were essential in order to ensure public engagement was maintained throughout the lifecycle of the project.

1.2 Objective

The objectives of this Beach Management Plan (BMP) are to:

- Identify stakeholders and their desired requirements for the management of the beaches;
- Explain constraints on the selection of a management solution; and
- Assess potential beach management solutions against a range of criteria.

As part of the evaluation process the potential management solutions will be evaluated against a range of criteria. The specific objective to be used to rank options and identify a 'preferred solution' has not been specified by CCBC at this time. It is likely to be directed by the available sources of funding, desires of the local community and the statutory responsibility of the council. This BMP does not therefore identify a preferred solution for each beach area, but will provide the information required to start the appraisal process to identify a preferred solution.

1.3 General approach

The approach taken for this BMP was progressive and has been presented in the following sections:

Section 2 describes the issues and objectives identified during the previous consultation with the public and LCF and also for CCBC.

Section 3 presents the environmental constraints that may affect the selection of options including the changing flood risk due to climate change.

Sections 4 and 5 outline how the options for each of the frontages were evaluated, including the identification of the different defences, uses of the areas and introduces the concept of management units. The long-list of options considered are described separately for the North Shore and West Shore in Sections 4 and 5 respectively. Each section assesses the options against the criteria and derives a short-list of options for future management of the beaches.

Section 6 provides a brief conclusion and recommendations for further work and on-going consultation.

1.4 Assessment Criteria

The assessment of the different options presented in this BMP has been at a high level and based on semi-quantitative data. CCBC identified the following criteria in the scope of work for the BMP (in the order presented in the scope of work):

1. Feasibility of the option
2. Capital scheme cost
3. Maintenance requirements and costs
4. Standard of protection provided
5. Potential funding sources
6. Sustainability / ability to respond to climate change
7. Uncertainties in modelling of the option / further modelling requirements
8. Amenity benefits and local capacity to realise the potential of such benefits
9. Negative impacts of the option – environmental, visual, accessibility etc.
10. Likely public reaction based on an independent review of the public consultation process

Most flood and coastal defence schemes include many components designed to work together to reduce the risk of flooding or coastal erosion and where possible provide additional environmental or amenity benefits. Each component of a scheme must be justifiable on a technical basis and contribute to the objective of the overall project.

For the North Shore a range of options have already been outlined that include different components (for example rock or timber groynes, submerged and surface piercing breakwaters and beach recharge). The combination of these components to form options has been retained and will be assessed as options.

For the West Shore however, the options previously considered are almost all the application of a single component to the whole frontage and the different components have not been combined into specific options. For the assessment here these options as previously presented are retained; however an additional option that uses different components for each section of the shore has also been developed.

An options assessment matrix has been developed in order to allow each of the potential options for the North Shore and West Shore to be assessed relative to each other and allow

consistent options appraisal. The criteria are based on the CCBC definitions however they provide additional information on some of the criteria. The assessment criteria are set out in Table 1-1.

Within these key areas there are a number of subcategories which are assessed. The options are graded using a Red, Amber or Green (RAG) rating system:

- Green indicates that a solution is considered to be significantly more beneficial relative to other options or in absolute terms, as appropriate.
- Amber indicates that an option is considered to be neither significantly more or less beneficial nor risky than other options.
- Red indicates that an option is considered to be significantly less beneficial or higher risk than other options.

Table 1-1. Assessment criteria

Group	Description (CCBC criteria)	Considerations
Technical	Functionality - Flood and coastal erosion risk management (4)	The Welsh Government specifies the standard of protection that is required for flood protection and this is administered by NRW. It has been assumed that all options will be required to meet this specification. However where an option does not increase the flood protection or is considered to provide marginal improvement then it will be graded Red.
	Constructability (1)	The feasibility of the option to actually be constructed is a key consideration. Where there are likely to be highly technical engineering requirements or it was considered that there was a significant risk (such as ground conditions) that could significantly affect the design the criterion has been marked as Red.
	Durability (1 and 6)	The sustainability of the option based on the materials used, the changes over time (such as the loss of beach sediment) and the ability of the scheme to be adapted for climate change are all considered in the durability.
	Impact on coastal processes (1 and 7)	An option that is considered to have little or no impact on coastal processes has been graded Green whilst one with significant impact (that may require additional mitigation) has been ranked Red.
Amenity	Recreational use (8)	The enhancement of the beach for recreational use or the provision of other recreational facilities will result in an option being graded Green. An option that results in a potentially unsafe environment will be graded Amber or Red.
	Access (8)	Access to the beach areas is considered critical for all options and no options are considered which limit the access of the public to the beach.
Environment	Permissions, consents and licences (1)	The ability to obtain different permissions, consents and licences will be driven in part by the likely impact (or benefits) that are perceived by statutory stakeholders. The assessment has been made on the basis of the spatial and temporal distribution and severity of the potential impact (or benefit).
	Archaeology and cultural heritage (9)	The presence of significant archaeological or culturally sensitive assets in the development areas would be graded Amber or Red.

Group	Description (CCBC criteria)	Considerations
	Landscape (9)	Where a development will result in a significant change to the landscape the scheme would be graded Amber or Red.
	Ecological designations (9)	If a scheme is likely to affect a significant area of ecological importance then it will be graded Amber. If the impact is considered to be significant and detrimental and difficult to mitigate then it will be graded Red.
Economic	Capital cost (2)	The capital cost of the scheme has been estimated based on concept design of each option. A range of costs have been provided as an indication of the likely capital cost. Schemes costing more than £5M are considered to be red whilst lower priced schemes may still not be graded Green unless there is considered to be high certainty of the price range and it is still a low cost solution.
	Maintenance cost (3)	The maintenance costs for the options have been estimated on an annualised basis. It should be recognised however that the annual costs could vary significantly for options involving periodic recharge of beach material and this is reflected in the cost estimates.
	External funding potential (5)	The possibility of securing external funding has been assumed to be primarily driven by the need for flood and coastal protection. Additional funds may be made available to such schemes if it will allow them to provide additional amenity benefits; however it is unlikely that purely aesthetic or amenity benefits will receive substantial funding. Schemes that are therefore likely to be proportionate for the flood risk have been ranked as Green and those that are considered to be excessive costs for the potential reduction in flood risk as Amber or Red.

2. Issues and management constraints

2.1 Introduction

A number of public consultation events have taken place with the LCF taking a lead role on behalf of many within the town. The LCF was established in response to the shingle replenishment works undertaken in spring 2014. The LCF, in conjunction with CCBC, canvassed local opinion regarding future defence requirements which provided the stimulus for the development of this Beach Management Plan. Nearly 3,000 people took part in this consultation process which highlighted the desire locally for public feedback to be incorporated into any future plans.

The LCF were involved in the early development of options for each of the frontages following the response garnered as part of the public consultation process. These options have been included in the long list of potential options which were appraised as part of this study. Engagement with the LCF was demonstrated throughout the duration of this project in order to ensure public feedback was a key driver in identifying a preferred option.

2.2 Current Management Practice

At present beach management along each of the frontages is generally undertaken on a reactive “as required” basis. Annual re-profiling occurs between the winter and summer seasons or after a storm event as demonstrated by the works following the 2013/14 event. CCBC has undertaken frequent condition assessments of the defences on both shores and monitors the beach levels annually.

The current management policy adopted under the Shoreline Management Plan (North West and North Wales Coastal Group, 2010) is ‘Hold the Line’. This report notes that “Beach recharge and beach management will provide beach stability and reduce risk to Llandudno”.

NRW has responsibility for the management of flood risk for existing developments. The NRW web site provides flood risk maps that show the areas that are liable to flooding for events that have AEPs of 0.1%, 1% and 3.3% (ARIs 1000, 100 and 30 years).

TAN 15 (Welsh Government, 2004) provides indicative guidance on the threshold frequency and tolerable conditions for different types of new development, as shown in Table 2-1 below. This provides guidance on determining flood risk issues, how to assess the consequences of flooding and any action that can be taken through development plans and management procedures in order to mitigate flood risk. The guidance also specifies several criteria about the depth and speed of flooding that must be considered.

CCBC commissioned the “Conwy Tidal Flood Risk Assessment: Llandudno inundation modelling” (HRW, 2006) and has recently commissioned AECOM to update the assessment and include the impacts of the revised estimates of the rate of sea level rise, increases in wind speed and wave heights due to climate change. The revised CTFRA has now been completed and the findings are considered in Section 2.6.

Table 2-1. TAN 15 guidance on AEP for different types of development

Type of Development	Threshold Frequency	
	Fluvial	Tidal
Residential	1%	0.5%
Commercial/Retail	1%	0.5%

Type of Development	Threshold Frequency	
	Fluvial	Tidal
Industrial	1%	0.5%
Emergency Services	0.1%	0.1%
General Infrastructure	1%	0.5%

The Welsh Government has set out a programme of support with the objective of improving coastal communities' resilience to climate change. This is set out in the 'Coastal Risk Management Programme – Guidance Notes for Local Authorities' (Welsh Government, 2015). This programme provides a one-off opportunity for local authorities to implement transformational projects for coastal communities, with the Welsh Government contributing 75% of the project costs (Welsh Government, 2015). The objectives which have to be met in order to achieve funding are set out in Figure 2-1 below.

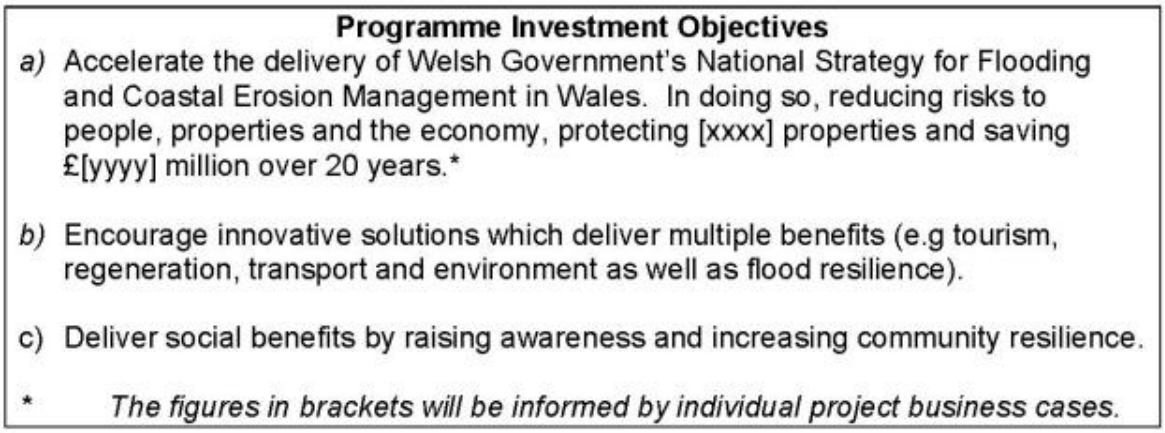


Figure 2-1. Programme investment objectives from CRMP guidance (Welsh Government, 2015)

In order to be eligible for capital funding, projects will have to clearly set out their capital expenditure. Projects are expected to demonstrate how they can achieve 'wider benefits' which includes local benefits (e.g. through employment or skills training as part of the construction process) or through achieving the goals set out in the 'Well-being of Future Generations Act' (Welsh Government, 2015).

The present BMP will form part of the processes to assist CCBC in establishing the necessary business case for an application for funding, if a flood or coastal risk is identified.

2.3 History of flooding, coastal erosion and defence construction

In 2004 HR Wallingford and CEUK (2004) were commissioned by CCBC to complete the Conwy Tidal Flood Risk Assessment (CTFRA) to examine the existing risk of flooding in Conwy from tidal inundation. Both Llandudno North and West Shore were included as part of this assessment. This report identified a number of historical flood events including tidal flooding simultaneously to the North and West Shore in the early part of the 20th century which caused flooding in Llandudno town centre. The CTFRA noted that most of the extreme flood events were caused by extreme sea levels in conjunction with high wave conditions, which indicates that high sea levels are the primary driver behind flood events.

2.3.1 North Shore

A review of the history of the development of the defences on the North Shore is provided in Table 2-2 based on the description of the natural processes and shoreline baseline report (CEUK, 2017) in Appendix B.

From a review of the historical development it is clear that the defences have required upgrading to deal with the incident storms on several occasions as the town has grown over the past 120 years. Low beach levels are noted to be a factor on at least two occasions (1893 and 1990) in the failure of the structures to provide sufficient protection to the town.

The movement of material is an on-going problem and more recently the re-cycling of material and re-profiling of the beach along the Llandudno Promenade and Craig-Y-Don frontages has been carried out, typically on an annual basis, from 2000-2013 with the beach being generally re-profiled prior to the summer season.

Past flood events have occurred due to low beach levels allowing high energy waves to reach the promenade and overtop the defences. The lack of beach protection to the defences also caused significant damage, most notably in 1937 and 1990. Since the completion of the 1996/2000 coast protection works the defences have been protected from significant damage and wave energy is decreased by the shingle beach. Storm events in 2005, 2010 and over the winter of 2013-14 caused the movement of shingle and cobbles onto the promenade along with water that drained back to the sea.

In spite of this, the December 2013 storm was close to overtopping the secondary sea wall, particularly near the paddling pool due to the west / northwest wind direction.

Table 2-2. Timeline of flooding, erosion and engineering response for the North Shore

Year	Description
1858	Completion of Original Pier.
1859	Storm destroys Original Pier.
1875	New Pier Constructed.
1880s	New Pier extended to join newly extended Pavilion (vertical pier wall constructed at the same time).
1893	Llandudno surveyor noted loss of beach material and that artificial protection would be required, to protect the town.
1894 - 1906	Concrete steps constructed from South Parade, west of Trevor Street, to Carmen Sylva Road. Levels reduced further down and three areas had to be extended seaward during the period.
1927	High tides and offshore winds - Flooded Nant y Gamar Road, Queens Road, houses along Victoria Street and Pleasant Street.
1927	Storm overtopped defences causing the flooding of Llandudno to Mostyn Street, estimated to be 4 feet deep, underground toilets at North Western Garden were submerged with people trapped inside.
1937	Storm destroyed sections of the original steps.
1937	New stepped revetment at George's Crescent and Craig-Y-Don and 9 timber groynes created between the bandstand west of Vaughan Street and Gwynedd Road (following the storm).
1950s	Following further storm damage, the new stepped revetment was extended westwards with also a new vertical pier wall and 4 groynes added to the west of those originally installed.
mid 1980s	Groyne field in poor condition.
1990	Lack of beach protection to the defences has also caused significant damage and flooding to Craig y Don.
1990s	Extensive studies taken place resulting in a new coastal defence approach adopted across Llandudno Promenade and Craig-y-Don frontage with the importation of gravel cobble to recharge the beach levels in front of the defences, repair works to existing defences, reconstruction to promenade with the addition of a flood wall (at the rear between Clarence Road and the Craig-y-Don Pool). Dwarf wall over the frontage to be elevated.
1996-1997	First phase of works carried out between Craig-Y-Don Boating Pool and Vaughan street. Cross shore concrete crib groyne constructed at the eastern end of the Craig-Y-Don boating pool.
1999 - 2000	Second phase of works between Vaughan Street to Trevor Street (included widening and extending the lifeboat slipway).
	Children's Corner was not modified as part of the new arrangements. Wind-blown sand from the West Shore has been used to recharge the beach once.
2000 - 2013	Recycling of material and re-profiling of beach along the Llandudno Promenade and Craig-Y-Don frontage, on an annual basis usually prior to the summer season (a few thousand tonnes at a time).
2005, 2010, 2013-14	Storm events caused flooding of the promenade and the movement of shingle and cobble onto the promenade. The December 2013 Storm came close to overtopping the secondary seawall (particularly near the paddling pool).
Winter 2013 - 2014	Approximately 30 000m³ of new beach cobble imported to replace beach material lost since the scheme was implemented.

2.3.2 West Shore

A review of the history of the development of the defences on the West Shore is provided in Table 2-3 based on the description of the natural processes and shoreline baseline report (CEUK, 2017) in Appendix B.

The first intervention works took place in 1905, prior to any notable development being present. The low beach levels are noted to be a significant factor (1950's and 1980's) in the failure of the defences to prevent overtopping. The groyne structures built in 1991-92 in association with beach recharge retained beach levels between Gogarth and Cerrig Duon.

The new groynes have been successful in reducing the flood risk along the shoreline however the raised beach levels are perceived to have increased the amount of wind-blown sand, which has become a nuisance to property owners.

A more detailed history of how the frontage has developed and past flood events can be found in the 'Natural Processes and Shoreline Baseline' report (CEUK, 2017) in Appendix B.

Table 2-3. Timeline of flooding, erosion and engineering response for the West Shore

Year	Description
1905	First intervention works at West Shore before any notable development existed. These minor works were breached on many occasions in the late 1920's and 1930's.
1927	Flooding of hinterland with driftwood and seaweed found as far inland as Maelgwyn Road.
1936	Major remedial works
1950's	Stepped concrete revetment with wave return wall and steel sheet piled toe was constructed. In the following decades the beach levels fell, exposure conditions worsened and the loading on the structure as well as overtopping risk increased.
1980s	Fallen beach levels lead to the damage of the structural integrity of the defences.
1991 - 1992	3 cross-shore, shore connected "fishtail" groynes were constructed at Cerrig Duon, opposite Lloyd street and at Gogarth. The upper beach was reinforced with a variety of graded sediment.
1993	As a result of the summer floods, the sand beach on the south of the Gogarth breakwater was washed away (by pumping of flood waters from the hinterland)
1994	Marine dredged aggregate from Liverpool Bay replaced lost sand beach. Breakwaters and recharge effective though have caused increased wind-blown sand from the upper beach across the immediate hinterland. This has produced localised dune features at the root of the Lloyd Street and Gogarth breakwaters.
2006	As part of the cycle path works (West Shore to Deganwy) the southernmost section of dunes reinforced with quarried cobble and section of rock revetment was built immediately to the south of Cerrig Duon. North Wales Golf Club dune section, North of the Cerrig Duon breakwater, had its upper beach reinforced with additional imported quarried cobble. An unbound cycle track was constructed along the beach crest.
On-going	Routine clearance of wind-blown sand.

2.4 Sensitive receptors

Before the potential environmental impacts or benefits of any coastal development can be assessed it is necessary to understand the present situation and identify any constraints or opportunities that may exist. An appraisal of the present situation has been undertaken and is included in full in Appendix A with the key points summarised here.

Constraints and opportunities have been considered in the context of national, regional and local planning policy, including the proposals set out in the local SMP2 and the objectives of the Water Framework Directive (WFD) (European Council Directive 2000/60/EC, Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (as amended 2015 & 2016)). The WFD established a framework for Community action in the field of water policy and takes a holistic approach to the sustainable management of water by considering the interactions of different water bodies. Its objectives include the protection, enhancement and restoration of all bodies of water. In Wales, Natural Resources Wales is the competent authority for implementing the WFD, although many objectives will be delivered in partnership with other relevant public bodies and private organisations. There is no specific guidance for the assessment of WFD compliance for beach management plans.

Figure 2-2 identifies the statutory designated sites within a 2km buffer of the North Shore. The environmental assessment found that there is the potential for disruption to local habitats due to construction works undertaken within the Special Area of Conservation (SAC) and Special Protection Area (SPA). It should be noted that there is a high degree of uncertainty at this stage in terms of what level of impact may occur and further assessment will be required as part of an HRA. For example any offshore breakwaters will potentially need further surveys in order to assess the bed substrate and further species assessments. The constraints map highlights that there are a significant number of Listed Buildings (primarily post-medieval Grade II buildings) located along the North Shore (in particular along the western end of the frontage). This will be a key consideration when identifying an option in order to ensure that these are adequately protected from both flooding and erosion. The majority of the resort is designated as the Llandudno Town Centre and Seafront Conservation Area.

Information supplied by the LCF on potential items of local heritage interest has been considered and no items of major concern were identified. The information will be included in the more detailed environmental review at a later stage in the project.

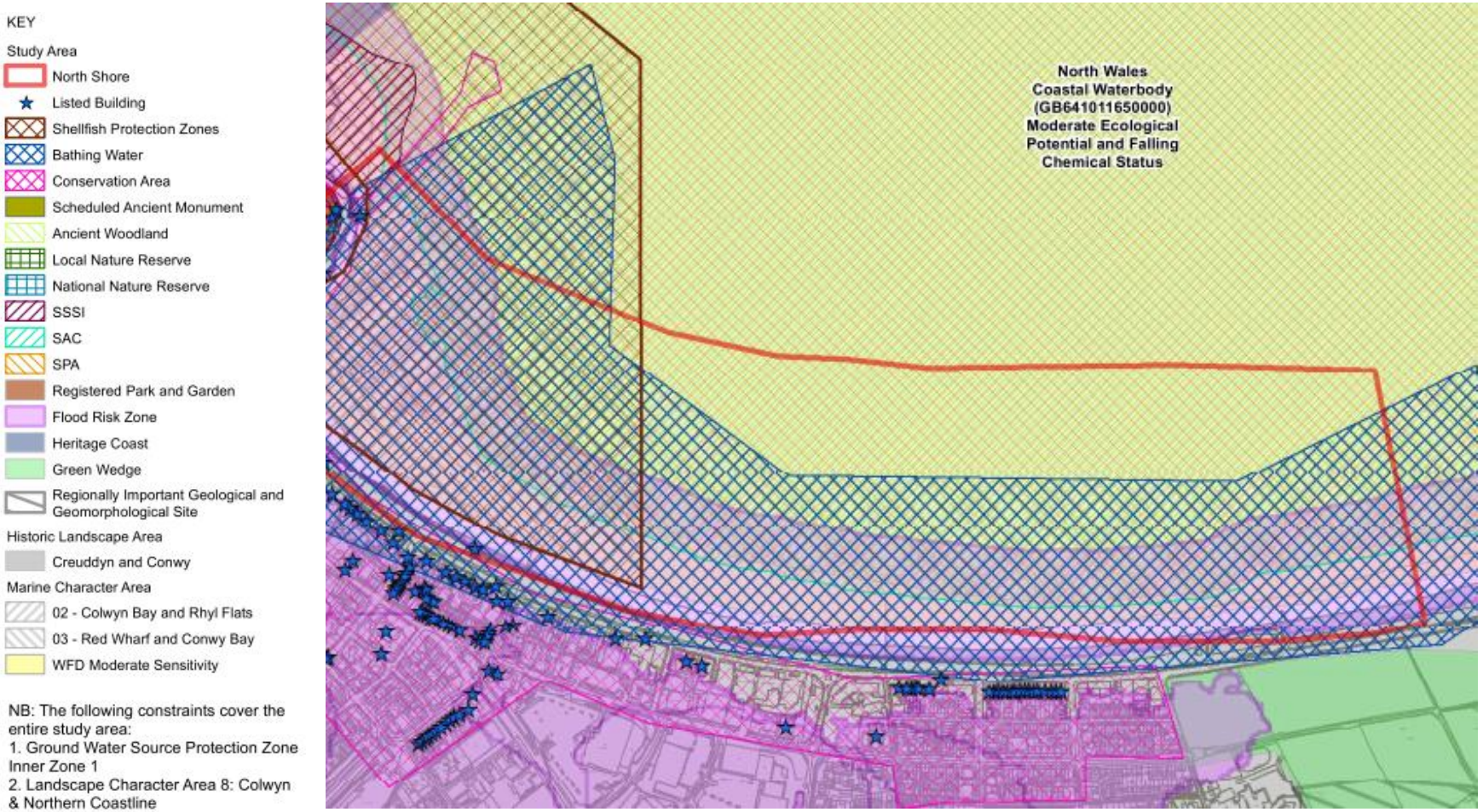


Figure 2-2. North Shore Constraints Plan (AECOM, 2017)

Figure 2-3 identifies any statutory designated sites within a 2km buffer of the West Shore. For this frontage it should be noted that the sand dunes system are a UK BAP habitat therefore this may be affected if the system is changed to prevent sand build up. In addition the West Shore lies directly within the Aber Afon Conwy SSSI and adjacent to the Menai Strait and Conwy Bay SAC and Liverpool Bay SPA.

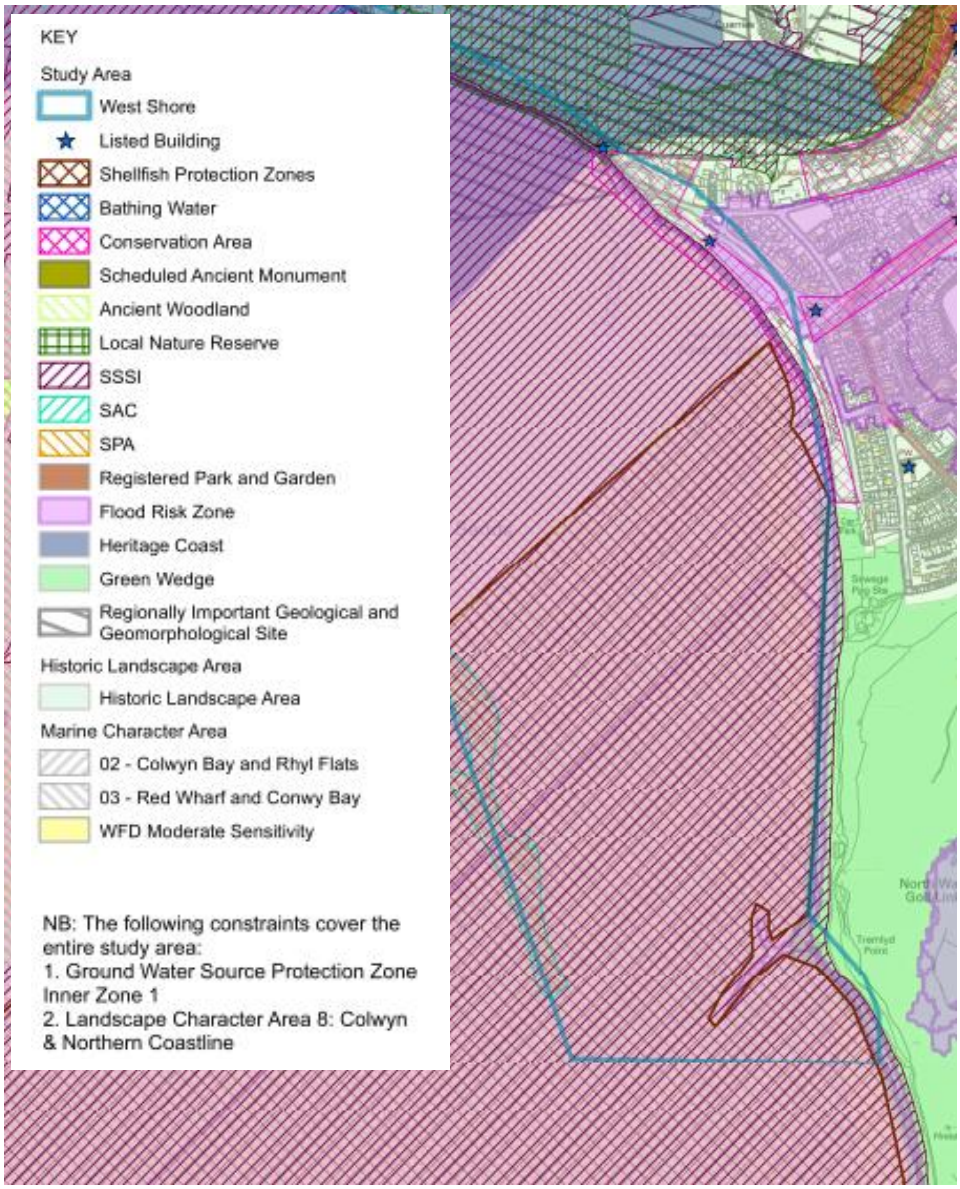


Figure 2-3. West Shore Constraints Plan (AECOM, 2017)

Any development of either frontage will need to take into account seasonal constraints in relation to bird species due to the sensitivity of the statutory sites close to the beach area. Further ecological assessments are recommended due to the proximity to statutory sites and the sensitivity of the area as shown in Figure 2-2 and Figure 2-3.

2.5 Condition assessment

Regular inspections of the coastal defences along this frontage have been undertaken by Conwy County Borough Council since 1996. The aim of these inspections has been to identify any defects in the assets and to support their on-going capital and maintenance programme.

CEUK undertook repeat annual inspections from 2002 to 2012 (see Appendix B for further details). The *pro forma* for this assessment provides information relating to asset code, location and structure type for defence lengths along with a condition assessment and a rate of deterioration since the previous assessment. In addition an assessment of the residual life under the following scenarios was undertaken: No Active Intervention (Do Nothing) and Continued Current Management.

In 2015 JBA undertook a survey of the profile and conditions of a number of the defences along the North and West Shore (assessment sheets are provided in Appendix C). For the North Shore the following defences were all assessed to be in a fair condition:

1. The main concrete stepped revetment
2. The sloping masonry around the pool at Craig-Y-Don
3. The promenade and secondary flood wall along the whole frontage

However the near vertical sea wall to the Pavilion Site, Grand Hotel and Children's Corner was not assessed.

For the West Shore, the following assets were examined and the two structures were considered to be in fair condition:

1. The main stepped wall structure
2. The concrete promenade and recurved wave wall

A separate assessment was made of the North West Golf Club Dunes but no condition grade was identified.

2.6 Existing flood risk

The inundation modelling undertaken as part of the CTFRA (2006) and based on the best estimates of the joint probability of waves and water levels, concluded that inundation of Llandudno is limited to extreme events of AEP 0.5% or less (200 years or more) unless a breach occurs. The flood risk due to a breach on the West Shore was found to be significant and the report cautions that action may be required to protect against the loss of life (HRW, 2006).

Since the CTFRA was undertaken the Environment Agency has published extreme water levels for a range of AEPs all around England and Wales (EA, 2008). These data are referred to as the Coastal Flood Boundary conditions (CFB) and are provided as ESRI shapefiles. The new CTFRA will update the assessment of the coastal flood risk for combined waves and water levels.

Additionally since the previous CTFRA the topographic data for the area has been significantly improved through the use of LiDAR surveys. A 2 m resolution LiDAR grid is available for the whole area.

Using the latest LiDAR data and the water levels used in the updated CTFRA, the land area that is below the extreme water levels corresponding to a range of ARIs for the Present Day (Figure 2-4) and Future after 100 years' climate change (Figure 2-5) have been identified. These images highlight that the town is in a bowl with the defences along the North Shore and West Shore acting as the rims to stop water flooding in from the sea. The analysis confirms that the existing defences provide a standard of protection against still water levels of 0.5% (200 years). However the future standard of protection falls below the AEP 0.5% and, as identified in the previous CTFRA, additional defences may be required to protect the town from flooding. Note also that once water has overtopped the defences there is no

natural drainage of surface water to the sea and the surface water drainage system will be required to drain the water.

The updated CTFRA has confirmed this assessment. The Present Day (2017) and Future (2117) flood risk for Llandudno is shown in Figure 2-6 to Figure 2-9 for the existing and post winter 2013/14 beach levels. These figures show that the beach levels are critical to the Present Day flood defence and also the flood risk increases significantly after 100 years of climate change. These maps include the risk of flooding from breaching, still water and wave overtopping.

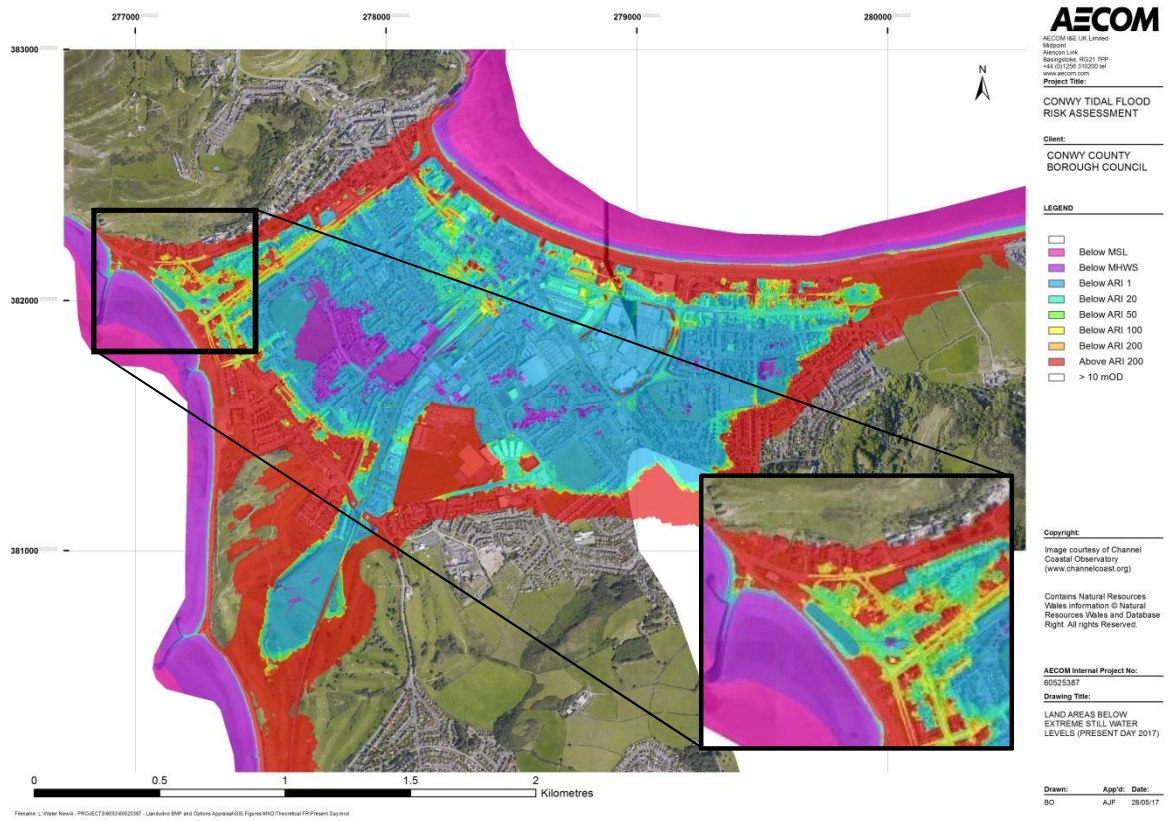


Figure 2-4. Land areas that are below the water levels for a range of ARIs for the present day (2017)

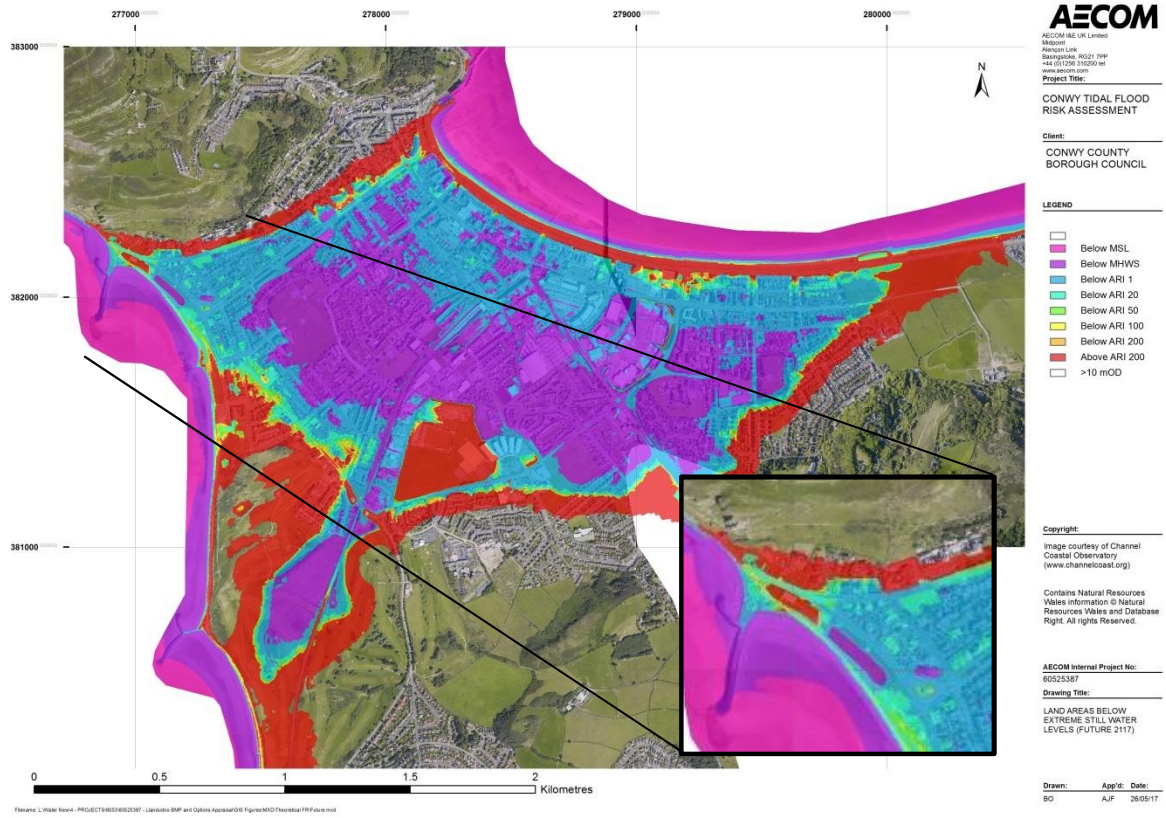


Figure 2-5. Land areas that are below the water levels for a range of ARIs for the present day +100 years (2117)

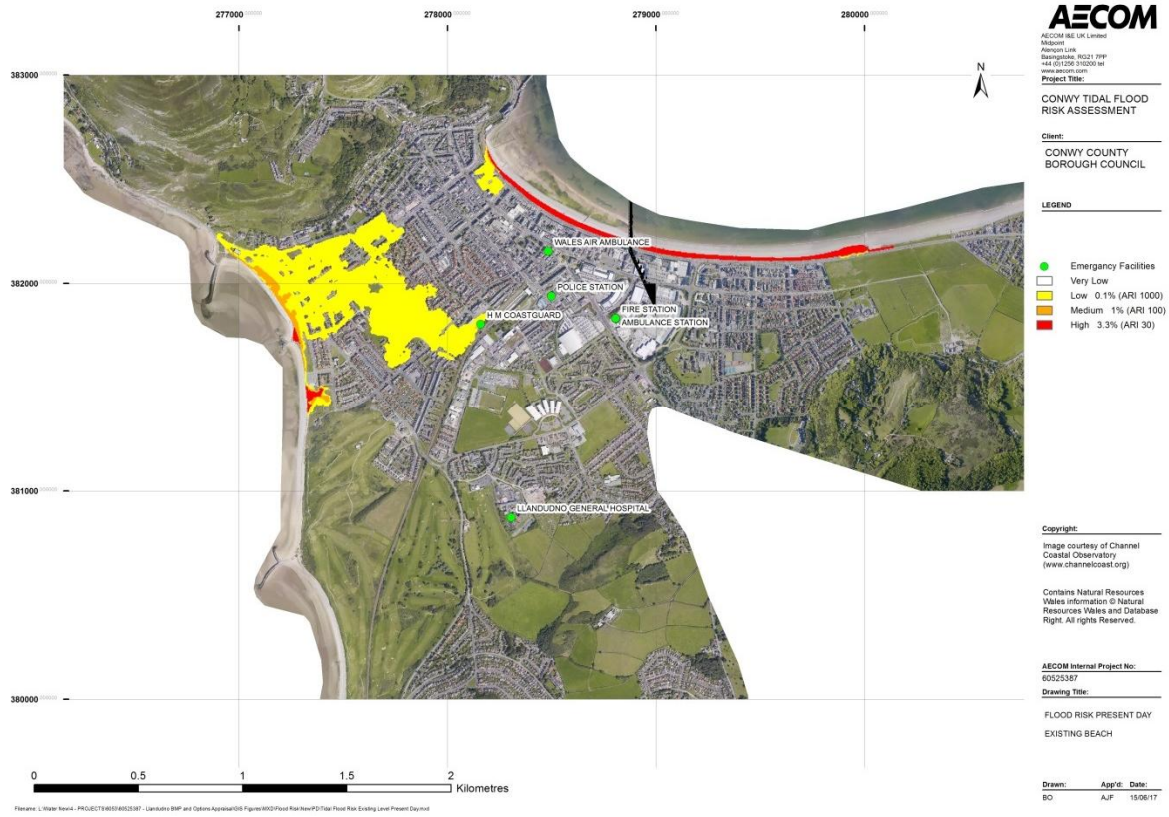


Figure 2-6. Present day (2017) flood risk in Llandudno based on existing beach levels

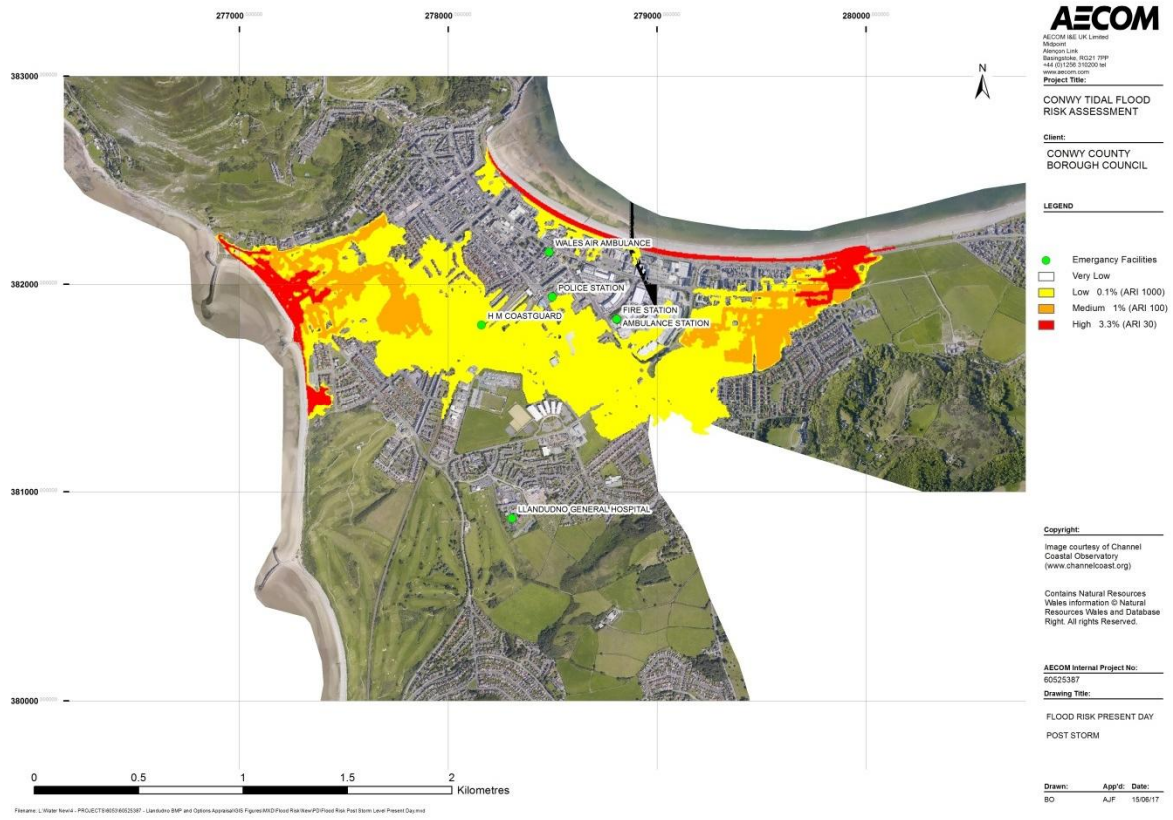


Figure 2-7. Present day (2017) flood risk in Llandudno based on Post 2013/14 Storms beach levels

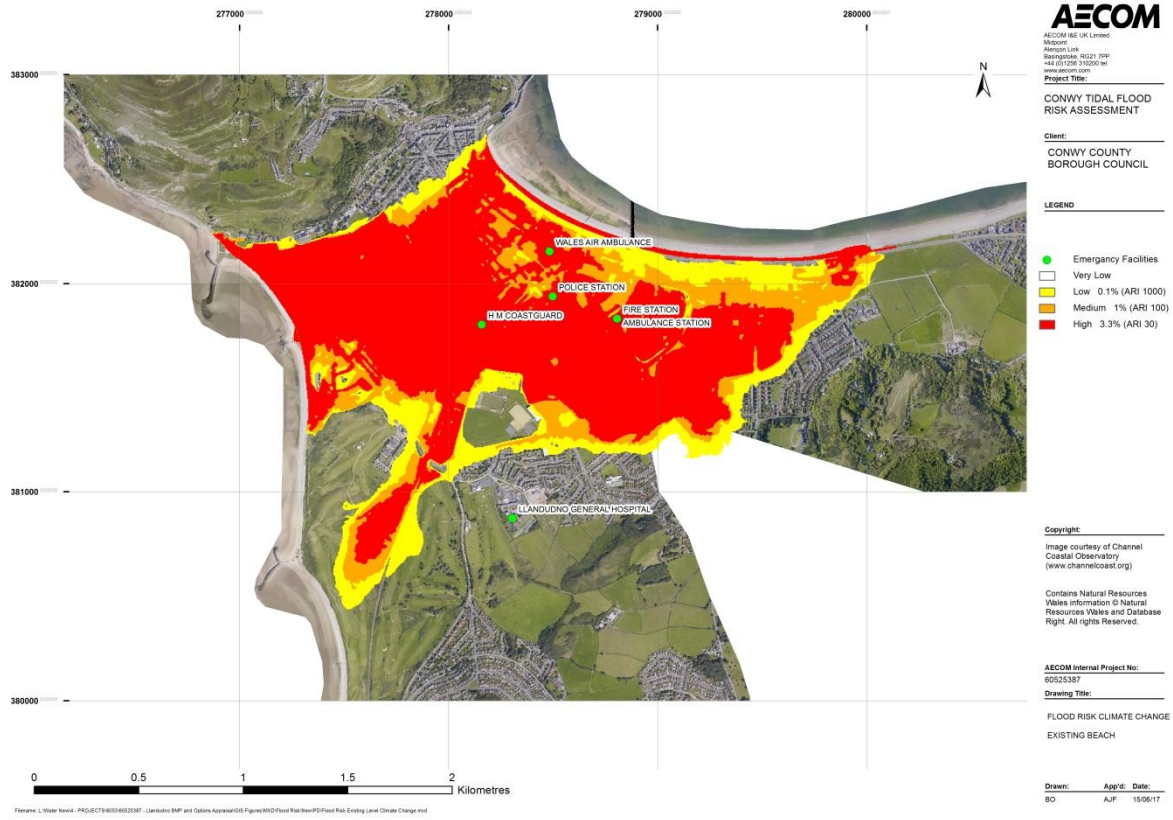


Figure 2-8. Future (2117) flood risk in Llandudno based on Existing beach levels

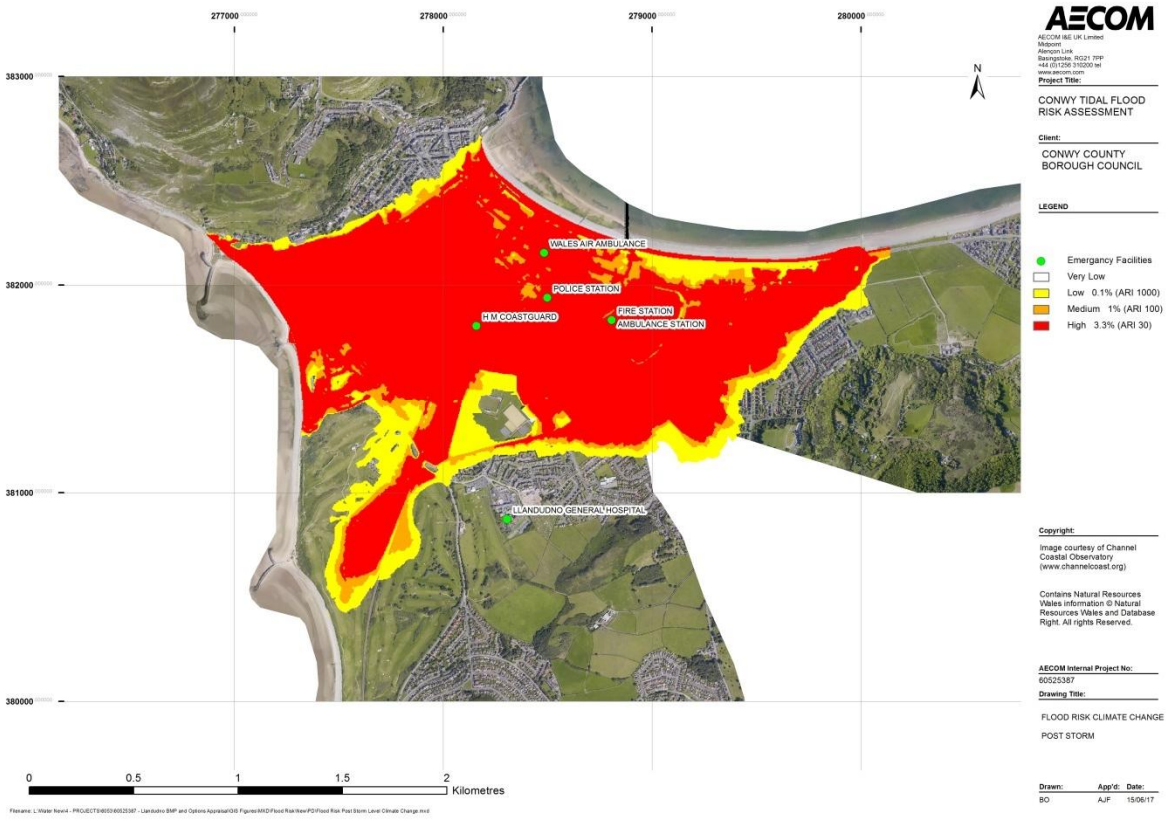


Figure 2-9. Future (2117) flood risk in Llandudno based on Post 2013/14 Storm beach levels

3. Environmental Constraints

3.1 Coastal processes appraisal

3.1.1 Site Description

The North Shore is located to the east of the Great Orme's Head while the West Shore is located on the western side of the headland.

The local geology is dominated by two Dyserth limestone group outcrops at the extremities of the North Shore frontage, the Great Orme and Little Orme. In between, the underlying geology consists of sedimentary rocks. Drift deposits consist primarily of wind-blown sand deposits or tidal flat deposits of clay, silt and sand formed 2-3 million years ago in the Quaternary period. The built up area of Llandudno is primarily built on sand deposits and marshland. Maps showing both the solid and drift geology of each of the frontages can be found in Appendix B of this report.

The defences along the North Shore frontage perform a pivotal role given the popularity of the area as both a holiday resort and a residential area. Coastal flooding has been an ongoing problem experienced at Llandudno, this is evidenced by the most recent flood event which occurred during the winter 2013/14 storms which caused significant damage to coastal defences around the Conwy coastline, in particular at Llandudno North Shore. Large scale shingle renourishment was undertaken to bring the beach back up to the standard of protection provided by the 1996-2000 work on the frontage.

3.1.2 North Shore

The North Shore is protected by a steep upper shingle beach and a flatter, lower sand beach. There is also a wide tarmacadam surfaced promenade with a low level wall fronted by a stepped concrete revetment on toe piles. The shingle was imported onto the foreshore over a 5 week period following the 2013/14 winter storms as the existing shingle beach protection levels had fallen below previously determined trigger levels required to protect the structures. Figure 3-1 shows the current North Shore profile following the re-nourishment works in 2014. The variations in the frontage profile over a number of years, including the 2014 post storm profile, are illustrated in Figure 3-2. This highlights the extreme erosion that occurred as a result of the 2013-14 storm events and the increased flood risk which resulted from this lower defence standard.

Figure 3-1. View from east to west of the current North Shore profile (AECOM, 2016)

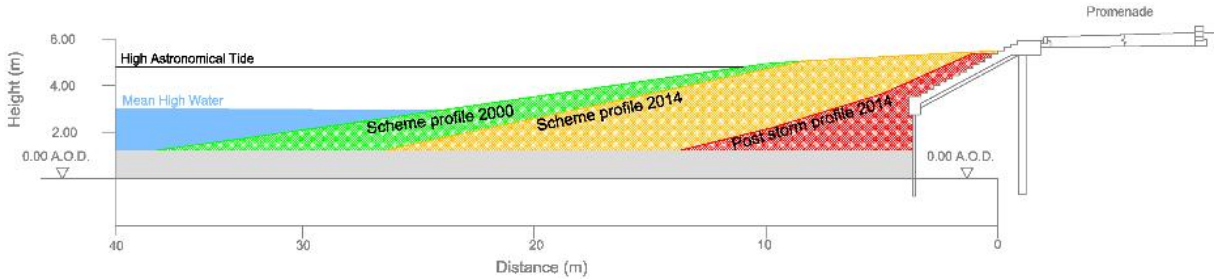


Figure 3-2. Typical North Shore cross section showing scheme profile for 2000, 2014 and post storm 2014 (CCBC, 2016)

Monitoring of the beach at North Shore has been carried out by the succession of Urban District, Borough and County Councils, since the start of the 20th century and is continuing to this day. The results of the beach monitoring have shown that the majority of the sections are showing loss of material since the recharge was completed in 2000. There have been losses of approximately 50 000m³ of material across the bay, even allowing for the 30 000m³ of material that was imported after the 2013-14 storm event. The monitoring data also showed that specifically there was a loss of 10 000m³ of material across the entire bay, 8 000m³ of which was lost at the recharged section, as a result of the 2013-14 storms.

3.1.3 West Shore

The West Shore consists of a more varied shoreline. The whole frontage is protected by a wide inter-tidal sand beach area. The beach foreshore gradient is very flat and the beach is predominately made up of sand with isolated gravel deposits.

Along the West Shore the defences consist of a stepped concrete seawall supported on a sheet piled toe with a promenade and a rear wave return wall along the crest. In addition there are 3 shore connected breakwaters located at Cerrig Duon, opposite Lloyd Street and at Gogarth. The main issue along the West Shore is the effect of windblown sand. This causes a build-up of material in front of properties and along the cycle path and requires regular removal (Figure 3-3).

Figure 3-3. Build-up of material along the West Shore cycle path (AECOM, 2016)

There is less historical data related to sediment movement at West Shore. Monitoring of the beach since 1997 following scheme implementation in 1992 has been carried out by the recording of beach plan surveys from the Great Orme to Deganwy. Since 2008 surveys have sub divided the longshore areas into upper and lower beach to record the changes across the sections of shingle/cobble beach and sand beach separately. The results of the analysis showed that the behaviour of material here is generally cyclical whilst the upper sections of beach are showing a stable/ modestly accreting trend and the lower sections of beach are showing losses. Some of these losses will be associated with aeolian transport of sand from the lower beach into the upper sections, which has been a direct contributor of the dune development at the root of the Gogarth and Lloyd St groynes and along the North Wales Golf Club frontage. The effects of the December 5th 2013 storm at West Shore appear to be a reverse of normal behaviour with overall an increase in lower beach volume coupled with a slight decrease in upper beach volume, with waves potentially mobilising inter-tidal sediments further offshore and moving them shoreward whilst at the same time causing scour at the upper beach and draw down of sediment into the upper parts of the lower beach.

In general the construction of the fishtail groynes along this frontage have acted to stabilise the upper beach conditions by intercepting waves from the predominant direction that

previously would have been incident on the seawall and blocking wave induced southerly longshore sediment transport across the frontage.

3.1.4 Climate change

The potential impacts of climate change on the risk of tidal flooding must be considered. Conwy County Borough Council has issued guidance on the inclusion of climate change in its projects (CCBC, 2016). The current Welsh Government guidance (Welsh Government, 2012) is based on the Environment Agency guidance "Adapting to Climate Change: Advice for flood and coastal risk management authorities" (EA, 2011). In February 2016 the Environment Agency published new guidance (EA, 2016) which states in the introduction that the new guidance supersedes the 2011 guidance; however this has not been adopted in Wales. The revised guidance provides information on how the different effects of climate change should be considered for the next 100 years. The guidance notes however state that there has been no change to the values for wind speed, wave height, storm surge or mean sea level since the 2011 guidance.

Figure 3-4 shows the relative sea level rise from 2017 based on the guidance for different emission scenarios. The graph shows the emissions scenario selected by CCBC, Medium Emissions Change Factor 95th percentile, as a green dashed line. All data has been downloaded from the DEFRA website (http://ukclimateprojections-ui.metoffice.gov.uk/ui/) or taken from the tables in the latest guidance. For the purposes of the present FRA the 95th percentile for the medium emissions scenario will be used. The resulting values for relative sea level rise compared to 2017 are shown in Table 3-1.

The EA Guidance (2016) provides a summary table that states the wave height should be increased by 5% between 1990 and 2055 and by 10% for 2056 to 2115.

The impacts of climate change are included in the wave and water level conditions described in Section 3.1.4.

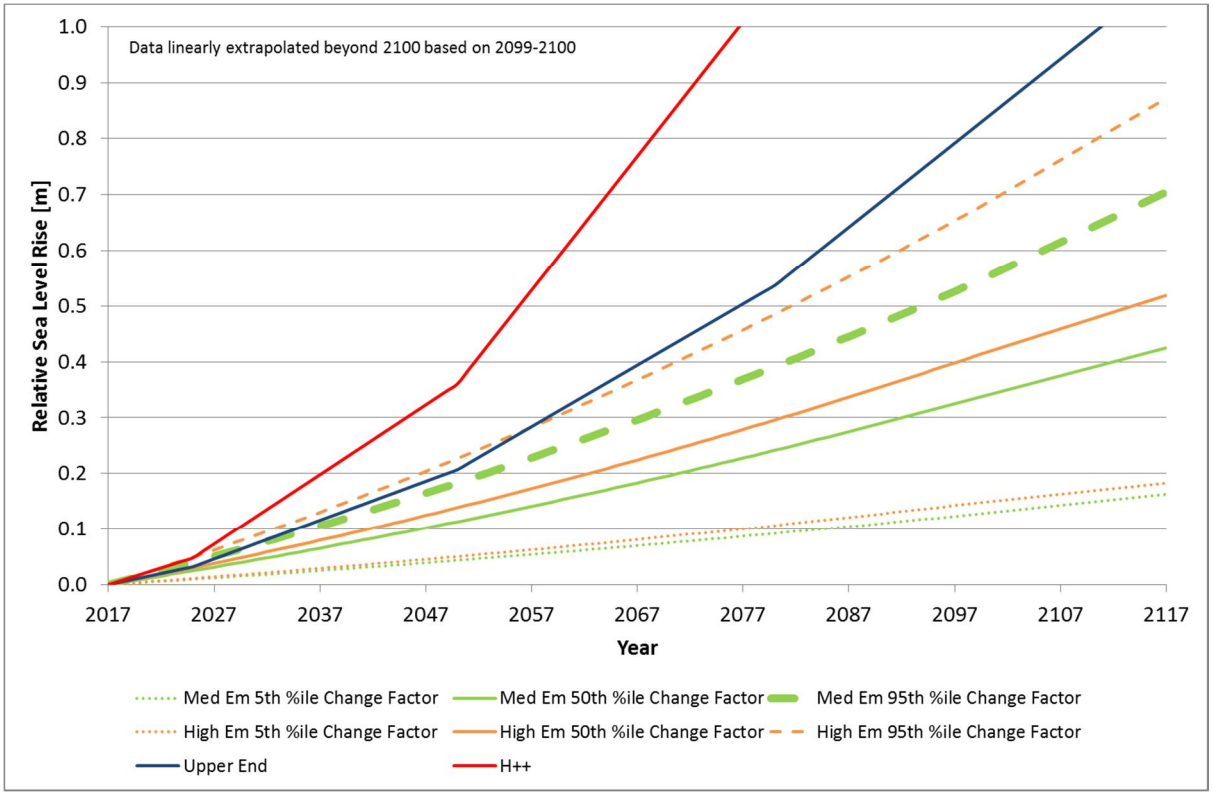


Figure 3-4. Relative Sea Level Rise [m] for different scenarios

Table 3-1. Increase in Mean Sea Level relative to 2017 for different years based on the 95th percentile for the Medium Emissions Scenario

Year	Increase in MSL [m] relative to 2017	Year	Increase in MSL [m] relative to 2017
2017	0.000	2077	0.369
2027	0.051	2087	0.445
2037	0.106	2097	0.526
2047	0.165	2107	0.615
2057	0.228	2117	0.705
2067	0.296		

3.1.5 Wave and water level conditions

The wave and water level conditions for the North and West Shore were provided by CCBC for the purposes of the CTFRA. The information provided a database of 124 474 wind, wave and water level combinations that were transferred from the offshore to the nearshore. The water levels are based on the Environment Agency Coastal Flood Boundary conditions (EA, 2008).

Table 3-2. Extreme water levels as defined by CCBC including the allowance for sea level rise of 0.7 m for 2017 to 2117.

Return Period [years]	Present Day (2017) [mODN]	+100 Years Climate Change (2117) [mODN]
1	4.77	5.47
2	4.84	5.54
5	4.95	5.65
10	5.03	5.73
20	5.11	5.81
25	5.14	5.84
50	5.22	5.92
75	5.27	5.97
100	5.31	6.01
150	5.36	6.06
200	5.40	6.10
250	5.42	6.12
300	5.45	6.15
500	5.51	6.21
1000	5.60	6.30
10000	5.91	6.61

3.1.6 Beach processes, wave run-up and overtopping

The beach processes affecting the North and West Shores are driven by the tidal range and wave conditions. For the purposes of this BMP it is necessary to understand the different way in which a shingle and a sandy beach respond to the same wave and water level conditions.

The mobility of sediment is a function of the currents close to the sea bed and the size of the particles of sediment. Currents at the bed may be generated by tidal flows or waves, with the strongest currents occurring close to the breaking point of the waves. Large heavy particles are able to resist stronger currents than small fine particles.

A shingle beach profile may be characterised (Figure 3-5) by the key features of the profile. The crest is the highest point on the face of the beach and the step occurs below the still water level close to the breaking point of the waves. The waves break on the ‘step’ and rush up the slope, pushing material up the slope to build the crest. The material is then not pulled back down the face of the beach as some of the water drains through the beach. The coarser the beach the more the asymmetry between the sediment moved onshore and offshore becomes. As the tide rises the location of the step and elevation of the crest will vary with the highest crest elevation forming at the highest water level. As the tide rises however, the step will move landward, material being dragged down the profile due to slope stability and the turbulence of the breaking wave. The beach crest will also migrate or ‘roll over’ as sediment is pushed higher than the existing crest level.

If the crest reaches a hard point such as a sea wall then, if the crest of the wall is too low, the material and water will overtop the sea wall.

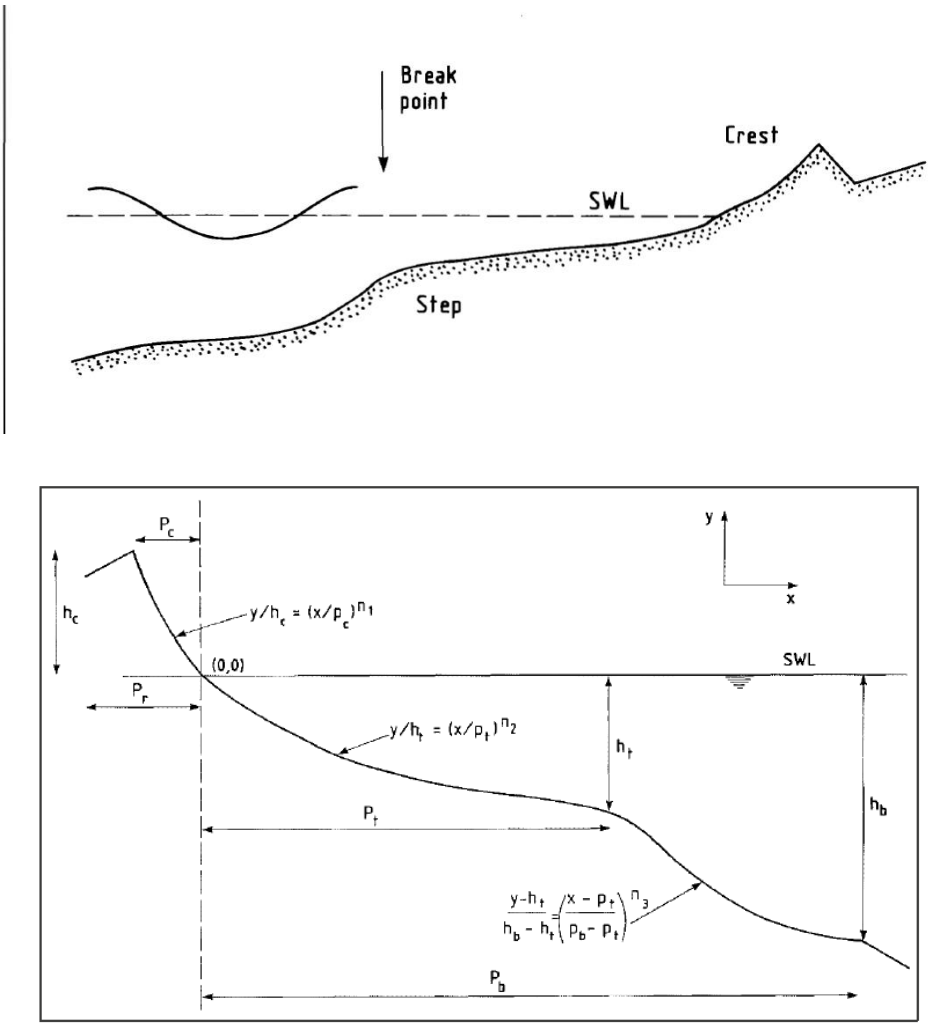


Figure 3-5. Simplified (top) and schematised (bottom) shingle beach profiles (after Fig 1.2 and 4.1, Powell, 1990)

A similar beach profile characterisation may be undertaken for a sand beach (Figure 3-6). Note the steep beach profile (solid line) characteristic of swell waves with a clear beach crest (berm) and the shallow profile of the storm profile (dashed line). Note also the presence of the bar on the storm profile.

On a sand beach the breaking wave draws sediment down the profile forming a bar and there is less asymmetry between the sediment moved onshore and offshore by the uprush and backwash of the water. The crest may be built up; however the tendency is for the profile to flatten such that the breaking waves are broken more gradually by a lower beach gradient and the beach crest levels are 'drawn-down'.

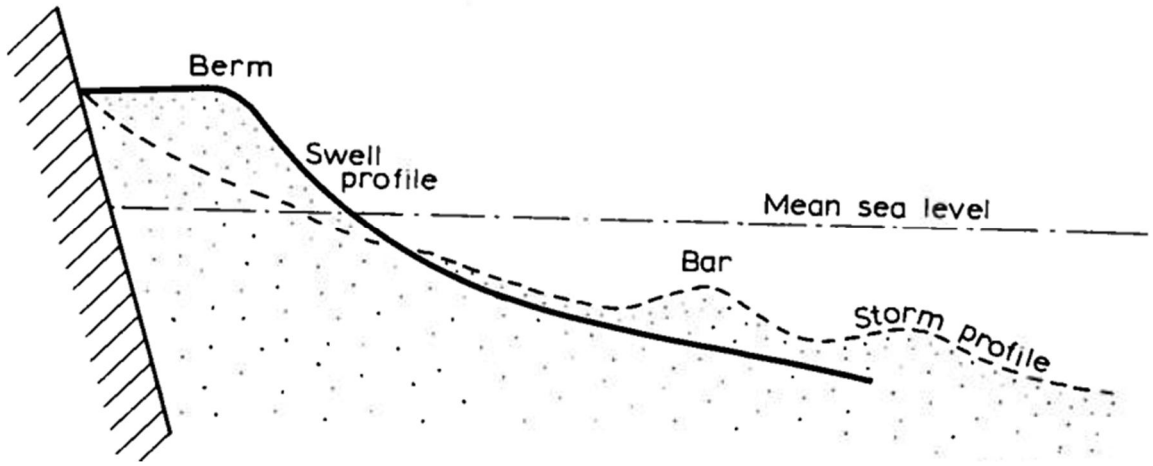


Figure 3-6. Simplified sand beach profiles (after figure 6.2, Pethick, 1984).

The consequence of the beach lowering in front of a sea wall is significant. Firstly, if the beach levels simply lower the potential for overtopping is increased (Figure 3-7).

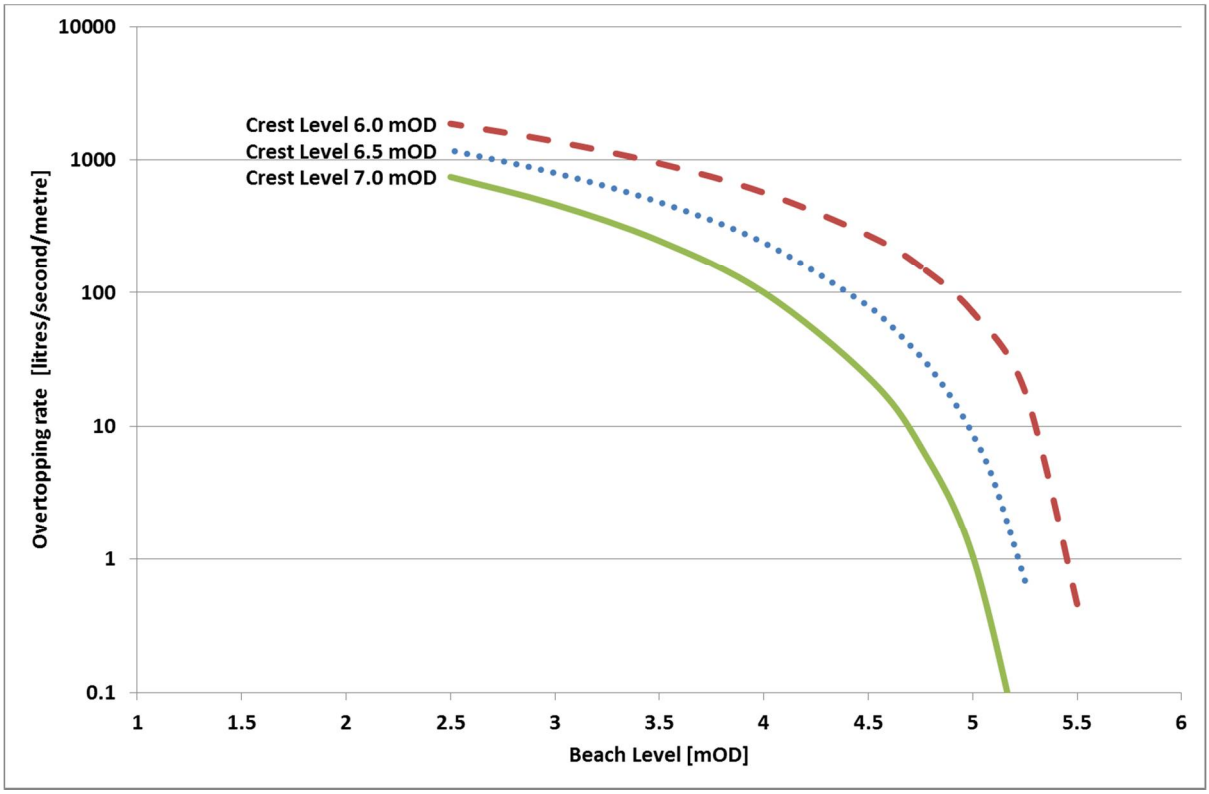


Figure 3-7. Estimated overtopping rates for the 1 in 100 year wave and water level condition for a range of sea wall crest elevations and beach levels at the toe of the stepped revetment such as on the North Shore.

If beach levels continue to lower, often under a falling tide during a storm, then the beach levels may reduce such that the toe of the structure becomes more reflective. If this occurs then the reflected wave energy combines with the incident wave energy to form a clapotis (the point at which the incoming and reflected waves combine to form a much higher wave than would normally occur at that location and depth of water). The potential for scour under the clapotis is much higher than under just the incident wave as the near bed currents are much larger. This level of scour can result in the exposure of the toe of the sheet pile wall at the base of the stepped revetment. If this occurs then the structural integrity of the stepped

revetment is at risk and could result in a structural failure on a subsequent high tide, particularly if high wave energy also occurs.

It is therefore essential that beach levels in front of the existing sea walls are maintained both to limit the risk of overtopping and to protect the structural integrity of the sea walls.

3.2 Geotechnical assessment

No geotechnical assessment has been undertaken as part of this BMP. This means that no assessment has been made as to the ability of the ground to support proposed solutions. For most solutions this is not likely to be a critical factor or can readily be overcome with reasonable engineering design. However, where options propose structures in locations where no structures already exist, the geotechnical risk should also be considered. This is of particular concern for options where the sea bed will be required to support large rock structures and settlement may occur.

3.3 Environmental assessment

The complete Preliminary Environmental Appraisal along with the frontage constraints maps for both North and West Shore can be found in Appendix A of this report. An initial assessment of the existing situation is provided in Section 2.4 and the assessment of the individual options is presented in Sections 4.4 and 5.4 for the North Shore and West Shore, respectively.

4. North Shore Option Development and Assessment

4.1 Introduction

The North Shore could be considered as a single section of coastal defence protected by a long shingle beach. However, on closer consideration it is clear that there are some areas that are different to others, for example the paddling pool is a specific use at the eastern end and has different requirements to the sandy beach area known as Children's Corner. To help in the distinction of the management options for each section of the beach it has been divided into Management Units. These are based on the different factors that may affect the selection of a management option for that section of shoreline and described in the following section.

The LCF identified a number of Strategic Management Zones for the North Shore as shown in Figure 4-1. This subdivides the frontage into its different uses and has influenced the selection of the management units. The proposed management units for the North Shore are shown inFigure 4-2 and listed in Table 4-1.

Figure 4-1. Strategic Management Zones for North Shore, Llandudno (Llandudno Coastal Forum 2016)

Section 4.2 provides a summary of each MU that describes the location, issues and objectives, and constraints. The long-listed options are presented in Section 4.3 and are cross-referenced to the MU that will be affected by each option.

The qualitative assessment of each option is summarised in the tables shown in Section 4.4 with the options recommended for inclusion on the short-list highlighted in the final assessment table.

Section 4.5 identifies what additional work is required to refine the designs of the short-listed options.

Table 4-1. Management units for the North Shore

Management Unit
MUN1: Point of headland to the Pier Wall
MUN2: Children's Corner from the Pier Wall to Trevor Street slipway
MUN3: Trevor Street slipway to Tudor Road.
MUN4: Tudor Road to the Craig-y-Don paddling pool.
MUN5: Craig-y-Don paddling pool
MUN6: Craig-y-Don paddling pool to the start of the Fishing Zone at Craigside

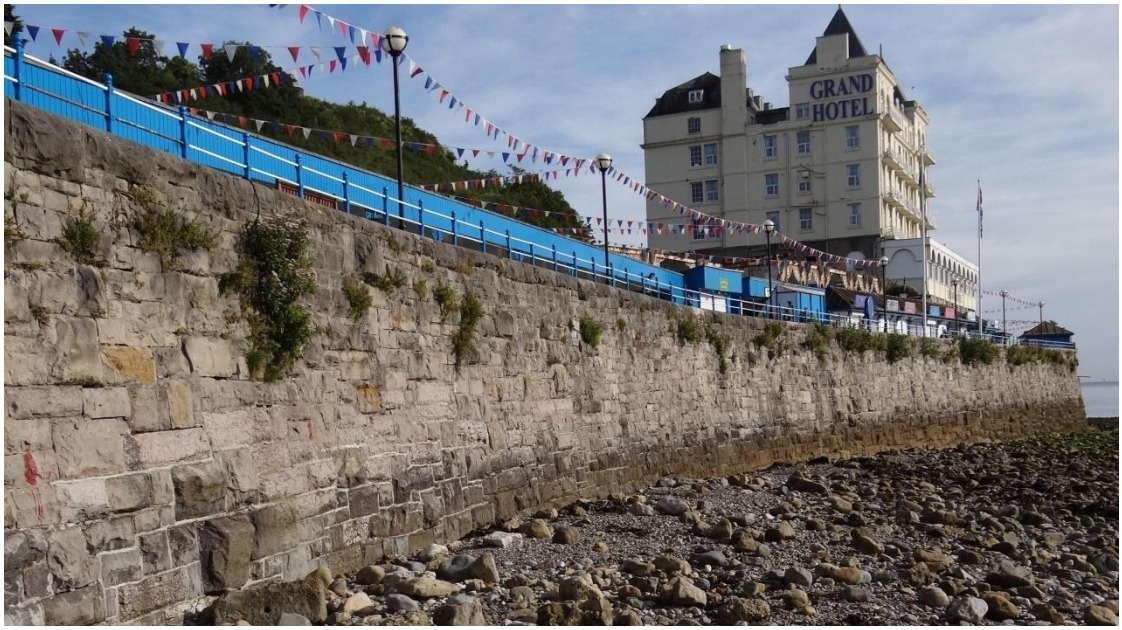
Figure 4-2. Aerial view of the North Shore with key features and Management Units shown

4.2 Management units

4.2.1 Introduction

A description of each MU is provided in the following sections. For each MU there is a photograph, a general description, identification of the specific issues, objectives and constraints. The options that are presented in Section 4.3 and affect the MU are also identified for convenience in cross-referencing.

4.2.2 MUN1: Point of headland to the Pier Wall



Description

The near vertical wall that leads to the pier is privately owned and therefore not the responsibility of CCBC. The maintenance of the beach in front of this wall (and the wall in MUN2) is the responsibility of CCBC. The MU only includes the parts that are owned and managed by CCBC.

Issues and Objectives

The sea wall was not surveyed by JBA in the National Survey of Assets, but in previous surveys by CEUK the risk of failure was considered to be Medium due to the condition rating of 3.

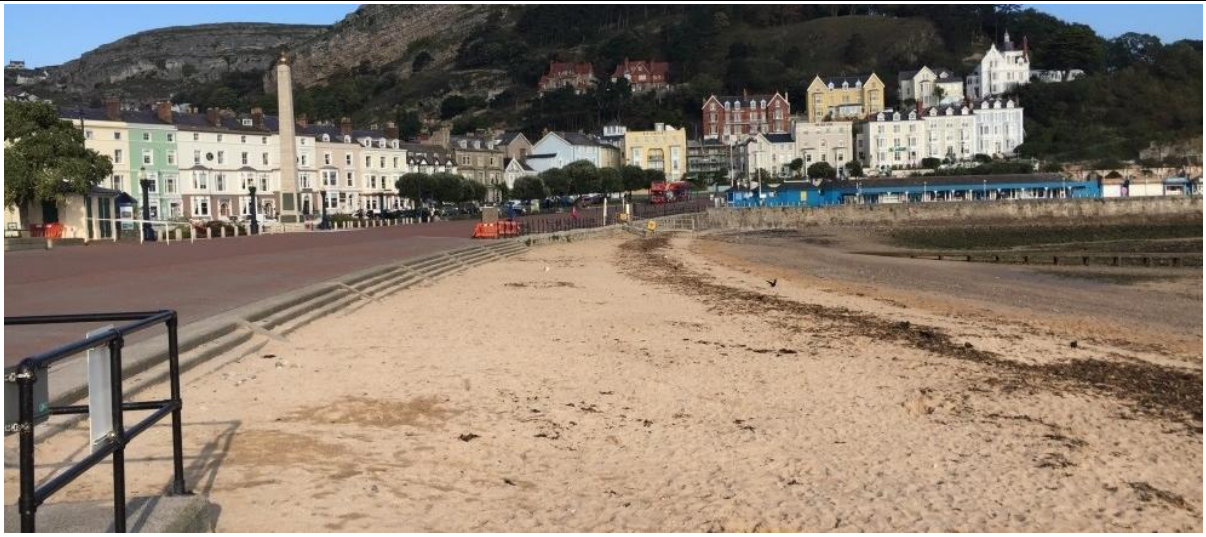
Constraints

Any changes to this wall are considered beyond the scope of this BMP; however given the importance of the wall as the boundary to the beach area and also as a support for the Pavilion site and the lack of its inclusion in the recent JBA inspection, the sea wall should be assessed again.

Options

No options are presented for this MU; however action on the sea wall could affect the options for MU2.

4.2.3 MUN2: Children's Corner from the Pier Wall to Trevor Street slipway



Description

This area consists of a sandy beach which is backed by a stepped concrete revetment with a wide promenade. The northern limit is bounded by the sea wall that leads to the pier and the southern limit by the Trevor Street slipway. The area has traditionally been popular with visitors to the area due to the sandy beach present.

Issues and Objectives

This MU is identified by LCF as being in the 'Beach Zone' and it is anticipated that the actual beach area will be used (rather than the just the water or promenade). The sandy nature of the beach and proximity to the town centre mean that this is a tourist destination.

This section was not modified as part of the previous beach recharge works undertaken in 1996-2000. The beach was not recharged in 2014.

The beach has been recharged from the back by CCBC adding sand taken from the West Shore; although this is generally considered a stable beach by CCBC. Cobble and shingle material that has been moved westerly across the slipway has been separated out and recycled to the east of the slipway.

The area is considered to be the only area along the North Shore where there is an immediate and future flood risk due to still water levels and during storm events waves may overtop the beach, particularly at the top of the Trevor Street Slipway.

The objective for this MU is to maintain the beach area as an amenity whilst ensuring adequate flood protection is achieved.

Constraints

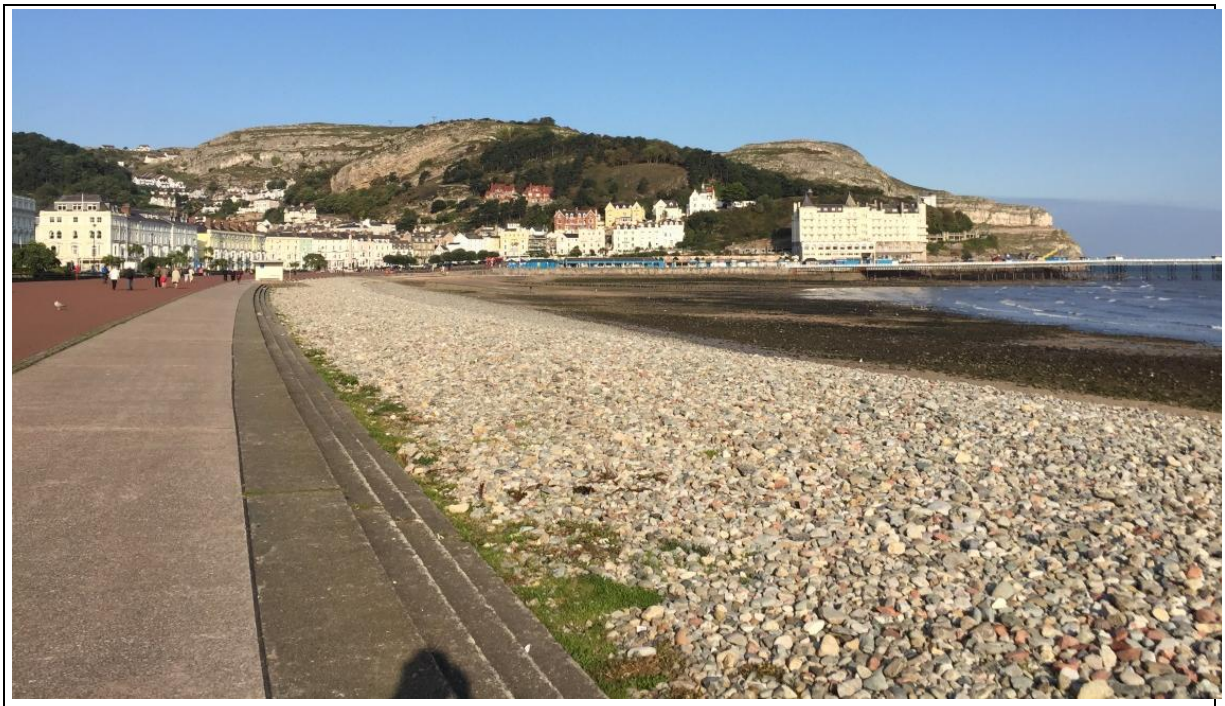
The area is exposed to less wave energy than the MUs to the east.

Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the steps.

Options

The frontage wide options of breakwaters, groynes and beach nourishment will affect this management unit (Options NS1-4). Additionally the Option NS5 will specifically address the beach levels within this MU.

4.2.4 MUN3: Trevor Street slipway to Tudor Road



Description

This unit consists of a steep upper shingle beach and a flatter, lower sand beach. The beach is backed by a stepped concrete revetment and wide promenade. The northern limit is bounded by the Trevor Street slipway and the southern limit by the boundary between the beach zone and the boating zone at Tudor Road.

The beach was recharged with shingle material in 2014 following the storm events.

Issues and Objectives

The low tide platform is a sandy beach area that may be utilised only during low tides. The shingle beach is steep and limits access to the low tide platform except via the Trevor Street Slipway. The shingle beach crest can be raised during storms and spill onto the promenade.

The objective for this MU is to continue to provide flood protection and retain access to the beach.

Constraints

The management unit is more exposed to wave energy than those to the west. Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the steps.

Options

The frontage wide options of breakwaters, groynes and beach nourishment will affect this management unit (Options NS1-4).

4.2.5 MUN4: Tudor Road to the west edge of the Craig-y-Don paddling pool

Description

This unit consists of a steep upper shingle beach and a flatter, lower sand beach. The beach is backed by a stepped concrete revetment and wide promenade. The northern limit is bounded by the border between the beach zone and the boating zone at Tudor Road and the southern limit by the western edge of the paddling pool.

The beach was recharged with shingle material in 2014 following the storm events.

Issues and Objectives

The low tide platform area is not easily accessible and the shingle beach crest can be raised during storms and spill onto the promenade.

The objective for this MU is to continue to provide flood protection and maintain access to the beach.

Constraints

This management unit is significantly exposed to wave energy and is highly dynamic. The damage to the bandstand is as a consequence of beach lowering and attrition by shingle.

Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the steps.

Options

The frontage wide options of breakwaters, groynes and beach nourishment will affect this management unit (Options NS1-4).

4.2.6 MUN5: Craig-y-Don paddling pool

Description

The paddling pool consists of a sloping stone wall on the seaward side with a dwarf crest wall and a rear promenade. The limits of this management unit are bounded by the extents of the paddling pool.

Issues and Objectives

The sloping front wall allows waves to run up the face and overtop into the paddling pool. This results in significant overtopping by waves and large amounts of shingle being thrown onto the pool and surrounds. Damage from the stones is possible and the mix of water and stones overtopping in a storm event could present a risk to life.

The objective for this MU is to maintain the paddling pool as an amenity and provide adequate flood protection.

Constraints

This management unit is significantly exposed to wave energy.

The pool is a popular destination for tourists and a valuable amenity to the North Shore. The extension of the paddling pool out across the beach results in a narrower beach allowing higher waves to reach the pool wall.

Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the revetment.

Options

The frontage wide options of breakwaters and groynes will affect this management unit (Options NS1-4).

Option NS6 will specifically address wave overtopping within this MU.

4.2.7 MUN6: East edge of the Craig-y-Don paddling pool to the start of the Fishing Zone at Colwyn Road

Description

This unit consists of a steep upper shingle beach and a flatter, lower sand beach. The beach is backed by a vertical wall. The western limit is bounded by the eastern limit of the paddling pool and the eastern limit by the boundary between the boating and fishing zone at Colwyn Road.

No recharge was applied to this section of the beach following the 2013-14 winter storms.

Issues and Objectives

The beach in this section protects the B5115 and must be maintained to provide access to and from Llandudno.

Constraints

This management unit is backed by grassland rather than properties as is the case for the majority of the frontage; however the road is an important element of the local infrastructure and must be protected.

Beach levels must be maintained to prevent erosion of the beach and scour at the toe of the vertical wall.

Options

The frontage wide options of breakwaters and groynes will affect this management unit (Options NS1-4).

4.3 Long-list of options

The long-list of options includes options similar to those proposed by the LCF with additional options developed as part of this BMP. Each option has been developed to address specific issues and may comprise several components. The components that have been considered as part of this study are listed below and summary tables of the advantages and disadvantages of each component are provided in Table 4-3 to Table 4-6:

- Breakwater (submerged and surface piercing)
- Groynes (timber and rock)
- Beach nourishment (sand and shingle)
- Wave return wall

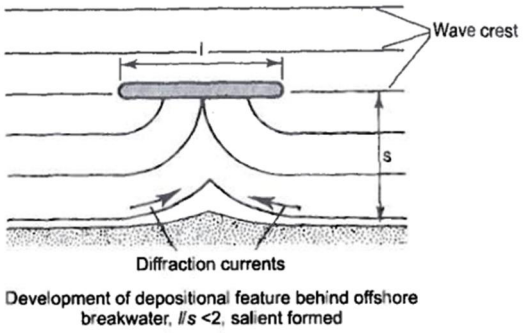
The options are listed below in Table 4-2 and described in the following sections.

Table 4-2. Long-list of Options for the North Shore

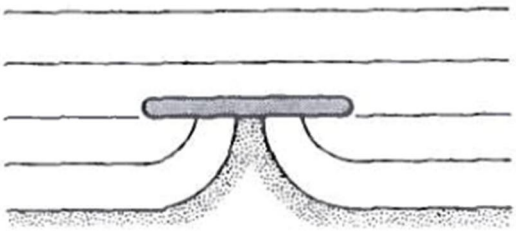
Option	Description
'Do nothing' and 'Do minimum'	'Do nothing' means to allow the defences to deteriorate and not undertake any maintenance. This is not considered acceptable or viable and is not considered any further. 'Do minimum' would mean undertaking the minimum maintenance to maintain the health and safety of people using the beach areas. This option is considered as a baseline for comparison.
Option 1: Detached breakwaters and groynes.	Option 1a: Surface piercing or emergent breakwaters; and Option 1b: Submerged breakwaters. Both are in combination with rock groynes, the removal of some of the existing shingle and replacement with sand.
Option 2: Fishtail rock groynes	Option 2a: Fishtail groynes; and Option 2b: Larger fishtail groynes/ breakwaters. Both options include additional rock groynes, the removal of some of the existing shingle and replacement with sand.
Option 3: Traditional Timber Groynes.	Removal of the shingle and cobbles from MU3, re-nourishing with sand and installing a number of timber groynes, possibly with a breakwater to protect MU1.
Option 4: Beach Nourishment	Option 4A: A single capital re-nourishment of the beach with sand of sufficient quantity to last 20 years. Option 4B: An initial capital re-nourishment and periodic maintenance recharge of the sand. Existing shingle will be removed from the upper beach and sand will be placed on the beach. No control structures are proposed along the frontage.
Option 5: Beach Nourishment at Children's Corner	Shingle in MU2 will be removed and sand will be placed on the beach with maintenance required periodically. No additional control structures are proposed along the frontage.
Option 6: Wave return wall for Paddling Pool	A wave return wall will be added to the crest of the paddling pool revetment.
Option 7: Wave return wall along the promenade	A wave return wall would be constructed along the promenade to increase the standard of protection.

Table 4-3. Advantages and disadvantages of Breakwaters

Description (When is it viable?)	Advantages	Disadvantages



Development of depositional feature behind offshore breakwater, *l*/*s* <2, salient formed



Equilibrium depositional feature behind offshore breakwater, *l*/*s* >2, tombolo formed

(Figures after Figure 6.2, “Rock Manual” (CIRIA, 2007)

The primary purpose is to dissipate the wave energy to protect an area behind the breakwater. The reduction in wave energy reduces the amount of sediment moved both along and across the beach. Breakwaters can be detached or shore connected and can also be submerged or visible above the surface.

- Effective in any tidal range for shingle
- Most effective only in a micro-tidal environment for sand with a detached breakwater
- Effective in micro-tidal has limited effect for sand with a shore connected breakwater
- Ideally used in areas with a dominant drift direction
- Constant wave climate, not storm dominated for a detached breakwater
- Any wave climate for a shore connected breakwater
- Strong shoreline tidal currents ("fishtail" only) for shore connected breakwater
- Salient or tombolo may form behind detached breakwaters (build-up of beach material)

- The higher the crest of the breakwater is above the still water level the more effective it is likely to be.
- Breakwaters can be designed to encourage plant growth and other aquatic life. Some breakwaters then become nearshore recreational dive sites because of the accessibility and aquatic life.

- High crested breakwaters are often considered to negatively impact the aesthetics of a beach as they can limit the view seawards, particularly if they are near to the shore.
- A high tidal range also means that the crest level needs to be high, but the structure may be accessible at low water if a salient or tombolo forms.
- Breakwaters that are submerged under normal tidal conditions are likely to be ineffective during extreme events where the water level is significantly higher than the normal tidal range.
- Rock breakwaters are relatively expensive to build. The costs are higher for breakwaters in deeper water due to the increase in the volume of rock and the size of individual rocks.
- Breakwaters, particularly nearshore detached breakwaters, can result in “rip” or “return” currents between or at the ends of structures producing unsafe swimming conditions near structures. (Where the lack of wave energy makes the area attractive for non-swimmers.)

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Table 4-4. Advantages and disadvantages of Groynes

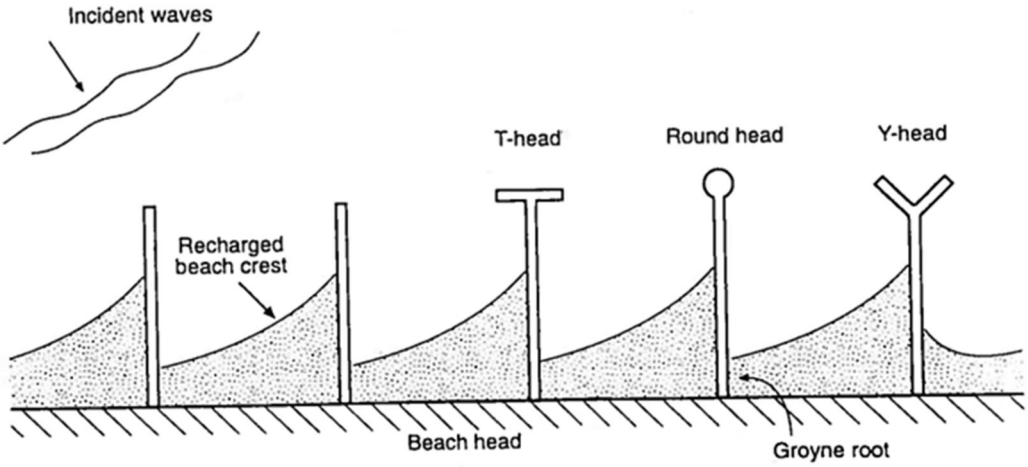
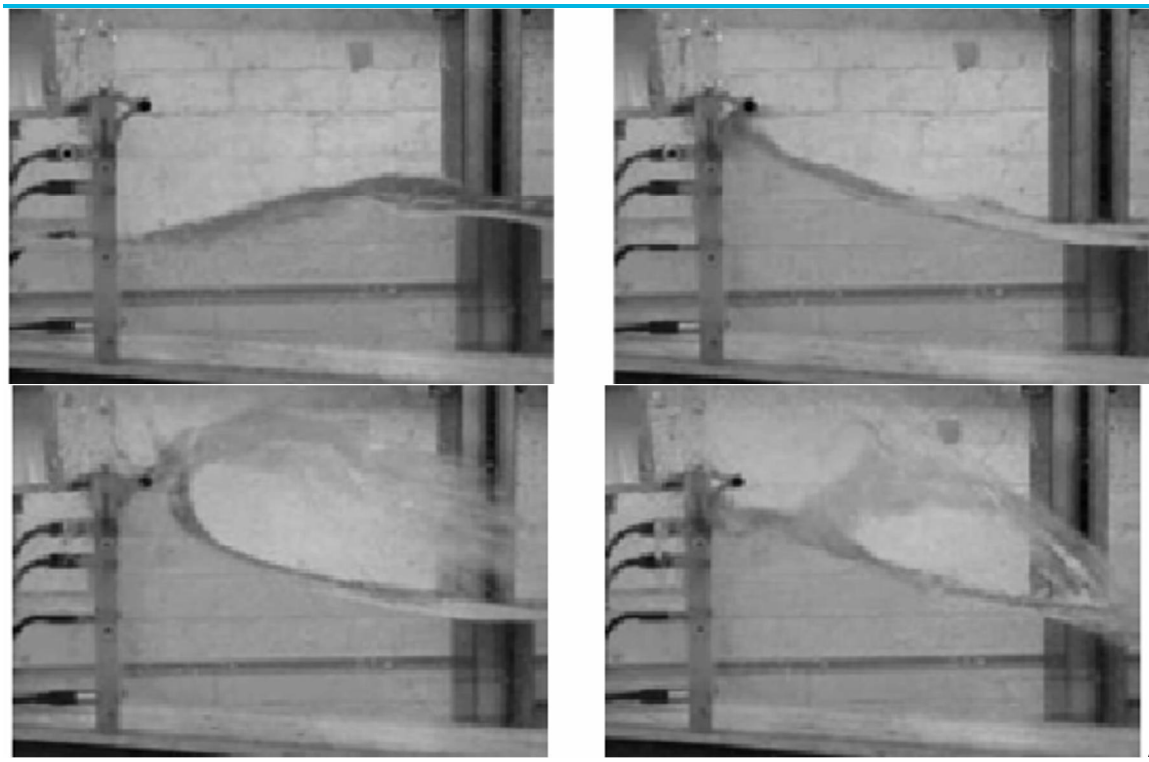
Description (When is it viable?)	Advantages	Disadvantages
 Figure after Figure 8.2, CIRIA, 1996 One of the most common forms of coastal protection. Groynes are shore attached structures that interrupt the longshore movement of sediment and are well suited to environments with high rates of gross transport and low rates of net transport. · Effective in any tidal range for shingle · Effective only in a micro-tidal environment for sand · Low vertical sided structure (normally timber), suitable for low wave energy · Large mound type structures (normally rock) suitable for high wave energy	· Allows for variable levels of protection along the frontage · Slows the rate of longshore drift so the beach material is present, this is aesthetically pleasing and also acts as a form of coastal protection. · Can be used only across part of the profile to control a minimum beach crest width at the back of the beach	· Can induce local currents which increase erosion, particularly on sand beaches · Vertical structures potentially unstable with large cross-structure beach profile differences · Requires recharge to avoid down drift problems · Timber groynes are not sustainable in the long-term and are prone to damage on shingle beaches

Table 4-5. Advantages and disadvantages of beach nourishment/recharge

Description (When is it viable?)	Advantages	Disadvantages
 (Photograph of a small hopper dredger after Figure 14.7, CIRIA, 2010)		
A soft-engineering approach to coastal protection with the aim of replacing or recharging the existing beach with similar or different sediment. The new material may be used to raise the beach crest level or widen the beach. · The beach is raised in level and the profile is altered so that the wave energy can be more efficiently dissipated before the energy reaches the back of the beach. · Sediment may be sacrificial to allow sediment supply to down drift sites to continue. · Normally used under one of the following circumstances: · losses of beach material or a shortage of beach material · a self-contained beach (cell) or · to further enhance the recreational value of the area.	· Less likely to have a negative impact on coastal environments down drift of location. · May improve the recreational use of the beach along with the aesthetics, as no visible structures would be present · Does not discriminate options for future schemes	· Requires maintenance such as recycling of material, further recharge campaigns · Problems with sourcing the material required for the beach recharge as it is required to be of a certain grade · May not be a total solution depending on the coastal processes and volume of recharge.

Table 4-6. Advantages and disadvantages of recurve or wave return walls

Description (When is it viable?)	Advantages	Disadvantages
 A A sequence of photographs showing the effect of a wave return wall in reducing overtopping by redirecting the up-rushing water seaward (towards the right). (Photographs after Figure 7.18, EA, 2007)		
Sea walls are normally large concrete structures extending along the coastline that are designed to maintain the position of the shoreline. A recurve can be added to the crest of the wall in a variety of shapes depending on the site location and what would be the most optimum shape. · Effective in any tidal range for shingle · Effective in any tidal range for sand · A high vertical sided structure, suitable for absorbing/ deflecting wave energy · Large impact on the visual aesthetics of the coast/ beach	· An option can be to have a pavilion built on top of the wall; this can act as access to the beach and also have good social interactions with the public. · Usually the structure has a very long residual life when maintained · Addition of a recurve wall may be a very cost effective improvement to an existing sea wall to increase the standard of protection as an adaptation to climate change.	· Suffers problems due to foreshore lowering erosion · Often implemented with other measures to stabilise material at the toe of the structure · The whole sea wall can be a very expensive structure · Implication with sediment distribution, as the natural supply of material from eroded cliff faces will be removed · May have a negative impact with public due to not wanting change to the frontage

4.3.1 'Do nothing' and 'Do minimum'

The 'Do nothing' or 'Do minimum' options for the future management of the beach areas have been considered.

Under the 'Do nothing' option the defences would not be maintained, no clearing of shingle would occur and there would be no on-going maintenance or monitoring of the beach areas. The 'Do nothing' option is considered technically unacceptable since there is a minimum amount of maintenance required to maintain the safety of the area as a place of work and leisure for the general public. It is also clear from the CTFRA that there is a high risk of flooding in the future and some action is going to be required to provide appropriate protection against flooding. This option would underlie any economic assessment of the options; however for the purposes of identifying options at this stage it is not deemed to be viable and is not considered any further.

The 'Do minimum' option would require the defences to simply be maintained for the purposes of health and safety and would include *ad hoc* management similar to the present management of the defences. The option is also identified as failing to provide the necessary flood protection in the future and therefore not technically viable. The activities that are identified as being performed for the 'Do minimum' option is considered to apply equally to all options. For example all options will need to monitor the beach levels, clear shingle and undertake minor repairs. This means that the costs of the 'Do minimum' option are included in all options and the cost for comparison is effectively £0.

4.3.2 Option 1: Detached Breakwaters (MUN1-6)

Emerged Detached Breakwaters (Option 1A)

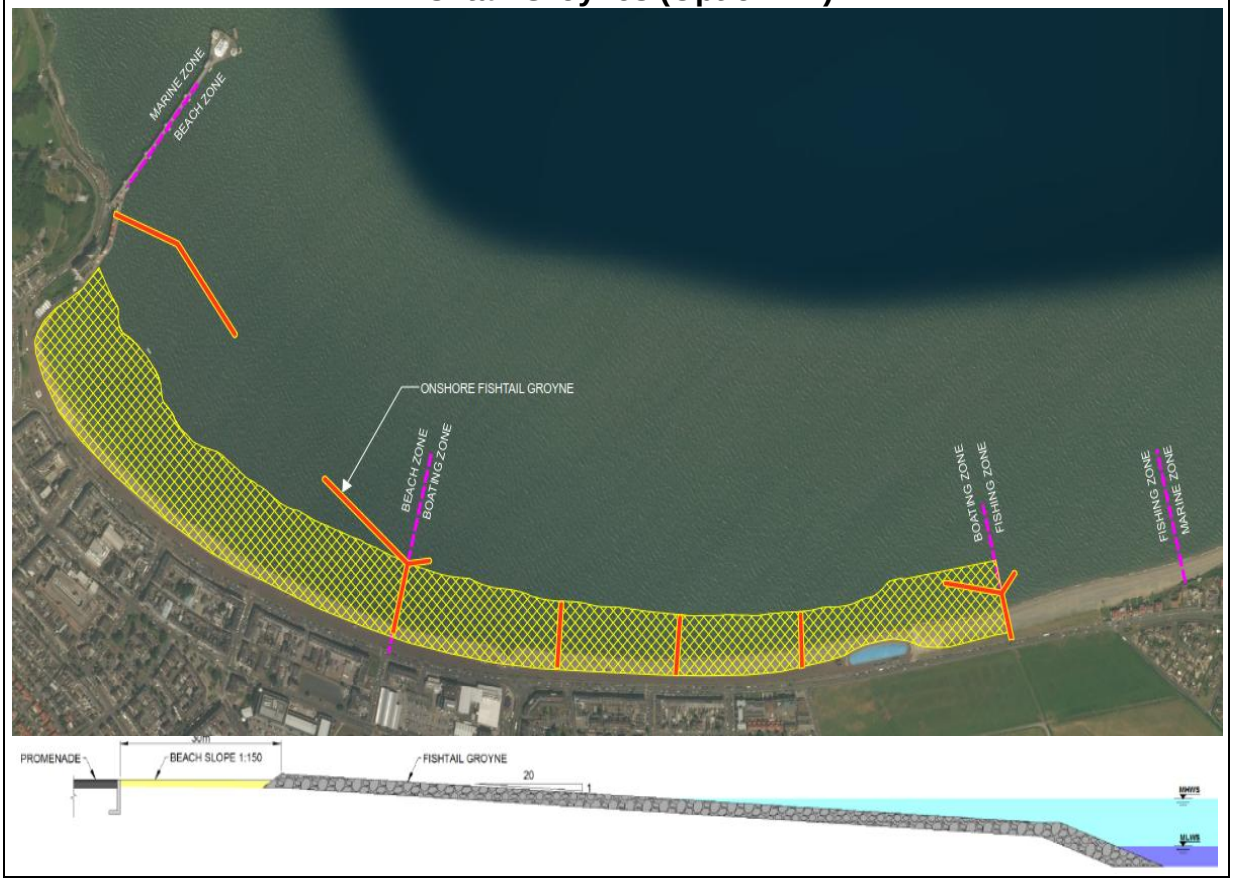
Submerged Detached Breakwaters (Option 1B)

Description	
Two breakwater variations have been considered as part of this long list of options; emerged detached breakwater and submerged detached breakwaters in combination with beach nourishment. The beach protected by the breakwaters will be recharged with sand (and any existing shingle cobbles removed). The specific arrangement of breakwaters will need to be determined through extensive numerical and physical modelling to identify the new beach plan shape with specific attention to the formation of a salient or tombolo.	
Advantages	**Disadvantages**
· Breakwaters will reduce the amount of wave energy reaching the shoreline and therefore reduce the loss of material offshore or alongshore. · Groynes will limit the amount of material moved along the beach. · May create a salient or a tombolo – these are coastal formations of beach material which may or may not be connected to the coastline depending on the feature being considered. · Allow some alongshore material drift. · Stable pocket beaches will be created on the landward side of the groynes. · Allows the existing shingle in MU3 to be removed potentially improving the aesthetics of the beach for some people.	· Large engineering works with potential impacts on local area during construction. · Significant amount of rock armour material required. · High construction cost. · Significant visual impact, particularly for the emerged breakwater. · Requires removal of the existing shingle in MU3 incurring a high cost although material could be recycled to other parts of the beach. · Some work is on privately owned frontage and therefore may require additional agreements/approvals.

4.3.3 Option 2: Fishtail rock groynes (MUN1-6)

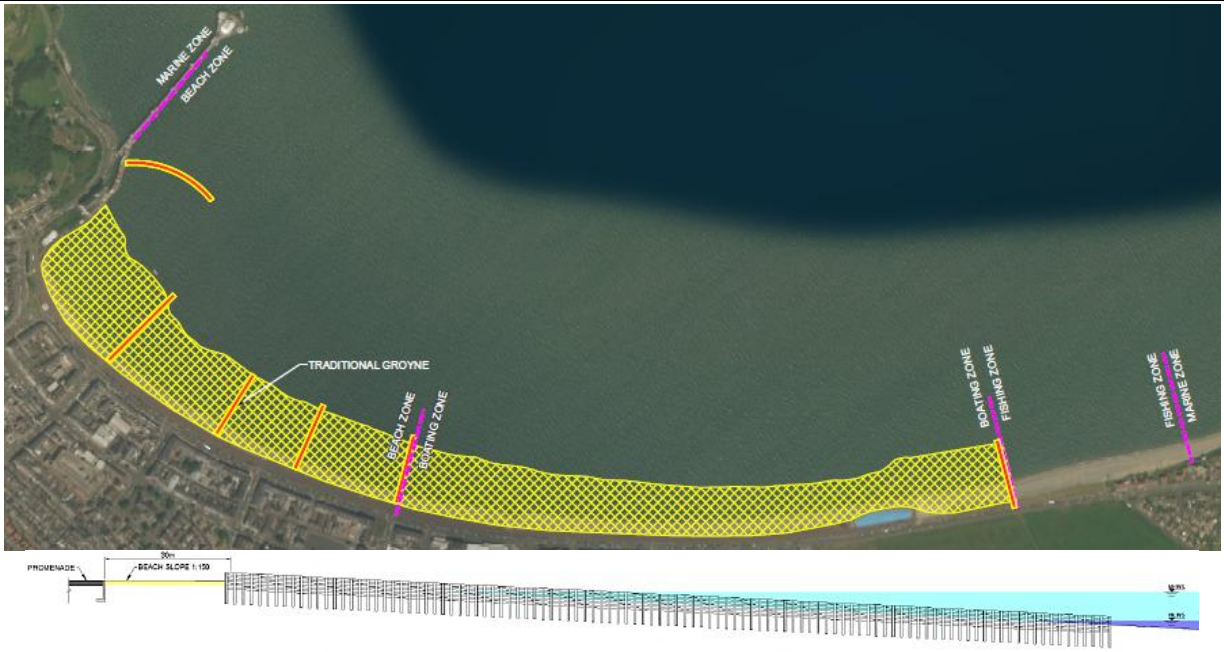
Fishtail Groynes (Option 2A)

Fishtail Groynes (Option 2B)



Description	
Two different configurations of groynes to retain beach nourishment material have been considered; one consisting of fishtail groynes and the other a combination of offshore breakwaters and shore connected groynes.	
Advantages	**Disadvantages**
· Groynes cause the waves to break therefore reducing material erosion. · May create a salient or a tombolo – these are coastal formations of beach material which may or may not be connected to the coastline depending on the feature being considered. · Structures will allow some alongshore material drift · Stable pocket beaches will be created on the landward side of the groynes.	· Significant amount of armour material required. · High construction cost. · Significant visual impact. · Some work is on privately owned frontage and therefore may require additional agreements/approvals. · May restrict existing uninhibited access along the beach.

4.3.4 Option 3: Traditional Timber Groynes (MUN1-6)

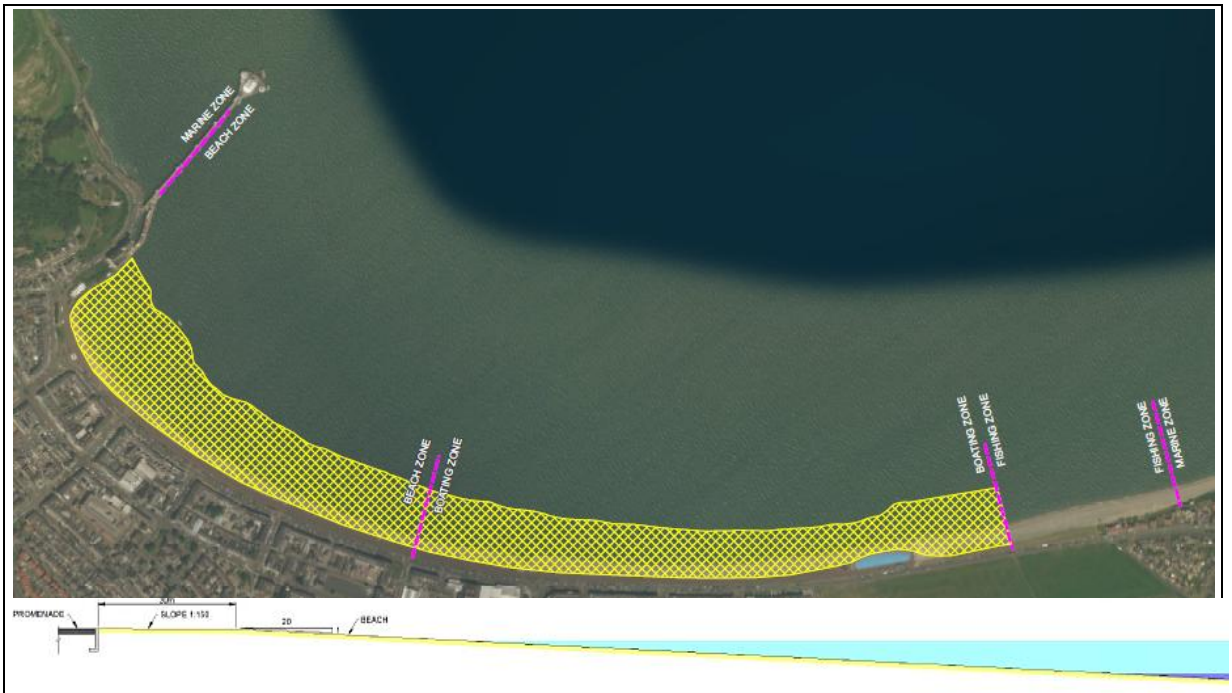


Description

This option involves removing the shingle and cobbles from MU3, re-nourishing with sand and installing a number of timber groynes, possibly with a breakwater to protect MU1.

Advantages	Disadvantages
· Timber groynes will partially block longshore sediment transport and retain material.	· Visual impact. · Impacts on adjacent areas. · High initial cost for construction of structures. · Continual regular maintenance required as groynes will deteriorate over time. · Limited effectiveness at reducing cross-shore transport and therefore loss of sediment offshore.

4.3.5 Option 4: Beach Nourishment (MUN1-6)

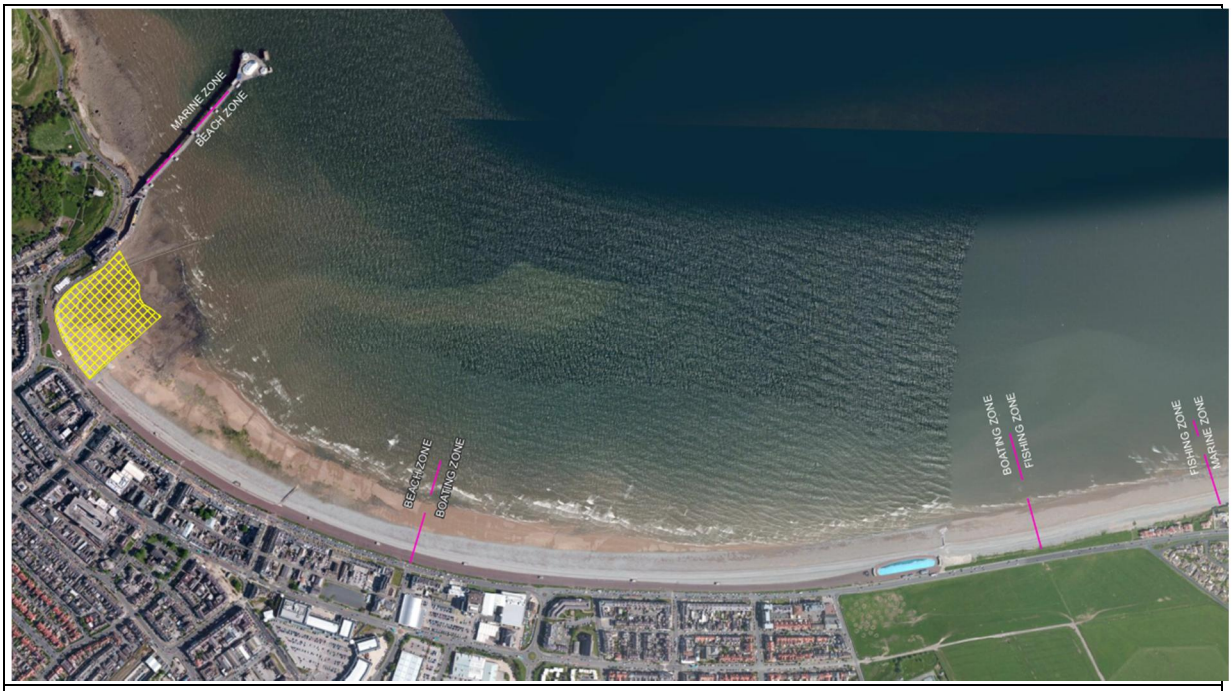


Description

For this option the existing shingle will be removed from the upper beach and sand will be placed on the beach as either a single capital replacement scheme (Option 4A) or as a programme of capital re-nourishment and maintenance recharge. No control structures are proposed along the frontage.

Advantages	Disadvantages
· Flexible coastal management solution i.e. option is reversible and scalable. · Positive impact on adjacent areas through the maintenance of natural sediment transport processes.	· Variable standard of protection provided as beach sediment moves alongshore and down the profile. · Estimating the rate of losses with a high level of confidence is not practical and there is a high risk of higher (or lower) recharge amounts required resulting in higher (or lower) than expected maintenance costs. · Requires more frequent monitoring and management (all options require some monitoring and management).

4.3.6 Option 5: Beach Nourishment Children's Corner (MUN2)

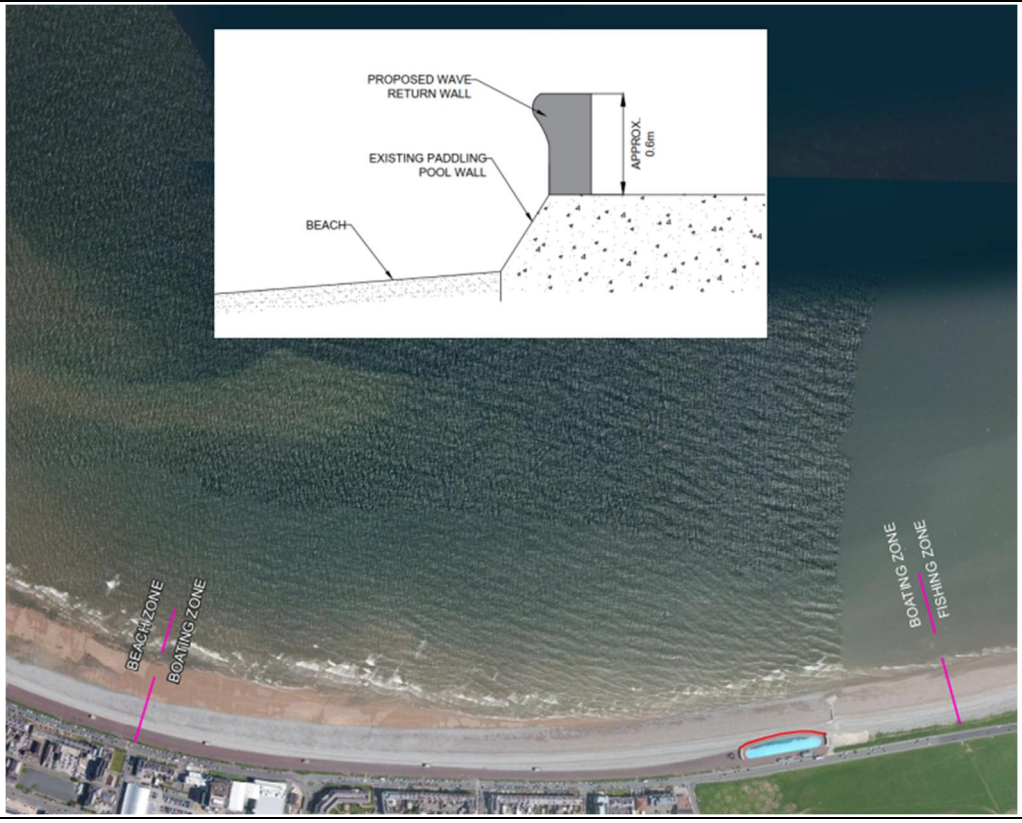


Description

Shingle in MU2 will be removed and sand will be placed on the beach with maintenance required periodically. No additional control structures are proposed along the frontage.

Advantages	Disadvantages
· Will provide a discrete sandy beach area as an amenity. · Low volumes of sand will be required for the capital re-nourishment and could be stockpiled within the borough.	· Sand will be lost as it is drawn down the profile; possibly very quickly. · Additional wave return wall may be required if beach levels reduce significantly.

4.3.7 Option 6: Wave return wall for Paddling Pool (MUN5)

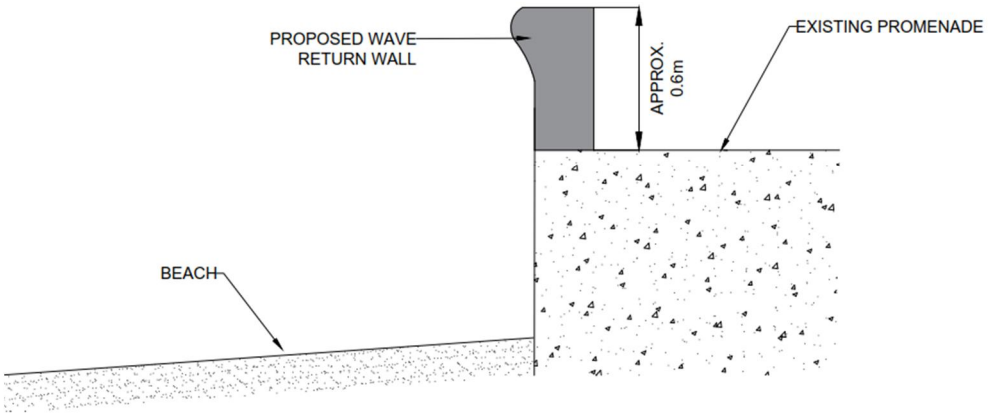


Description

A wave return wall will be added to the crest of the paddling pool revetment. This will possibly taper down to the existing sea wall crest level on the promenade. Individual pre-cast concrete blocks will be fixed to the existing revetment on the seaward side of the paddling pool.

Advantages	Disadvantages
· Will lower the amount of wave and shingle overtopping the revetment. · Cost effective solution to increasing the standard of protection.	· Risk that the existing revetment is not suitable for attaching pre-cast units. · Visibility of the sea from the paddling pool will be affected. · Concrete would be susceptible to surface abrasion due to movement of shingle during storms.

4.3.8 Option 7: Wave return wall along the promenade



Description

A wave return wall would be added along the crest of the existing stepped revetment sea wall.

Advantages	Disadvantages
· Cost effective method of increasing the standard of protection. · Limit the amount of overtopping of water and shingle onto the promenade in the future under climate change scenarios.	· Impact of visibility of the sea and beach from the promenade or seating at the back of the promenade. · Requires stop-logs at the top of slipways that rely on active management before or during a storm. · Concrete would be susceptible to surface abrasion due to movement of shingle during storms.

4.4 Assessment of Options

The estimated capital and maintenance costs for each option are shown below in Table 4-7 and a summary of the environmental assessment is provided in Table 4-8. The qualitative assessment of each option has been undertaken against each of the identified criteria and the resulting table is shown in Table 4-9. The options recommended for taking forward to a short-list are indicated by the shading of the option as Green.

Table 4-7. Capital and Maintenance costs (2017) for the North Shore Options

Option	Capital cost	Annual Maintenance costs
Option 0: 'Do minimum'	£0	£0-£50k[1]
Option 1: Detached breakwaters and groynes.	Option 1A : £26m to 32m	£0 to £600k
	Option 1B: £19m to 23m	£0 to £600k
Option 2: Fishtail rock groynes	Option 2A: £14m to 17m	£0 to £440k
	Option 2B £13.5m to 17m	£0 to £440k
Option 3: Traditional Timber Groynes.	£11 to 13.5m	£600k
Option 4: Beach Nourishment	Option 4A: £10.5m to 13m	£100k to 1.2m[2]
	Option 4B: £9.5m to 12m	
Option 5: Beach Nourishment at Children's Corner	£0.5 to 1m	£10 to 100k[3]
Option 6: Wave return wall for Paddling Pool	£20-100k[4]	£0 to 10k
Option 7: Wave return wall along the promenade	£0.3 to 1m[4]	£0 to 10k

[1] Depending on environmental conditions. Reactive maintenance such as required in 2014 may be periodically required if considered to be the minimum maintenance required.

[2] Depending on environmental conditions, Option 4 A likely to be lower cost in first few years with annual costs for the two options being closer towards the end of the 20 year scheme.

[3] Depending on the environmental conditions and the rate of sediment lost from the beach area. Periodic maintenance may be required.

[4] Includes a factor for the difficulty of constructing a wave return wall on an existing structure. Cost will be highly dependent on the method of fixing the wave wall to the existing structure and in the case of Option 7 the total length of frontage requiring the wall.

Table 4-8. Summary of the environmental assessment for each option

Option	Environmental Issues
Option 1: Detached breakwaters and groynes	· Temporary net loss of species diversity and significant land take · Potential impact on commercial shellfish beds and potential pollution during construction · Potential for temporary adverse noise and dust effects during construction · Visual amenity effects
Option 2: Fishtail rock groynes	· Temporary net loss of species diversity · Potential impact on commercial shellfish beds and potential pollution during construction · Potential for temporary adverse noise and dust effects during construction · Visual amenity effects
Option 3: Traditional Timber Groynes	· Temporary net loss of species diversity · Potential impact on commercial shellfish beds · Potential for temporary adverse noise and dust effects during construction · Visual amenity effects
Option 4: Beach Nourishment	· Temporary net loss of species diversity · Potential impact on commercial shellfish beds · Potential for temporary adverse noise and dust effects during construction · Visual amenity effects
Option 5: Beach Nourishment at Children's Corner	· Small scale construction works unlikely to result in significant adverse effects on the water environment · Option will result in segmentation of the beach zone and will have a potential visual effect
Option 6: Wave return wall for Paddling Pool	· Does not require any permanent development within the SAC and SPA · Limited construction works therefore unlikely to have a significant impact on the water environment
Option 7: Wave return wall along the promenade	· Does not require any permanent development within the SAC and SPA · Limited construction works therefore unlikely to have a significant impact on the water environment

Table 4-9. Assessment of the long-list of options for the North Shore

Criteria / Options	Amenity		Environment				Technical				Economic		
	Recreational use	Access	Permissions, consents and licences	Archaeology and cultural heritage	Landscape	Ecological designations	Functionality - Flood and coastal erosion risk management	Constructability	Durability	Impact on coastal processes	Capital cost	Maintenance cost	External funding potential
0: Do minimum								N/A			£0	£0 to £50k	N/A
1A: Detached Breakwaters											£26m to £32m	£0 to £600k	Low
1B: Submerged Detached Breakwaters											£19m to £23m	£0 to £600k	Low
2A: Fishtail Groyes											£14m to £17m	£0 to £440k	Low
2B: Onshore Fishtail Groynes											£13.5m to £17m	£0 to £440k	Low
3: Timber Groynes											£11m to £13.5m	£600k	Medium
4A: Beach Nourishment (Capital and Maintenance)											£10.5m to £13m	£100k to £1.2m	Medium
4B: Beach Nourishment (Capital only)											£9.5m to £12m	£100k to £1.2m	Medium
5: Beach Nourishment at Children's Corner											£0.5m to £1m	£10k to £100k	Medium
6: Wave return wall for Paddling Pool											£20k to £100k	£0 to £10k	Medium

7: Wave return wall for promenade											£0.3m to £1m	£0 to £10k	High

4.5 Short-list Options

The CTFRA has identified the key areas at risk of flooding and importantly the potential flow paths. The risk along the North Shore is from wave overtopping as the 0.5% AEP still water level does not exceed the defence level along the promenade. The two areas most at risk on the North Shore are MUN2 and MUN5. The use of the gate at the Trevor Street Slipway does provide a higher standard of protection; however the promenade level is lower at this location and therefore there is a risk of flooding if the gate is not closed.

The remainder of the promenade is at a lower risk of overtopping by waves if beach levels are maintained at present day levels. However, if beach levels lower due to prolonged periods of storm activity then the hard structures are required to protect against wave overtopping. This means that the options need to directly limit the flood risk for a range of beach levels and, if possible, maintain beach levels to minimise the flood risk.

Options 1 to 4 are focussed on maintaining beach levels which are at an increased risk of lowering if the beach consists of sand rather than shingle (finer sediment is more mobile than coarse sediment in the same wave and water level conditions). Option 5 addresses the localised beach levels and provision of an amenity beach whilst Option 6 directly addresses the risk of wave overtopping the paddling pool and reaching the area behind the paddling pool. Option 7 recognises the increasing risk over time and provides a relatively low cost solution to significantly improving the standard of protection of the frontage. Notably Option 7 will increase protection even if beach levels are lowered over time.

From this assessment it is considered reasonable that Options 5, 6 and 7 are carried forward to the short-list based purely on the provision of flood protection. However, if additional benefits are also considered, such as increased amenity, then it is plausible that a large structure, most likely a fishtail groyne, could be constructed to increase the area of the beach that could be replenished with sand thereby increasing the amenity value of the beach area at the western end. The level of design required to identify the optimum position and layout for this structure is beyond the scope of this BMP; however at this time it seems reasonable to retain the option. It should be noted however that for this option to be viable it may require additional sources of funding over the grant in aid funding for flood protection. It is also considered possible at this time that such an option could attract significantly more partnership funding thereby positively affecting the benefit cost ratio. Acknowledging these constraints and that a refined Option 2 affecting the western end of the North Shore needs to be developed with specific objectives and constraints; Option 2 has also been carried over to the short-list.

The short-listed options are summarised in Table 4-10.

Table 4-10. Shortlisted options for the North Shore

Option	Notes
7:Wave return wall for promenade	The long-term flood protection for the frontage is most likely to be most cost-effectively provided through the enhancement of the existing defences using a wave return wall along the front of the promenade. This will have the added benefit of limiting the frequency and amount of beach material being deposited on the promenade.
6: Wave return wall for Paddling Pool	This option is considered to be highly beneficial in preventing both potential flood waters and limiting damage due to beach material being thrown onto the paddling pool surface and surrounds.

5: Beach Nourishment at Children's Corner	Similarly to Option 2 this option is considered potentially viable without additional structures and with minimal sand re-nourishment. However additional sources of funding may be required to make this economically viable.
Option 2: Fishtail groynes	This option has been carried forward to the short-list on the basis that although Options 6 and 7 will probably provide the most cost-effective solution with respect to flood protection funding arrangements. Other sources of funding may become available (such as grants from other bodies or from local businesses) if a larger sandy beach area were to become part of the project.

5. Options for the West Shore

5.1 Introduction

The West Shore has several different types of shoreline that includes groynes, sea walls and dunes with a wide inter-tidal sand flat forming the beach. There are different land levels behind the shoreline with a range of land uses that combine to mean that there is a wide range in the level of flood risk. The Great Orme provides significant shelter and there is a variable exposure to wave energy along the frontage.

The LCF has identified a number of Strategic Management Zones within the West Shore. The uses for each of these locations are shown in Figure 5-1 below. This map shows that the West Shore is predominately designated as a recreation zone, with a Marine Zone located to the north of the frontage.

Figure 5-1. Strategic Management Zones for West Shore, Llandudno (Llandudno Coastal Forum 2016)

There is an acknowledged public concern regarding wind-blown sand and this could be considered the primary issue for the West Shore; however, the flood risk is a key consideration and the long-term future of the existing defences needs to be considered.

To be able to consider the different combinations of land use, shoreline features and exposure to waves the frontage was split into a number of Management Units as described in Table 5-1 and shown in Figure 5-1.

Section 5.2 provides a summary of each MU that describes the location, issues and objectives, and constraints. The long-listed options are presented in Section 5.3 and are cross-referenced to the MU that will be affected by each option.

The qualitative assessment of each option is summarised in the tables shown in Section 5.4 with the options recommended for inclusion on the short-list highlighted in the final assessment table.

Section 5.5 identifies what additional work is required to refine the designs of the short-listed options.

Table 5-1. Management units for the West Shore

Management Unit
MUW1: Frontage along Marine Drive to Gogarth Breakwater
MUW2: Gogarth Breakwater to Lloyd Street Breakwater
MUW3: Lloyd Street Breakwater to Dale Road car park
MUW4: Dale Road car park to Cerrig Duon Breakwater
MUW5: Immediately south of Cerrig Duon Breakwater

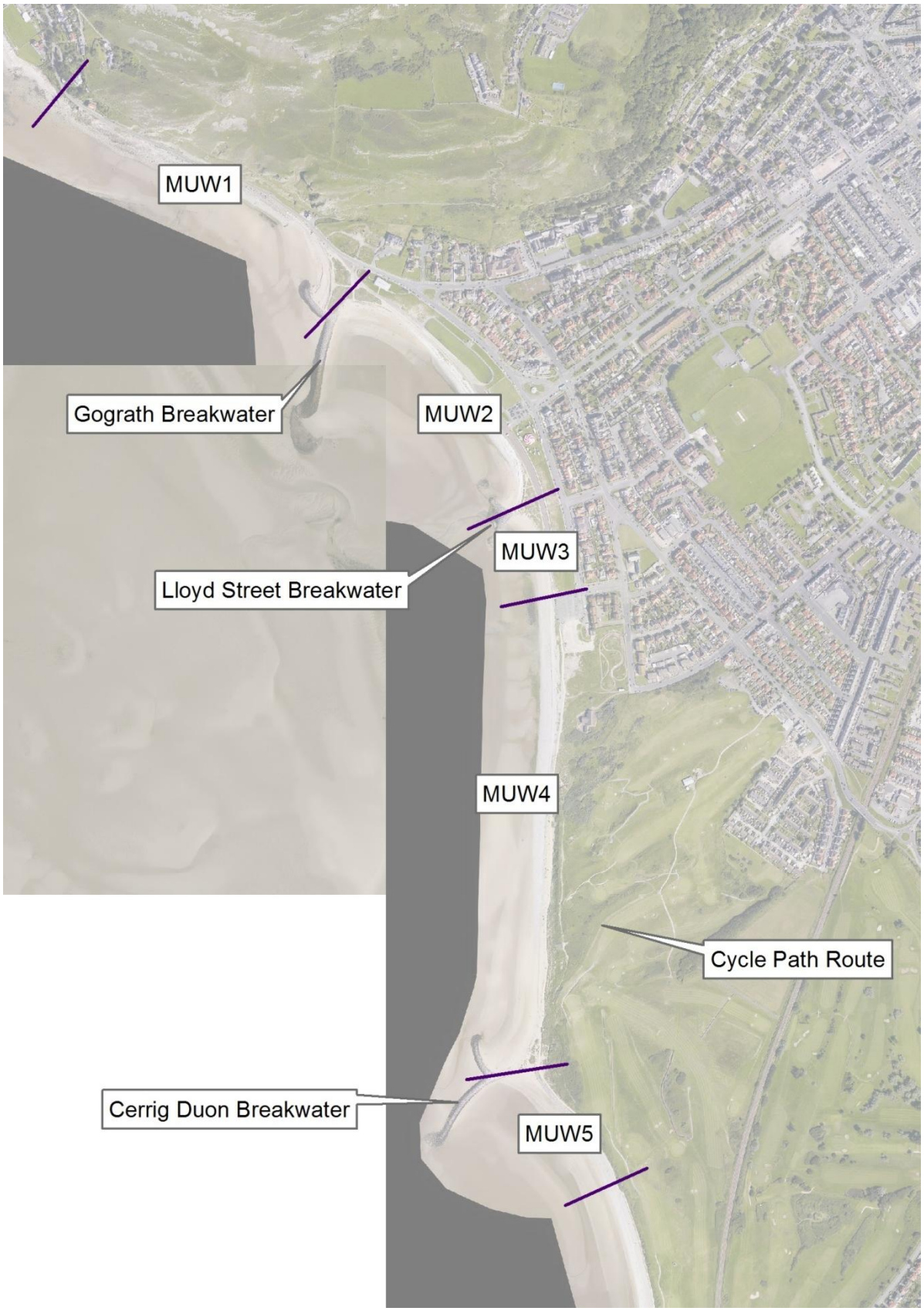


Figure 5-2. Aerial view of West Shore with key features (including the cycle path route) and Management Units

5.2 Management Units

5.2.1 Introduction

A description of each MU is provided in the following sections. For each MU there is a photograph, a general description, identification of the specific issues, objectives and constraints. The options that are presented in Section 5.3 and affect the MU are also identified for convenience in cross-referencing.

5.2.2 MUW1: Frontage along Marine Drive to Gogarth Breakwater

Description

The relatively narrow beach in this area consists of a sand and shingle upper beach with a lower sand beach. This beach is backed by a stepped concrete sea wall with a rear vertical wall. The northern limit extends approximately 600m north of the Gogarth Breakwater while the southern limit is bounded by the breakwater itself.

The steps across this section are in poor condition and have been overlaid in the past. The beach is currently protecting them to a varying degree.

Issues and Objectives

This management unit is not affected by wind-blown sand as it is backed by a vertical wall. Sand has accumulated on the north side of the Gogarth Breakwater and appears to be holding sufficient sand to protect the sea walls.

Constraints

This section is backed by a vertical wall which protects the adjacent roadway. Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the steps.

Options

The frontage wide options of periodic beach maintenance will affect this management unit (Option WS1-6).

5.2.3 MUW2: Gogarth Breakwater to Lloyd Street Breakwater

Description

The upper beach consists of shingle and cobbles with a lower sand beach. The beach is backed by a stepped concrete sea wall. The extents of this management unit consist of the Gogarth Breakwater to the north and the Lloyd Street Breakwater to the south.

The steps across this section are in poor condition and have been overlaid in the past. The beach is currently protecting them to a large degree but some steps remain exposed with spalls and exposed reinforcement evident

Issues and Objectives

The Gogarth Breakwater has been successful in protecting the beach in this MU. The area immediately behind the breakwater has a relatively high beach level and dunes have formed at the root of the breakwater.

Wind-blown sand is however an issue here due to the increased beach level relative to the sea wall crest elevation. Material has been removed from this MU to provide sand to the North Shore.

The relatively high beach levels in the lee of the Gogarth Breakwater are an indication of the success of the breakwater in protecting the beach. However at high tide the beach is very narrow suggesting that additional material on the upper beach could be required within the bay between the breakwaters.

The condition of the sea wall is considered by JBA (2015) to be fair. MUW2 is the area of the West Shore considered to be most at risk of being overtopped in the future due to extreme still water levels (without waves) and therefore the wall will to need to be improved in the future.

Constraints

Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the steps.

The houses immediately behind the sea wall and grassed areas are lower than the sea wall. Increases in the sea wall height or provision of dune management measures in the hinterland may reduce wind-blown sand, will reduce the flood risk but also obstruct the view of the sea.

Options

The frontage wide options of periodic beach maintenance, dune regeneration, breakwater removal, rock placement and sand traps will affect this management unit (Options WS1-6 and WS8-9).

5.2.4 MUW3: Lloyd Street Breakwater to Dale Road car park

Description

Natural shingle bank on the upper beach, with a lower sand beach. The northern limit is bounded by the Lloyd Street breakwater while the southern limit extends to the Dale Road car park. The sea wall extends along the back of the beach and is well protected by the beach.

Issues and Objectives

Wind-blown sand is an issue here due to the build-up of material behind the breakwater. Material removal is undertaken on an as required basis.

Constraints

Beach levels must be maintained to prevent wave overtopping and scour of the toe of the sheet pile wall at the bottom of the steps.

Options

The frontage wide options of periodic beach maintenance, dune regeneration, breakwater removal, rock placement and sand traps will affect this management unit (Options WS1-6 to WS8-9).

5.2.5 MUW4: Dale Road car park to Cerrig Duon Breakwater

Description

MU4 extends from the end of the sea wall in MU3 to the Cerrig Duon breakwater. The car park is at the back of the beach and is slightly higher than the land to the north. The dunes rise up from the southern end of the car park and provide a clear demarcation of the back of the beach. The cycle path that was built at the foot of the dunes has been eroded in some places by wave action and buried by sand in others. There is evidence of foredunes forming with some being vegetated. There is clearly a fine balance between the wave action and the supply of sand to this part of the beach.

Behind the dunes is a privately owned golf course.

Issues and Objectives

Wind-blown sand is an issue here, particularly along the cycle path, due to the build-up of material behind the breakwater. Material removal is undertaken on an as required basis.

The cycle path is considered to be an important asset and therefore should, if possible be protected.

Dunes are naturally formed by wind-blown sand. The action that is considered to be a problem elsewhere on the West Shore is to the benefit of the dunes.

The shingle bank between the south end of the sea wall and the elevated dunes of the golf club provides the lowest crest elevation across the West Shore frontage and is considered to be a section at risk of flooding in the future.

Constraints

The frontage is less well protected than the MUs to the north. Wave energy may reach the site directly with less protection from the Great Orme and no local breakwaters.

The dunes are an important habitat and need to be protected if possible.

Options

The frontage wide options of periodic beach maintenance and wall construction, dune regeneration, breakwater removal, rock placement and sand traps will affect this management unit (Options WS1-7, 9).

5.2.6 MUW5: Immediately South of Cerrig Duon Breakwater

Description

The Cerrig Duon breakwater is the northern boundary of this management unit and it extends approximately 300m to the south of this breakwater. The beach is backed by the southern end of the dunes and the upper beach is well protected by the breakwater. The upper beach is sand and shingle however the area immediately behind the breakwater is very fine soft sand.

Issues and Objectives

Wind-blown sand is an issue here, particularly along the cycle path. Material removal is undertaken on an as required basis.

Constraints

The protection of the breakwater means that the area experiences very low wave energy and will therefore fill with fine sediments. If wave action is extremely low then the area may become muddy if the fine sediment is in the water column.

Options

The frontage wide options of periodic beach maintenance, dune regeneration, breakwater removal, rock placement and sand traps will affect this management unit (Options WS1-7 and 9).

5.3 Long-list of options

The following are the range of long-list options that have been developed as part of this assessment in order to maintain the necessary standard of flood protection and reduce the effects of wind-blown sand along the West Shore frontage. These options were presented to the public for feedback on 17th November 2016. Feedback from this discussion has been considered as part of the ongoing development of these options. It is worth noting that most of the 'options' are really components of what would form a scheme for further development. For example, the option of dune regeneration is considered for the whole frontage, but may be suitable only in a few locations or as a long-term plan in combination with other stakeholders. Notwithstanding this the 'options' have been considered in the same way as the options for the North Shore. An additional option that suggests the most appropriate components for each MU is also presented as Option 9.

The options are listed below in Table 5-2 and described in the following sections.

Table 5-2. Long-list of Options for the West Shore

Option	Description
'Do nothing' and 'Do minimum'	'Do nothing' means to allow the defences to deteriorate and not undertake any maintenance. This is not considered acceptable or viable and is not considered any further. 'Do minimum' would mean undertaking the minimum maintenance to maintain the health and safety of people using the beach areas. This option is considered as a baseline for comparison.
Option 1: Periodic Beach Maintenance	This option assumes that the back of the beach is recharged with shingle and there is ongoing maintenance of the sand on the beach. Excess material will be removed regularly from the frontage and re-used in other areas (possibly the North Shore) where required.
Option 2: Dune Regeneration	Forming dunes at a number of locations with sand filled geotextile bags at their core. These will continue to accumulate material and grow over time, creating a barrier to windblown material. New plants will also be planted on the dunes to encourage growth of the dune.
Option 3: Concrete wall and periodic beach maintenance	A concrete wall will be constructed along the back of the beach from the Dale Road car park to the Cerrig Duon breakwater. Periodic beach maintenance will be undertaken across the entire frontage to remove excess material.
Option 4: Rock cover layer	A cover layer of 5-10kg rock will be placed over the existing beach material in order to prevent wind-blown sand. This will be backed by a retaining wall to prevent material loss.
Option 5: Sand Traps	This option involves the installation of sand traps along the West Shore. There are a number of existing sand traps in place however many of these have become inundated with material and are in a state of disrepair.
Option 6: Breakwater Removal	This option involves the removal of the three existing breakwaters which are located along the West Shore; the Gogarth breakwater, Lloyd Street breakwater and Cerrig Duon breakwater. The beach will be re-instated to a 'natural' state.
Option 7: Raised Walkway	This option involves constructing a raised timber walkway along the current cycle path route. This option will be raised above the current path level in order to avoid the accumulation of sand and material which currently obstructs the path route. It is assumed that the path will be approximately 300 mm above the existing ground level and not require a hand rail. Kerb rails will be required for wheelchair safety. The structure can be constructed from timber or recycled plastic.
Option 8: Wall repairs / raising	It is proposed to undertake local repairs to the existing wall structure where it is currently in a state of disrepair. Where required, the existing wall will be raised to improve the frontage defence standard.
Option 9: Combined Scheme	Combines components of Options 5, 7 and 8.

5.3.1 'Do nothing' and 'Do minimum'

The 'Do nothing' or 'Do minimum' options for the future management of the beach areas have been considered.

Under the 'Do nothing' option the defences would not be maintained, no clearing of shingle would occur and there would be no on-going maintenance or monitoring of the beach areas. The 'Do nothing' option is considered technically unacceptable since there is a minimum amount of maintenance required to maintain the safety of the area as a place of work and leisure for the general public. It is also clear from the CTFRA that there is a high risk of flooding in the future and some action is going to be required to provide appropriate protection against flooding. This option would underlie any economic assessment of the options; however for the purposes of identifying options at this stage it is not considered a viable option and is not considered any further.

The 'Do minimum' option would require the defences to be maintained for the purposes of health and safety and would include *ad hoc* management similar to the present management of the defences. The option is also identified as failing to provide the necessary flood protection in the future and therefore not technically viable. The activities that are required for the 'Do minimum' option are considered to apply equally to all options. For example all options will need to monitor the beach levels, clear shingle and undertake minor repairs. This means that the costs of the 'Do minimum' option are included in all options and the cost for comparison is effectively £0.

5.3.2 Option 1: Periodic Beach Maintenance (MUW1-5)

Description

This option assumes that the back of the beach is recharged with shingle and there is ongoing maintenance of the sand on the beach. Excess material will be removed frequently from the frontage and re-used in other areas (possibly the North Shore) where required.

Advantages	Disadvantages
· Low impact on the environment · Surplus material can be re-used in other areas	· Variable standard of protection provided as beach moves · Losses occur in places (requires periodic re-nourishment) · Requires regular management

5.3.3 Option 2: Dune Regeneration (MUW1-4)

Description

Forming dunes at a number of locations with sand filled geotextile bags at their core. These will continue to accumulate material and grow over time, creating a barrier to windblown material. New plants will also be planted on the dunes to encourage growth of the dune.

Advantages	Disadvantages
· Reduces wind-blown sand by trapping the sand in the dunes · Softer engineering solution · Low visual impact	· Dunes take time to become established · Requires periodic maintenance · High cost of geotextile bags · Geotextile bags must be capable of surviving a storm event if the covering sand is eroded.

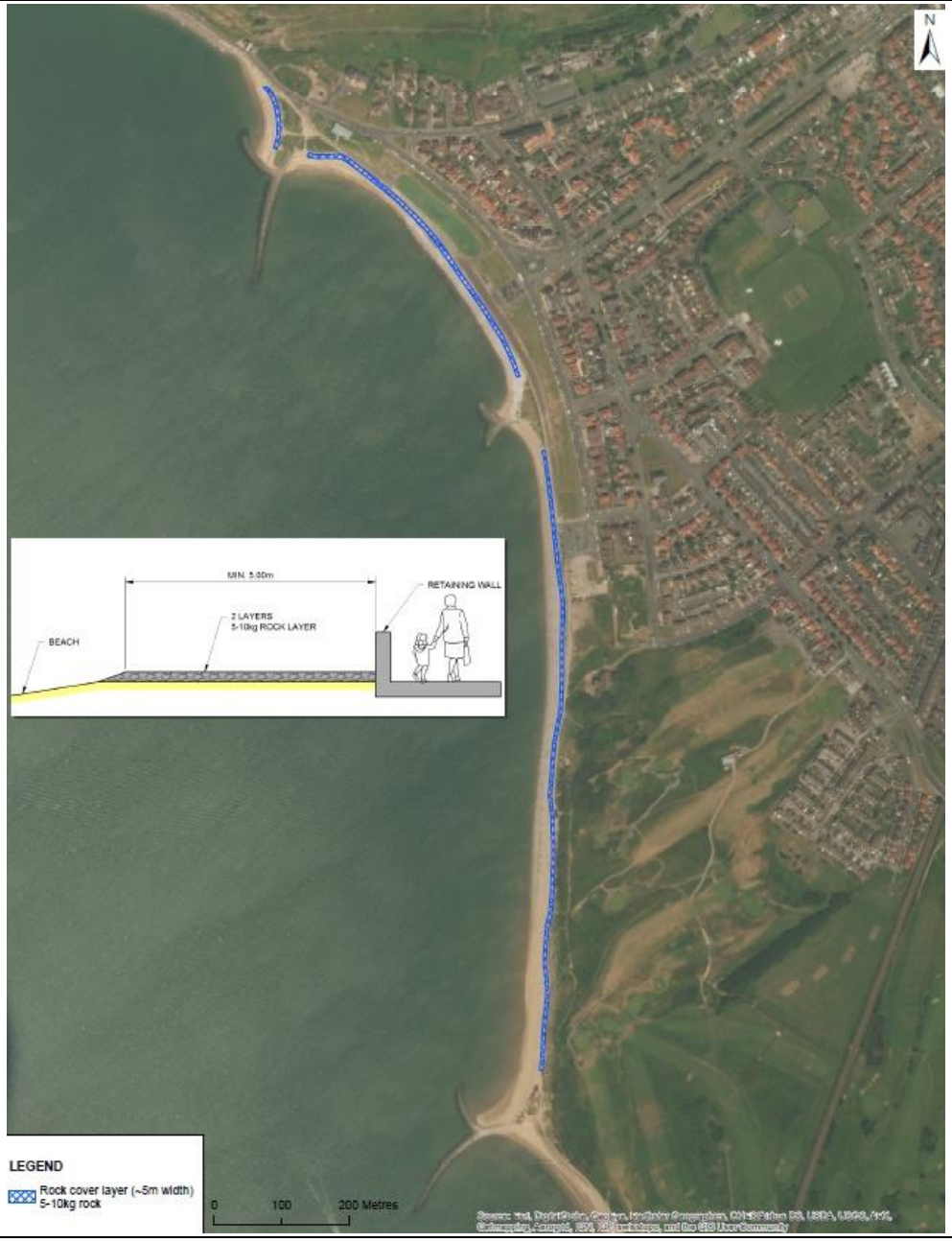
5.3.4 Option 3: Concrete wall and periodic beach maintenance (MUW1-5)

Description

A concrete wall will be constructed along the back of the beach from the Dale Road car park to the Cerrig Duon breakwater. Periodic beach maintenance will be undertaken across the entire frontage to remove excess material.

Advantages	Disadvantages
· Minimal impact on the environment · Increased flood protection along the southern end of the frontage	· Higher initial cost · Wil require some maintenance to remove excess material · Requires regular re-investment

5.3.5 Option 4: Rock cover layer (MUW1-5)

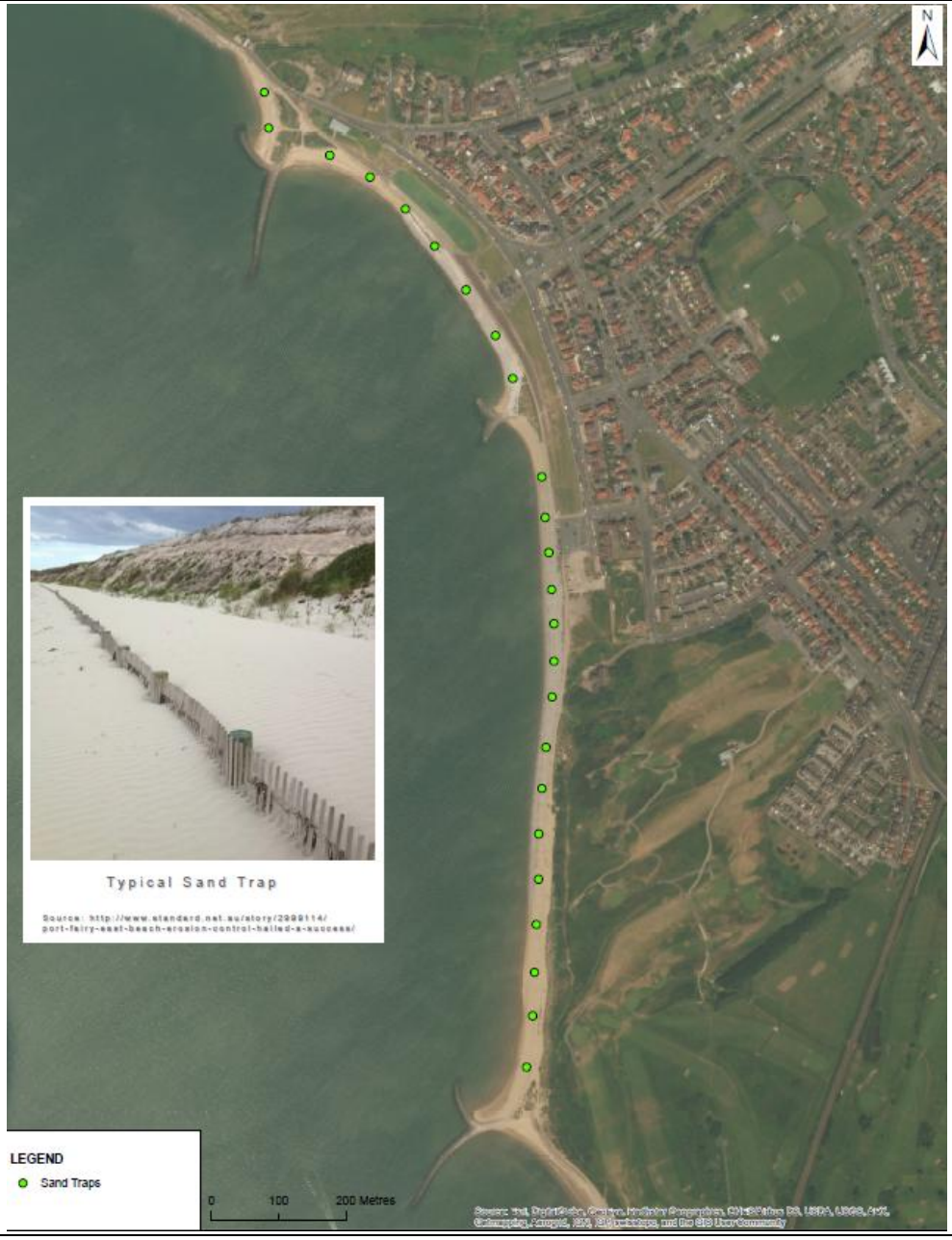


Description

A cover layer of 5-10kg rock will be placed over the existing beach material in order to prevent wind-blown sand. This will be backed by a retaining wall to prevent material loss.

Advantages	Disadvantages
· Reduces the wind-blown sand effects initially · Relatively low visual impact · Rocks likely to be mobilised during storms and will require further engineering to retain.	· High initial cost depending on rock size · Requires ongoing maintenance to maintain material in place · Rock may get clogged with sand. Over time this will build up and overtop the wall.

5.3.6 Option 5: Sand Traps (MUW1-5)



Description

This option involves the installation of sand traps along the West Shore. There are a number of existing sand traps in place however many of these have become inundated with material (demonstrating that they are working or have been engulfed by wave driven sediment transport) and are in a state of disrepair.

Advantages	Disadvantages
· Reduces wind-blown sand effects by trapping material · Low initial construction cost	· Fences need to be removed if they are almost covered because of safety issues of buried fences.

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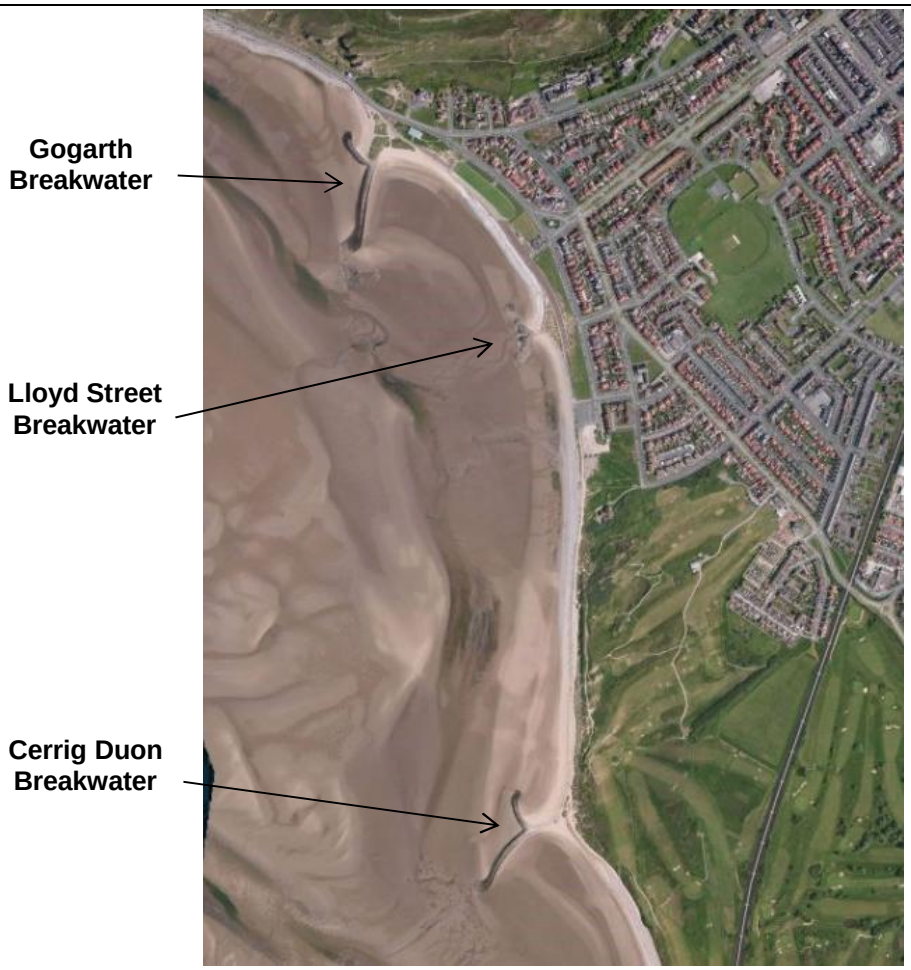
5.3.7 Option 6: Breakwater Removal (MUW1-5)

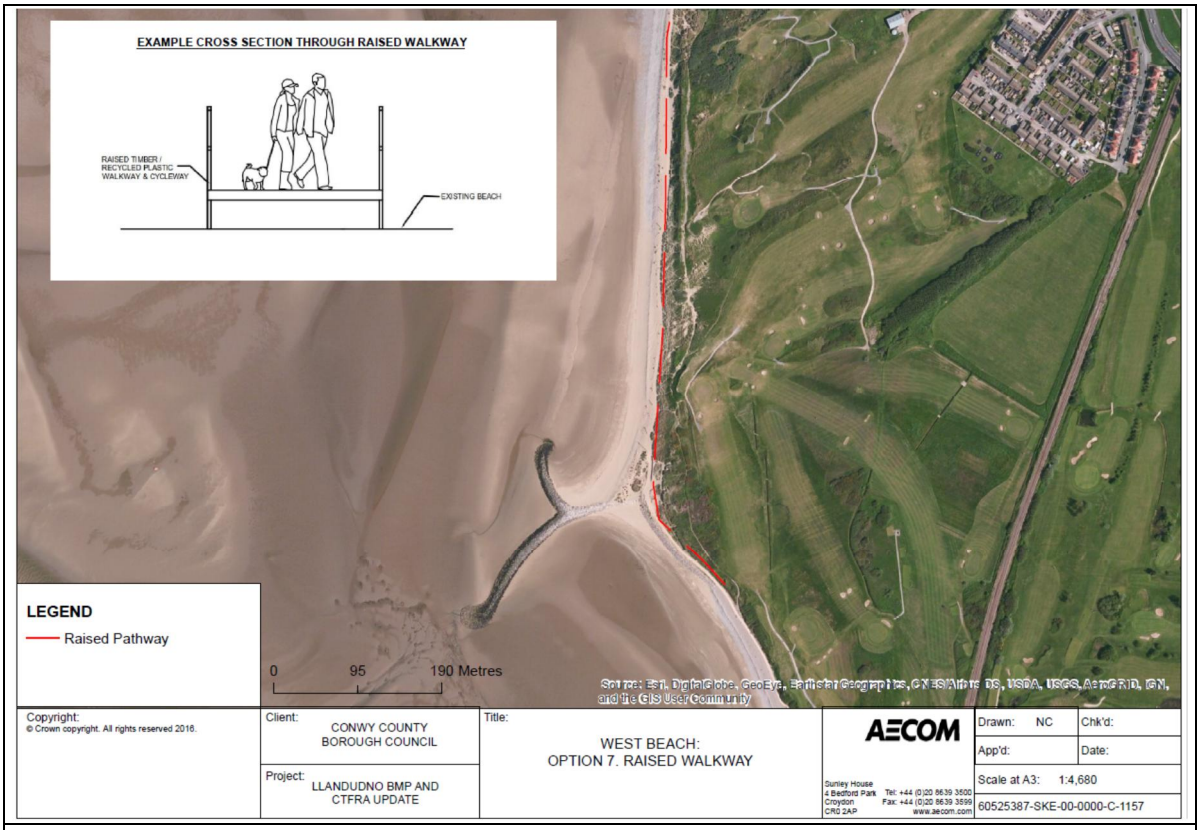


Description

This option involves the removal of the three existing breakwaters which are located along the West Shore; the Gogarth breakwater, Lloyd Street breakwater and Cerrig Duon breakwater. The beach will be re-instated to a 'natural' state however there would not be any beach renourishment or enhancement of the sea wall.

Advantages	Disadvantages
· Reduction in the build-up of material therefore reducing the wind-blown sand effects · Improved visual amenity	· Almost certainly an increase in flood / erosion risk along the frontage requiring additional works to be undertaken to provide adequate flood protection. (Note that the structures were built to provide flood and coastal protection and therefore their removal would also require the implementation of further works.) · Likely to result in significant changes to the shoreline alignment as the beach adjusts to a natural profile. · High cost for the removal of structures

5.3.8 Option 7: Raised timber (plastic) walkway / cycleway (MUW4+5)



Description

This option involves constructing a raised timber walkway along the current cycle path route. This option will be raised above the current path level in order to avoid the accumulation of sand and material which currently obstructs the path route. It is assumed that the path will be approximately 300 mm above the existing ground level and not require a hand rail along the entire length although some sections may need a handrail on one or both sides. Kerb rails will be required for wheelchair safety and access steps or ramps may also be required. The structure can be constructed from timber or recycled plastic.

Advantages	Disadvantages
· Will provide a continuous path along the shoreline from the car park to Carrig Duon Breakwater · Will remove the need for material removal along the path · Sustainability of option depends on the material used	· Potentially high cost · Sustainability of option depends on the material used

5.3.9 Option 8: Existing wall repairs / raising (MUW2-3)

Description

It is proposed to undertake local repairs to the existing wall structure where it is currently in a state of disrepair.

There are signs of degradation to the existing promenade steps and wave return wall, which will require replacement (and potentially raising to adapt to climate change) at some time in the future, if flood protection is to be maintained.

Advantages	Disadvantages
· Low cost · Will improve the flood defence standard along the frontage	· May not completely eradicate the wind-blown issue – material may be blown over the top of the wall · Raising the wall is dependent on the current condition of the structure

5.3.10 Option 9: Combined Scheme (MUW2-5)

Description

The proposed options presented above have assumed that a single management option will fulfil the requirements; however the different MUs have different issues and require different solutions.

This option combines the raising of the wall in MUW2 (part of Option 8) with sand traps (Option 5) for MUW4+5 in front of a raised cycle way (Option 7). This will provide the required flood protection, minimise the wind-blown sand issue, protect the dunes and

allow them to grow, whilst maintaining beach levels in front of the defences and public access to and along the shoreline.

Additional sand traps could be built on the grassed areas behind the sea wall in MUW2 and MUW3 to encourage accumulation of the grassed areas and lower the wind-blown sand issue for the residential properties.

Advantages	Disadvantages
· Will improve the flood defence standard along the frontage · Will reduce wind-blown sand in MUW2 and encourage dunes to grow in MUW4+5 · Will provide a continuous path along the shoreline from the car park to Carrig Duon Breakwater · Sustainability of cycleway option depends on the material used	· Unlikely to completely eradicate the wind-blown issue – material may blow over the top of the wall · Timing of remedial works to the existing wall is dependent on the residual life of the existing structure and climate change considerations · Fences need to be removed if they are almost covered because of safety issues of buried fences. · Sustainability of cycleway option depends on the material used

5.4 Assessment of Options

The estimated capital and maintenance costs for each option are shown below in Table 4-7 and a summary of the environmental assessment is provided in Table 4-8. The qualitative assessment of each option has been undertaken against each of the identified criteria and the resulting table is shown in Table 4-9. The options recommended for taking forward to a short-list are indicated by the shading of the option as Green.

Table 5-3. Capital and Maintenance costs (2017) for the West Shore Options

Option	Capital cost	Annual Maintenance costs
Option 0: 'Do minimum'	£0	£0-£50k[1]
Option 1: Periodic Beach Maintenance	£0.5m to 1.5m	£0 to 0.5m[2]
Option 2: Dune Regeneration	£100k to 500k	£0 to 5k
Option 3: Concrete wall and periodic beach maintenance	£400k to 600k	£300 to 400k
Option 4: Rock cover layer	£100k to £200k	£TBD[3]
Option 5: Sand Traps	£30k to £50k	£0 to 10k
Option 6: Breakwater Removal	£4m to 5m	£0[4]
Option 7: Raised Walkway	£0.5m to £1.5m[5]	£0 to 10k
Option 8: Wall repairs / raising	£1m to £2m[6]	£0 to 10k
Option 9: Combined Scheme	£2.4m	£0 to 20k

[1] Depending on environmental conditions. Reactive maintenance such as required in 2014 may be periodically required if considered to be the minimum maintenance required.

[2] Depending on the type of material placed and the amount of material moved by the waves during the year the scheme could require a significant expenditure to maintain the beach levels. The use of shingle would lower this risk.

[3] The amount of maintenance is unknown as it will relate to wind-blown sand and the maintenance of the rock cover layers.

[4] The removal costs presented here do not account for the need that another option will be needed to provide adequate flood and coastal defence. Note that the structures were built to maintain beach levels and provide flood and coastal protection.

[5] The walkway could be constructed from timber, but a more sustainable solution could be recycled plastic. The incorporation of hand rails and the height above the sand will be a factor in the costs as well as the number of beach access points.

[6] The cost will depend on how much of the existing wall can be retained and how much needs to be replaced. This cost estimate is also considered to be sufficient to cover the cost of a secondary defence wall instead of upgrading the forward defence.

Table 5-4. Summary of the environmental assessment for each option

Option	Environmental Issues
Option 1: Periodic Beach Maintenance	· Sand dunes are a BAP habitat and this could be lost if material is removed
Option 2: Dune Regeneration	· Modified landscape arrangements · Potential social impacts
Option 3: Concrete wall and periodic beach maintenance	· Sand dunes are a BAP habitat and this could be lost if material is removed · Visual amenity effects
Option 4: Rock cover layer	· Visual amenity effects
Option 5: Sand Traps	· Sand dunes are a BAP habitat and this could be lost if material build up is affected
Option 6: Breakwater Removal	· Potential disruption to commercial shellfish beds · Potential for adverse impacts to the water environment during breakwater removal
Option 7: Raised Walkway	· Visual amenity effects
Option 8: Wall repairs / raising	· Visual amenity effects
Option 9: Combined Scheme	· Sand dunes are a BAP habitat and this could be lost if material build up is affected · Visual amenity effects

Table 5-5. Assessment of the long-list of options for the West Shore

Criteria / Options	Amenity		Environment				Technical				Economic		
	Recreational use	Access	Permissions, consents and licences	Archaeology and cultural heritage	Landscape	Ecological designations	Functionality - Flood and coastal erosion risk management	Constructability	Durability	Impact on coastal processes	Capital cost	Maintenance cost	External funding potential
0: Do minimum								N/A			£0	£0 to £50k	N/A
1: Periodic Beach Maintenance											£0.5m to £1.5m	£0 to £0.5m	Low
2: Dune Regeneration											£100k to £500k	£0 to £5k	Low
3: Concrete wall and periodic beach maintenance											£400k to £600k	£300 to £400k	Medium
4: Rock cover layer											£100k to £200k	£TBD	Low
5: Sand Traps											£30k to £50k	£0 to £10k	Low
6: Breakwater Removal											£4m to £5m	£0	Low
7: Raised Walkway											£0.5m to £1.5m	£0 to £10k	Medium
8: Wall repairs / raising											£1m to £2m	£0 to £10k	Medium

9: Combined scheme											£2.4m	£0 to £20k	High

5.5 Short-list Options

The CTFRA has identified the risk for both the Present Day (2017) and after 100 years of climate change (2117). The primary risk on the West Shore is wave overtopping in the short-term with increasing flood risk from wave overtopping, breaching and still water levels in MUW2-4 after 100 years of climate change.

The only measure that is considered to provide the increase in flood protection that is required is the enhancement of the existing sea wall and this is the basis of Option 3 and 8 and incorporated into Option 9.

Despite the potential to slightly raise beach levels, the options that try to address the wind-blown sand or to protect the cycleway are considered to not provide any significant flood protection and are therefore unlikely to attract appreciable funding from any source.

By combining the enhancement of the sea wall with other measures such as the walkway/cycle path and sand traps in Option 9, it is considered more likely that funding for the additional measures could be secured.

Table 5-6. Shortlisted options for the West Shore

Option	Notes
8: Wall repairs / raising	The increase in flood protection is likely to be achieved most cost effectively through the enhancement of the existing sea defences. This could be through the replacement/raising of the existing wave return wall or the construction of a secondary defence behind the existing sea wall. It is likely that the wall will also need to be extended south across the car park.
9: Combined scheme	If possible other measures that can help to maintain beach levels and reduce the wind-blown sand issues could be incorporated into the preferred scheme. It is possible that they will provide additional flood protection benefit by maintaining beach levels; however this would require careful consideration and investigation to demonstrate. See below for why the cycleway has been included.
7: Raised Walkway/cycleway	The access to the shoreline in this area is considered to be very important and the presence of the cycleway is a key feature of that access. There is a clear need to provide a more permanent solution that is robust and will resist both loss of sand due to storm activity and excess material due to wind-blown sand. The raised walkway/cycleway is considered to be the most effective solution to providing this level of access to the shoreline.

6. Conclusions and Recommendations

This BMP has presented a range of options for the future management of the beaches of Llandudno. It has considered the two frontages in a similar manner and acknowledges that each has unique issues and objectives. The overriding consideration however that is likely to affect any option going forwards is the standard of flood protection that is presently afforded by the defences and will be required in the future under projected climate change.

The CTFRA has quantified the flood risk to Llandudno from the effects of waves, still water levels and the risk of breaching. The conclusion is that the flood risk increases significantly from the Present Day to after 100 years of climate change. This means that work will be required to improve the flood protection in the future.

A review of different options for each shore has been undertaken that has identified a short-list of options for the enhancement of each shore. The short-listed options are considered to be the most likely to be approved for funding. Each option will require further development and may result in variations. For example the West Shore option includes the enhancement of the existing sea wall. It may be possible to undertake this in a variety of ways, each potentially providing different amenity benefits. A further options appraisal will be required to finalise this. The retention of Option 2 on the North Shore is also an acknowledgement that whilst unlikely to be justifiable solely for flood protection, it is possible that the provision of an extended sand beach may encourage funding from additional sources such as private businesses.

Following this assessment it is recommended that an application to the Welsh Government should be made for funding to undertake the necessary studies to build the business case for flood protection works.

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Appendix A. Environmental assessment

Draft Beach Management Plan for the North and West Shores, Llandudno, North Wales: Preliminary Environmental Appraisal

Introduction

In developing a viable and sustainable Beach Management Plan it is important to consider both the environmental constraints of the proposed development area and any opportunities for environmental enhancement that could be delivered synergistically.

A good understanding of the environmental baseline and potentially significant environmental effects, determined through desk based assessment, site survey, and consultation with statutory stakeholders with regulatory and conservation responsibilities is needed in order to appraise the suitability of beach management options.

As part of the development of a draft Beach Management Plan, AECOM has undertaken a Preliminary Environmental Appraisal to consider the likely potential significant effects of a range of beach management options for the following topics in accordance with the current version of Construction Industry Research and Information Association (CIRIA) C685 Beach Management Manual (2nd Edition) (2010):

- Ecology and fisheries;
- Water and sediment quality;
- Geology and geomorphology;
- Landscape setting;
- Archaeology and cultural heritage; and
- Amenity issues.

Amenity issues include a range of sub-topics such as noise, dust, air quality, socio-economic, access and recreation. For the purpose of this appraisal, fisheries interests have been covered under 'Water and sediment quality'.

Environmental constraints plans are presented in Figures 1, 2 and 3. The following appendices also support this assessment:

- Appendix A Scheme Options;
- Appendix B Site Photos; and
- Appendix C Socio-economic uses along North Shore.

Proposed Options

The Llandudno Coastal Forum, which comprises of Conwy County Borough Council, Llandudno Town Council and various local trade, commercial and environmental groups (http://www.llandudnocoastalforum.co.uk/members/) identified the following four ideas to be considered as the basis for beach management options for the North Shore:

- Existing shingle management option for comparison;
- Idea 1 Imported sand beach with offshore breakwaters (Beach Zone only);
- Idea 2 Imported sand beach with shore connected breakwaters; and

- Idea 3 Imported sand / shingle beach with traditional groynes.

These options have been reviewed and the following long list of options compiled for further consideration and environmental appraisal:

- Option 1A Emerged detached breakwaters and beach nourishment;
- Option 1B Submerged detached breakwater and beach nourishment;
- Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment;
- Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment;
- Option 3 Traditional Groynes and beach nourishment;
- Option 4 Beach Nourishment only;
- Option 5 Periodic beach nourishment at 'Children's Corner' (from Pier wall to Trevor Street slipway); and
- Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don.

Please refer to Appendix A for Option Drawings.

For the West Shore, the following eight options have been appraised:

- Option 1 Periodic Beach Maintenance - Excess material will be removed regularly from the frontage. This surplus material can be re-used in other areas where required;
- Option 2 Dune Regeneration - Forming dunes at a number of locations with sand filled geotextile bags at their core. These will continue to accumulate material and grow over time, creating a barrier to windblown material;
- Option 3 Concrete Wall and Periodic Beach Maintenance - A concrete wall will be constructed along the back of the beach from the Dale Road car park to the Cerrig Duon breakwater (to the south). Periodic beach maintenance will be undertaken across the entire frontage to remove excess material;
- Option 4 Rock Cover Layer - A cover layer of 5 -10 kg rock will be placed over the existing beach material in order to prevent wind-blown sand. This will be backed by a retaining wall to prevent material loss;
- Option 5 Sand Traps - installation of sand traps along the West Shore;
- Option 6 Removal of the existing 3 breakwaters;
- Option 7 Installation of a raised timber or plastic walkway; and
- Option 8 Undertake repairs / raise existing wall along the northern section of the frontage.

Planning Policy

The following section provides a summary of the national, regional and local planning policy that applies to the study area and likely proposed development.

National Planning Policy

Planning Policy Wales (Edition 9, November 2016) sets out the Welsh Governments strategic land use planning policies. It is supported by a series of Technical Advice Notes (TANs) and procedural guidance circulars, all of which are available on the Welsh Governments website (http://gov.wales/topics/planning/policy/ppw). Chapter 5 of Planning Policy Wales covers the national policy on conserving and improving natural heritage and the coast.

In addition to Planning Policy Wales, the Welsh Government also published in November 2015 an initial draft version of the Welsh National Marine Plan (WNMP) setting out the overall objectives of optimising opportunities for the sustainable development of the Welsh marine and coastal zone.

The main principles of integrated coastal zone management (ICZM) embedded into relevant plans and projects, recognising the importance of the coast for:

- The conservation of the natural and historic environment;

- Urban and rural development, including housing, local industry and agriculture; and
- Tourism, leisure and recreation.

Regional Planning Policy

Regional planning policy for the coast of Wales is set out in a series of Shoreline Management Plan (SMP), which are currently on their second cycle and are typically referred to as 'SMP2s.' The purpose of a SMP is to provide a large-scale assessment of the risks associated with coastal processes and to present a policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable way. The SMP provides a framework for developing sustainable coastal defence, based on better understanding of coastal processes and taking into account the interactions of the natural and man-made environment.

The North Shore at Llandudno is included in the North West England and North Wales Shoreline Management Plan (SMP2) that was published by the North West & North Wales Coastal Group in 2010. Specifically, the North Shore is located Policy Unit 11a.1 - Great Orme to Little Orme, within Sub-cell 11a – Great Orme's Head to Southport. Section 3.2 of the SMP2 describes the rationale for the proposed short, medium and long term policies of Hold the Line. It states that "*historical construction of a mixture of seawalls, revetments, groynes and flood embankments has prevented shoreline erosion and managed flood risk to coastal towns (including Llandudno), tourism assets and infrastructure. However, these structures have resulted in a lowering of beach levels, erosion of sand dunes and the need for long term beach management*." The SMP2 considered whether managed realignment could be a viable alternative, but given the lack of space for such a policy at the North Shore it would not be suitable. The plan also states that there is a "*strong justification to continue to manage erosion and flood risks for most of this frontage over the next century by maintaining defences on their current alignment, but that this is likely to result in increasing beach loss over time*." The plan therefore recommends that "*beach management will become increasingly important to sustain beaches, which are important for coastal defence, amenity, tourism and environmental conservation*."

The West Shore at Llandudno is included in the West of Wales Shoreline Management Plan 2 (SMP2) prepared by Royal Haskoning in 2012 for the Cardigan Bay and Ynys Enlli to the Great Orme Coastal Groups. The SMP2 for West Wales allocates West Shore into Policy Unit 20.11 and recommends a short term (i.e. until 2025) and medium term (i.e. until 2055) policy of hold the line, with managed retreat proposed in the longer term (i.e. from around 2105) with the intent to sustain and improve flood defences in line with sea level rise to Llandudno. The management proposed is intended to address the long term flood risk to Llandudno and erosion along West Shore. Current shoreline coastal defence is provided by three fish tail rock groynes plus beach management. However, there is concern that rising relative sea levels will result in an increased probability of wave overtopping and erosion along the golf course to the south. Existing defences and management measures may need to be adapted to provide adequate protection from these impacts and the SMPs suggests that this may include setting defences back and encouraging the creation of beach or sand dunes. However, these proposals are unlikely to fully resolve existing sand blown issues to properties behind West Shore.

Local Planning Policy

The seaward limit of planning control is generally the mean low water mark (MLWM), but between high (MHWM) and MLWM the planning system usually needs to operate in conjunction with a range of sectoral controls over coastal and marine development (i.e. Marine Licencing which is the responsibility of Natural Resources Wales). The need for a Marine Licence and other consents and permissions is discussed later in this appraisal. The following describes local planning policy.

Local planning policy in Llandudno is set out within the Conwy Local Development Plan 2007-2022 (Adopted October 2013). Section 4.4 of the Local Development Plan (LDP) recognises that tourism makes a vital contribution to the economy of the borough, which is focused and therefore most important in the traditional coastal holiday resorts such as Llandudno. Local planning policy therefore seeks not only to protect these traditional attractions and facilities, and to improve the

overall quality of existing accommodation, but also to promote and support tourism in off-peak seasons whilst safeguarding environmental and heritage qualities.

Conwy County Borough Council will regulate development so as to conserve and, where possible, enhance the Plan Area's natural environment, countryside and coastline, in the context of seeking to support the wider economic and social needs of the borough. This is described by *Strategic Policy NTE/1 – The Natural Environment* and will be delivered through a range of policy measures, the most relevant to this study being:

- Safeguard the areas biodiversity, geology, habitats, history and landscapes through the protection and enhancement of sites of international, national, regional and local importance, in line with *Policy DP/6 – National Planning Policy and Guidance*;
- Respecting, retaining or enhancing the local character and distinctiveness of the individual Special Landscape Areas in line with P*olicy NTE/4 – 'The Landscape and Protecting Special Landscape Areas* and as shown on the Proposals Map;
- Protecting the Coastal Zone in line with *Policy NTE/5 – The Coastal Zone*; and
- Preventing, reducing or remedying all forms of pollution including air, light, noise, soil and water, in line with *Policy DP/6 – National Planning Policy and Guidance*.

Paragraphs 5.3.8 and 5.3.11 of Planning Policy Wales protect biodiversity on sites of national importance (for example, Sites of Special Scientific Interest (SSSI)). Sites of local importance (such as Local Nature Reserves and Wildlife Sites) are not protected through national policies, but will be recognised in the LDP due to their local importance. Conwy County Borough Council's Supplementary Planning Guidance (SPG) *LDP5 – Biodiversity in Planning* provides further information on this topic.

Policy NTE/3 – Biodiversity states that "*new development should aim to conserve and, where possible, enhance biodiversity*" through a number of actions, the most relevant being sensitive siting, layout and design; avoiding European protected sites or those of national or local importance; creating, enhancing and managing wildlife habitats and natural landscapes including connectivity; and contributing to achieving targets in the Conwy Local Biodiversity Action Plan (LBAP).

The policy also requires that all proposals should include a Biodiversity Statement detailing the extent of impact on biodiversity and that the Council will "*refuse proposals which would have a negative impact on a European Site, protected or priority species or habitat unless the impact is adequately mitigated and appropriate remediation and enhancement measures are proposed and secured by planning conditions or obligations*."

Overall, Conwy County Borough Council is committed to the protection and enhancement of biodiversity and will work with partners to ensure a proactive approach to the protection, enhancement and management of biodiversity in support of the Conwy LBAP. The Council is also committed to enforcing the Habitats Regulations for the protection of Natura 2000 sites and development proposals will only be allowed after it has been demonstrated that there will be no adverse impact on the integrity of any such site in accordance with Policy DP/6. Policy NTE/3 also "*supports species protection legislation and Local Biodiversity Action Plan targets, and ensures that any harm to a species or habitat is weighed against the benefit of a development proposal. The judgement will be made on the basis of the expected effect on the species, the local, national or international significance of the population of the species, and its abundance, rate of decline or degree of threat*."

The visual character of the landscapes, seascapes and townscapes in the borough, both within and outside of designated areas, is highly valued by residents and visitors, and Conwy County Borough Council places a high priority to the protection, conservation and enhancement of this landscape character. New development should also be well-designed and help sustain and / or create landscapes and townscapes with a strong sense of place and local identity.

Policy NTE/4 – The Landscape and Protecting Special Area (such as Great Orme and Creuddyn Peninsula) states that development proposals will have to "*show particular regard to the character of each locality in order to minimise their impact and will only be permitted if it is shown to be capable of being satisfactorily integrated into the landscape*; *all proposals, both within and outside Special Landscape Areas (SLAs) will be considered against the Development Principles and other policies in the LDP designed to protect the environment and landscape character*."

The purpose of Policy NTE/4 is to ensure that the local character of these areas is not altered by inappropriate forms of development and that features which contribute to local distinctiveness are preserved.

Policy NTE/5 – The Coastal Zones states the development will only be permitted outside settlement boundaries where the development:

- Specifically requires a coastal location;
- Does not adversely affect the open character of the zone;
- Does not adversely affect the nature conservation value of the zone with any effects identified mitigated for;
- Does not detract from the tourism value or facilities;
- Does not interfere with natural coastal processes;
- Does not impede the function of any existing coastal defence structures; and
- Accords with the Development Principles of the Plan.

The LDP states that the "*need to control development along coastlines is important for environmental and economic reasons. Coastlines warrant special protection as they are often sensitive to development due to their open character and they also provide habitats for certain species of plants, mammals and birds…A high proportion of Conwy's coastline is protected from flood risk although breaching from the sea is a continual risk…The coastline of Conwy is a significant factor in attracting visitors to the area. Due to the role which tourism and recreation plays in the local economy it is important to maintain and enhance the attractiveness of the area through the development of improved facilities*."

Paragraph 4.6.2.4 of the LDP states that "*much of the coastal area, particularly in the Urban Development Strategy Area, is at risk from flooding and there is a need to prevent inappropriate development in areas at risk. This risk is likely to increase in the future as a result of climate change and a rise in sea level*". Strategic policy *DP/1 – Sustainable Development Principles* states that "*Development will only be permitted where it is demonstrated that it is consistent with the principles of sustainable development*" including identifying and addressing flood risks. Furthermore, Policy DP/6 requires all development to be consistent with national planning policy as set out in Planning Policy Wales (Edition 9, November 2016).

In addition to the above, Conwy County Borough Council has prepared a number of SPGs that are relevant to the proposed management of beaches as the North and West Shores, Llandudno. These include:

1. LDP27: Coastal Flood Risk Protocol (Adopted July 2015);
2. LDP5: Biodiversity in Planning (Adopted November 2014); and
3. LDP15: Llandudno Conservation Area Management Plan (Adopted March 2015).

Environmental Impact Assessment

Environmental Impact Assessment (EIA) is required for those developments which fall within Schedule 1 to the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 (as amended) (henceforth referred to as 'the EIA Regulations'), and may be required for development falling within Schedule 2 to the EIA Regulations. Schedule 2 development means development, other than exempt development, of a description mentioned in Column 1 of the table in Schedule 2 where:

- Any part of that development is to be carried out in a sensitive area; or
- Any applicable threshold or criterion in the corresponding part of Column 2 of that table is respectively exceeded or met in relation to that development.

A sensitive area, for the purposes of the Regulations, includes, among other things, a Site of Special Scientific Interest (SSSI), a proposed or listed Ramsar site, a potential or classified Special Protection Areas (SPA) or a candidate Special Areas of Conservation (cSACs) or designated Special Areas of Conservation (SAC). However, the fact that a development would affect a sensitive area would not, of itself, justify the requirement for EIA although it would increase the possibility of EIA being required. That judgement must be taken on the particular merits of each case. Local planning authorities should consult Natural Resources Wales if uncertain about the significance of a project's likely effect on the environment. Overall, EIA will only be required for Schedule 2 development where that development is likely to have a significant effect on the environment, irrespective of the above Schedule 2 criteria.

Habitats Regulation Assessment

The Conservation of Habitats and Species Regulations 2010 (as amended) are commonly referred to as the 'Habitats Regulations'. The Habitats Regulations (Regulation 8) define 'European sites' as candidate Special Areas of Conservation (cSACs), Special Areas of Conservation (SACs), Special Protection Areas (SPAs), and Sites of Community Importance (SCIs).

Regulation 102 of the Habitats Regulations states that "*A competent authority, before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which:*

(a) is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and

(b) is not directly connected with or necessary to the management of that site,

(c) must make an appropriate assessment of the implications for that site in view of that site's conservation objectives."

Regulation 102 further states that "*In the light of the conclusions of the assessment, and subject to considerations of overriding public interest, the competent authority may agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the European site or the European offshore marine site (as the case may be)*."

The application of the Habitats Regulations involves the precautionary principle. That is that plans and projects can only be permitted having ascertained no adverse effect on the integrity of the site. However, plans and projects may still be permitted if there are no alternatives, and there are imperative reasons of overriding public interest as to why they should go ahead. In such cases compensatory measures will be necessary to ensure the overall integrity of network of sites.

Habitats Regulations Assessment (HRA) ultimately comprises four tasks:

- Task 1 Screening - for the likely significant impacts/effects;
- Task 2 Appropriate Assessment - which is carried out if any significant effects are highlighted during Task 1,
- Task 3 Consideration of the alternatives in the plan/project, if there is a significant effect, and
- Task 4 Consideration as to whether there is an overriding public interest, if there is a significant effect. If so, compensation measures also need to be considered.

Water Framework Directive Assessment

European Council Directive 2000/60/EC establishing a framework for Community action in the field of water policy (known as the 'Water Framework Directive') came into force in December 2000 and

was transposed in Wales by the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003 (as amended 2015 & 2016). The WFD takes a holistic approach to the sustainable management of water by considering the interactions between surface water (including transitional and coastal waters, rivers, streams and lakes), groundwater and water-dependent ecosystems. Its objectives include the protection, enhancement and restoration of all bodies of surface and groundwater with the aim of achieving good surface water status and good groundwater status by 2015, or by later cycles in certain situations.

Under the WFD, 'waterbodies' are the basic management units, defined as all or part of a river system or aquifer. Waterbodies form part of a larger 'river basin districts' (RBD), for which 'River Basin Management Plans' (RBMPs) are used to summarise baseline conditions and set broad improvement objectives. In Wales, Natural Resources Wales is the competent authority for implementing the WFD, although many objectives will be delivered in partnership with other relevant public bodies and private organisations (e.g. local planning authorities, water companies, Rivers Trusts, large private landowners and developers). As part of its regulatory role and statutory consultee on planning applications and environmental permitting (under the Environmental Permitting Regulations (England and Wales) 2010 (as amended), Natural Resources Wales must also consider whether proposals for new developments have the potential to:

- Cause a deterioration of a waterbody from its current status or potential; and / or
- Prevent future attainment of good status or potential where not already achieved.

In determining whether or not a development is compliant or not compliant with the WFD objectives for a water body, Natural Resources Wales must also consider the potential indirect effects on adjacent WFD water bodies and the conservation objectives of any European level Protected Areas (e.g. Natura 2000 sites, designated bathing waters and shellfisheries) and water dependent SSSIs, where relevant.

There is no specific guidance for the assessment of WFD compliance for beach management plans. Guidance has existed for some time for preparing WFD assessments of Shoreline Management Plans, and this could be adapted for use as a framework to support the development of suitable beach management options. Alternatively, in December 2016 the Environment Agency published the guidance '*Clearing the Waters for All*' for how to assess the impact of certain coastal activities on WFD designated estuarine (transitional) and coastal waters up to one nautical mile out to sea. In light of no alternative in Wales, this WFD assessment guidance would be more appropriate for the assessment of beach management schemes as they progress and a more detailed assessment is required to support applications for planning permission and a Marine Licence.

Consideration of BREXIT

Much of the environmental legislation in the UK is rooted in European Directives and therefore it is appropriate at this feasibility stage to consider briefly the likely implications of the outcome of last June's referendum for the UK to leave the European Union. For the most part, environmental European Directives have been transposed into law by national legislation and thus, until the UK formerly leaves the European Union and these national pieces of legislation are revoked, the requirements of these directives remain in place. At this point in time it is expected that the UK will continue to maintain the same standard of environmental protection and that these provisions will be enshrined within a Great Repeal Act. However, over time it is likely that environmental laws and requirements on new developments will evolve as new national legislation is passed, that may or may not be similar to the prevailing European Union standards.

Approach and Methodology

This Preliminary Environmental Appraisal is based on a technical review of existing information and data readily available from online, publically accessible places, and direct data requests to third parties, and a targeted Site Walkover Survey carried out by a Marine Ecologist and Landscape

Architect. Where appropriate, baseline data has been presented on a series of Environmental Constraints Plan presented as:

- Figure 1 Study Area Constraints Plan;
- Figure 2 North Shore Environmental Constraints Plan; and
- Figure 3 West Shore Environmental Constraints Plan.

The desk study and site visit data has been used to determine the importance of environmental receptors (with reference to best practice guidance) and how these might constrain future management options, or present an opportunity for environmental enhancement.

Key stakeholders include various Conwy Borough Council departments, Natural Resources Wales, Gwynedd Archaeological Trust and these bodies and organisations should be consulted during subsequent stages of development of the Beach Management Plan to obtain further baseline information, evaluate emerging options, and comment on the scope of future assessment.

Both constraints and opportunities have been considered in the context of national, regional and local planning policy, including the proposals set out in the local SMP2 and the objectives of the WFD.

A risk assessment of each shore option has been carried out and the results fed back into the development of the preferred Beach Management Plan as part of the iterative process of option development. Any limitations have also been identified and the uncertainty that results considered in the appraisal so that appropriate follow up surveys and assessment can be identified, together with where licences, consents and permissions may be required.

Risk Assessment

Risk is defined as the outcome of the probability of an environmental impact occurring and the consequences of that impact in terms of the effect on natural and environmental receptors in the context of planning policy and other regulatory frameworks.

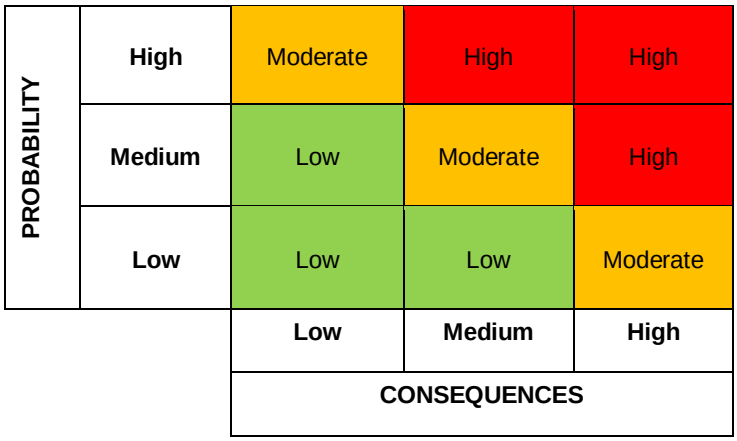
The **probability** of an environmental impact occurring depends on many factors including but not limited to the presence of a particular receptor on the site, the distance between the receptor and the source of the impacts, and timing. The probability of an environmental impact will therefore depend on natural circumstances, but also how the scheme is designed, constructed and operated.

The **consequences** of an environmental impact also depend on many factors including but not limited to the importance and / or sensitivity of a receptor, and the magnitude, frequency (i.e. short, medium or long-term), timing, and duration (i.e. whether the impact is temporary or permanent) of the impact.

For each scheme option for the North and West Shores an initial risk assessment has been undertaken for each environmental topic listed earlier. The risk presented for each management option represents the reasonable worst case of any topic specific adverse effect that could conceivably be caused by the scheme. The risk assessment does not consider every potential impact per topic per option.

Two risk assessment results are reported, the first represents the predicted risk without any mitigation measures being taken into account. The second assessment demonstrates the likely risk once possible mitigation measures have been considered. Risks have been determined using the professional judgement of environmental specialists, knowledge of similar schemes, the applicability and likely effectiveness of standard mitigation measures using the risk assessment matrix in Diagram 1. However, this is an initial assessment only and further assessment will be required as options are developed.

Diagram 1 Risk Assessment Matrix



Preliminary Environmental Appraisal

Ecology and Fisheries

An Ecological Walkover was undertaken of the Llandudno North Shore and West Shore to assess the marine and terrestrial habitats by a suitably qualified AECOM marine and terrestrial ecologist. Methodologies and data collection followed standard protocol developed by the Marine Nature Conservation Review (MNCR) 1996: review and methods and the Phase 1 Habitat Survey and Marine Habitat Classification (Joint Nature Conservation Committee, 2007 and 2004). The survey recorded habitat types and the plant and marine algal species they support and other notable ecological features. However, these are indicative of the habitat surveyed, rather than detailed inventories of the species present on site. In addition, the survey visit was undertaken on the 8th November, which is a sub-optimal time for survey following appropriate guidance (JNCC, 2007).

An appraisal was made of the potential suitability of the habitats. Field signs, features with potential to support protected species and evidence of their presence were recorded when encountered, but at this time no detailed surveys were carried out for species. If additional detailed surveys are recommended for particular species or groups these are described below.

CMACS previously carried out a full intertidal survey of an outflow pipe on the West Shore beach area in December 2011. The CMACS survey area lies west of the first breakwater, outside of the study boundary that AECOM were surveying for this study. It is likely that the similar habitats will still be present in this area, although due to the breakwaters this data cannot be relied upon for the areas AECOM are surveying.

Limitations

A thorough botanical survey was not undertaken due to seasonality limitations, and therefore some components of the vegetation may not have been recorded. However, this is not considered to significantly affect the quality or integrity of the survey to identify the potential to support protected or notable plant species.

The surveyors arrived on site approximately at low tide, so the tide was slowly coming in during the survey meaning that some areas may not have been observed.

It should be noted that ecosystems are dynamic and constantly changing, and therefore species may move or new species may be recorded in subsequent years. For this reason, and in accordance with current guidance, the existing survey data has a ‘shelf-life’ of, and should only be relied on for a period of, two years from the date of survey (8th November 2018). After this date, update surveys are likely to be required and advice sought from an appropriately qualified ecologist to determine survey scope and methods. However, regardless of this as a preferred option is developed further surveys at the optimum time should be carried out.

Environmental Baseline

The survey area for the North Shore beach was from Llandudno Pier to just east of the Craig-Y-Don Paddling Pool.

The survey area for the West Shore beach included the area of beach in between the northern most and southern most breakwaters, a distance of approximately 1.25 km.

Ecological Desk Study

A search for statutory designated sites was undertaken within a 2 km buffer of the North Shore and the following was identified (see Figure 1 and 2):

- Menai Strait and Conwy Bay SAC lies directly adjacent to the north of the north shore ecological survey area - The primary reason for designation is for its habitats:
    1. Sandbanks which are slightly covered by sea water all the time;
    2. Mudflats and sandflats not covered by seawater at low tide; and
    3. Reefs.
- Liverpool Bay SPA lies seaward of MLWS across the entire North Shore frontage - The SPA is designated for its bird species such as Common Scoter (*Melanitta nigra*) and Red Throated Diver (*Gavia stellate*);
- Coedwigoedd Penrhyn Creuddyn / Creuddyn Peninsula Woods SAC - Primarily designated for its *Tilio-Acerion* forests of slopes, screes, and ravines is approximately 1 km to the south of the North Shore;
- Maes-Y-Facrell, Peny Gogarth National Nature Reserve (NNR) is located approximately 900m to the east of the North Shore;
- Creigiau Rhiwledyn/ Little Ormes Head Site of SSS) (approximately 500m to the east of the North Shore);
- Creuddyn SSSI (Part of the Coedwigoedd Penrhyn Creuddyn / Creuddyn Peninsula Woods SAC) is approximately 550 m to the south of the North Shore;
- Pen Y Gogarth / Great Orme's Head SAC is directly adjacent the northern point of the North Shore;
- Pen Y Gogarth / Great Orme's Head SSSI is directly adjacent the northern point of the North Shore; and
- Aber Afon Conwy SSSI is approximately 1.2 km to the south-west of the North Shore.

A search for statutory designated sites was also undertaken within a 2 km buffer of the West Shore and the following was identified (see Figure 1 and 3):

- Menai Strait and Conwy Bay SAC lies directly adjacent the Conwyn Sands area which borders the ecological survey area - The primary reason for designation is for its habitats:
    1. Sandbanks which are slightly covered by sea water all the time;
    2. Mudflats and sandflats not covered by seawater at low tide; and
    3. Reefs.
- Liverpool Bay SPA lies directly adjacent the Conwy Sands area which borders the ecological survey area - Designated for its bird species such as Common Scoter (*Melanitta nigra*) and Red Throated Diver (*Gavia stellate*);
- Pen Y Gogarth / Great Orme's Head SSSI is approximately 100 m to the north of the West Shore);
- Aber Afon Conwy SSSI – the site is directly within this SSSI;
- Maes-Y-Facrell, Peny Gogarth NNR is approximately 600 m to the north of the West Shore;
- Pen Y Gogarth / Great Orme's Head SAC is approximately 100 m to the north of the West Shore;
- Chwareli A Glaswelltir Degannwy SSSI is approximately 1.8 km to the south-east of the West Shore); and
- Bwlch Mine SSSI is approximately 1.8 km to the south-east of the West Shore ecological survey area).

A full desk study has not been undertaken as this does not form part of the scope. It is recommended that a full desk study is undertaken as options are developed.

In summary, the North Shore beach habitat being surveyed lies adjacent the Menai Strait and Conwy Bay SAC, the Liverpool Bay SPA, the Creigiau Rhiwledyn/ Little Ormes Head SSSI and the Pen Y Gogarth / Great Orme's Head SSSI. The West Shore lies directly within the Aber Afon Conwy SSSI and adjacent the Menai Strait and Conwy Bay SAC and the Liverpool Bay SPA.

Marine/Beach Assessment

North Shore

The habitats within and surrounding the survey area consists mainly of marine coastal environments with a small amount of terrestrial habitat towards the eastern end of the survey area and along the promenade. The marine and coastal environments consist of a range of habitats including low energy littoral rock (LR.LLR) and fucoids on sheltered marine shores (LR.LLR.F) found towards the western end of the beach and surrounding Llandudno Pier. Further east the beach ranges between shingle (pebble) and gravel shores (LS.LCS.Sh), littoral sand (LS.LSa) and Polychaetes in littoral fine sand (LS.LSa.FiSa.Po).

Llandudno Pier is constructed from metal and wood supporting pillars that protrude out into the sea, this extends back onto the shore into a solid stone supporting wall which runs between the promenade and the beach. The beach is accessed down from steps off the main promenade. There are two wooden landing stages that petrude across the beach and can be seen at low tide. Species growing in the low energy littoral rock habitat was dominated by flat / spiral wrack (*Fucus spiralis*), with components of bladder wrack (*Fucus vesiculosus*) *Enteromorpha sp.* and red alga (*Polysiphonia lanosa*). Faunal species include barnacle sp. (*Balanus sp*.), common periwinkle (*Littorina littorea*), limpet sp. (*Patella sp*.), dog whelk (*Nucella lapillus*) and Gammerus sp. The littoral rock does not encompass a diverse intertidal under boulder community. In the fine littoral sand habitats, lugworm (*Arenicola marina)* was present.

Oystercatcher (*Haematopus ostralegus*), herring gull (*Larus argentatus*), jackdaw (*Corvus monedula*) and turnstone (*Arenaria interpres*) were recorded foraging within the lower shore during the survey.

West Shore

The habitat within and surrounding the survey area consists mainly of marine coastal environments, with coastal dune habitats bordering the beach to the east. There is a golf course to the east of the sand dunes which has amenity terrestrial habitat; there is also amenity terrestrial habitat further to the north in the recreational car park. The marine and coastal environments are dominated by Shingle (pebble) and gravel shores (LS.LCS.Sh), and Polychaetes in littoral fine sand littoral sand (LS.LSa.FiSa.Po). The breakwaters are made up of large boulders and rocks that are man-made structures, classed as high energy littoral rock (LR.HLR) habitats.

Species growing on the high energy littoral rock habitats are communities dominated with channel wrack (*Pelvetia canaliculata*) and egg wrack (*Ascophylum nodosum*), with components of flat/spiral wrack (*Fucus spiralis*), bladder wrack (*Fucus vesiculosus*) Ulva sp (*Ulva sp*) and pepper dulse (*Laurencia pinnatifida*). Faunal species include barnacle sp. (*Balanus sp*.), and common periwinkle (*Littorina littorea*),

In the fine littoral sand habitats, lugworm (*Arenicola marina)* was present.

Oystercatcher (*Haematopus ostralegus*) and herring gull (*Larus argentatus*) were recorded foraging within the lower shore during the survey, and jackdaw (*Corvus monedula*) recorded on the upper shore.

Terrestrial Assessment

North Shore

Within the survey area the promenade runs adjacent the top of the beach, there are ornamental species which have been planted along the promenade for landscape value. Further east within the proposed Fishing Zone, there is no retaining wall between the beach and the walkway, just steps that lead down onto the beach. There are areas of amenity grassland that run along the walkway and top edge of the beach, this is dominated by red fescue (*Festuca rubra*), white clover (*Trifolium repens*), ribwort plantain (*Plantago lanceolata*), yarrow (*Achillea millefolium*), greater plantain (*Plantago major*), creeping buttercup (*Ranunculus repens*) and dock sp (*Rumex sp.) th*ere were also large fields of improved neutral grassland on the opposite side of the road across from the proposed Fishing Zone that was used for grazing livestock. Within this field oyster catcher and pied wagtail (*Motacilla alba*) were recorded foraging.

West Shore

Coastal sand dune habitat was present along the eastern edge of the survey area and to the rear of existing breakwater structures. It should be noted that coastal sand dunes are a UK BAP priority habitat (UK Biodiversity Action Plan; Priority Habitat Descriptions. BRIG (ed. Ant Maddock) 2008.). The sand dune habitats were dominated by marram grass (*Ammophila arenaria),* with components of lyme grass *(Leymus arenarius),* colts foot *(Tussilago farfara),* bramble *(Rubus fruticosus),* red fescue (*Festuca rubra*), ribwort plantain (*plantago lanceolata*), creeping thistle (*Cirsium arvense), blackthorn (Prunus spinosa),* yarrow (*Achillea millefolium*), ragwort (*Jacobaea vulgaris*), sea buckthorn (*Hippophae rhamnoides*), rock samphire (*Crithmum maritimum*), sea beet (*Beta vulgaris subsp. Maritima*), white poplar (*Populus alba*) and fennel (*Foeniculum vulgare*). This habitat borders onto a golf course and amenity grassland areas to the east.

West Shore is contained within the Aber Afon Conwy SSSI which is designated for its marine and terrestrial invertebrate biology interest. The tidal reach of the site extends approximately 16 kilometres, encompassing Conwy Bay between Penmaenbach Point and Great Orme's Head at its seaward limit, to its upstream boundary south of Tal y Cafn. The shoreline is backed by natural rock and boulder clay cliff, sand dune, salt marsh and woodland, with artificial substrate and sea defence walls forming the boundary throughout the remainder of the estuary.

Aber Afon Conwy SSSI also supports the nationally scarce belted beauty moth **Lycia zonaria** Britannica which can be found at Morfa Conwy. However, as this area will not be affected it will not form part of this assessment.

The coastal plain estuary is of particular importance as it has the largest extent, most complete zonation, richest variety and best examples of high quality intertidal estuarine communities, between Bardsey Island and Great Ormes Head. The site also supports the most typical example of estuarine rocky and sediment communities in East Gwynedd and supports nationally important bivalve 'piddock' communities.

The site also supports frequently high numbers of waders, especially curlew *Numenius arquata*, redshank *Tringa tetanus* and oystercatcher *Haematopus ostralegus*. Regularly high numbers of migratory salmon *Salmo salar*, which spawn in upstream regions of River Conwy, are present within the SSSI.

Potential Environmental Effects

North Shore

All options will result in some construction and permanent development within the SAC and SPA and thus will require a HRA to be undertaken. This will need to consider the potential for adverse impacts on designated features, particularly the direct permanent loss of habitat, but also indirect changes as a consequence of changes hydrodynamic conditions and short term construction effects. Further review of existing data and potentially surveys may be required to determine the presence of SAC designated habitats and the use of the areas affected by birds designated under the SPA. Where possible, designated habitats should be avoided, but where this is not possible a full range of mitigation will need to be considered as part of the HRA process.

Construction works close to the SPA may also disturb (e.g. noise and visual effects) designated birds and cause changes to intertidal areas that may have an adverse impact on foraging, although at this stage the level of potential impact is very uncertain.

There were organisms recorded within the North Shore that are permanently attached to the substrate (e.g. barnacles and algae). These organisms will be sensitive to the loss of any substrata that may be removed as part of the proposed options and these communities will, therefore, be lost. These organisms may also be sensitive to smothering if new shingle/boulders/sand are to be positioned on top of what is already there. Algal species need sunlight to be able to live so will die off quickly if this is not available. However, for options that include new structures, then these would potentially provide suitable habitat for these species to recolonise.

The more mobile organisms, such as common periwinkle, limpets, dog whelk and *gammerus sp*., will be less sensitive to potential deposits as they generally move into more sheltered areas out of the way, some of the potential options may also provide suitable habitat for these species to colonise.

There is also the potential for the sand habitat areas to be disturbed during the works of these potential options, and also the birds that may use this habitat to forage.

West Shore

There were organisms recorded within the West Shore that are permanently attached to the larger substrate on the breakwaters (e.g. barnacles and algae). These organisms will be sensitive to the loss of any substrata that may be removed as part of the proposed options and these communities will, therefore, be lost. These organisms may also be sensitive to smothering if new shingle/boulders/sediment are to be positioned on top of what is already there. Algal species need sunlight to be able to live so will die off quickly if this is not available. However, where options include the construction of new structures (e.g. groynes), then these would potentially provide suitable habitat for these species to recolonise.

The more mobile organisms, such as common periwinkle, will be less sensitive to potential deposits as they generally move into more sheltered areas out of the way, some of the potential options may also provide suitable habitat for these species to colonise.

If there is also the potential for the sand habitat areas to be disturbed during the works of these potential options, then this may also cause disturbance to the birds that may use this habitat to forage.

Sand dunes are a UK BAP habitat and are formed by how the beach naturally works as an ecosystem (e.g. wind-blown sand). If the supply of wind-blown sand is interrupted this habitat could be lost or degraded.

Risk Assessment

Table 1 provides a summary of the options risk assessment for ecology for the North Shore options and Table 2 for the West Shore options:

Table 1 Ecological Risk Assessment for the North Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1A Emerged detached breakwaters and beach nourishment	Option may result in a temporary net loss of species diversity. This option is expected to result in the largest land take and disturbance during construction.	Difficult to determine at this time as it is subject to further survey and assessment as part of the HRA process. With time it is possible that the presence of a new breakwater may result in a positive gain for species diversity by providing new substrate for species to colonise.
Option 1B Submerged detached breakwater and beach nourishment	Option may result in a temporary net loss of species diversity. However, the footprint of development is smaller than Option 1A.	Difficult to determine at this time as it is subject to further survey and assessment as part of the HRA process. With time it is possible that the presence of a new breakwater may result in a positive gain for species diversity by providing new substrate for species to colonise.
Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment	Option may result in a temporary net loss of species diversity. However, the footprint of development is substantially smaller than Option 1A or 1B.	Difficult to determine at this time as it is subject to further survey and assessment as part of the HRA process. With time it is possible that the presence of a new breakwater may result in a positive gain for species diversity by providing new substrate for species to colonise.
Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment	Initial option may result in a temporary net loss of species diversity. However, the footprint of development is substantially smaller than Option 1A or 1B.	Difficult to determine at this time as it is subject to further survey and assessment as part of the HRA process. With time it is possible that the presence of a new breakwater may result in a positive gain for species diversity by providing new substrate for species to colonise.
Option 3 Traditional Groynes and beach nourishment	Option may result in a temporary net loss of species diversity. However, the footprint of development is substantially smaller than Option 1A, and also requires less land take within the SAC than Options 2A, 2B, 1A, and 1B.	With time this will result in a positive gain for species diversity.
Option 4 Beach Nourishment only	Option may result in a temporary net loss of species diversity but does not require any permanent development within the SAC and SPA.	With time this will result in a positive gain for species diversity.
Option 5 Periodic beach nourishment at 'Children's Corner' (from Pier wall to Trevor Street slipway)	Option may result in a temporary net loss of species diversity but does not require any permanent development within the SAC and SPA.	With time this will result in a positive gain for species diversity.
Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don	The addition of a wave return sea wall may increase the risk of beach scour in front of the paddling pool at Craig-y-Don. However, the new wall would be very limited in its lateral extent and would be located above MHWST. Lateral movement of beach deposits is likely to replenish any beach sediment temporarily scoured following storms or extreme high tide events.	Regular monitoring and beach replenishment could mitigate any adverse effects in the long term.

Table 2 Ecological Risk Assessment West Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1 Periodic Beach Maintenance	Option may result in a temporary net loss of species diversity and would need to be compatible with management objectives for the SSSI. Although, there would be no direct impacts on the SAC/SPA, the proposed works may still need to be screened for any potential likely significant effects, particularly if works are undertaken during the winter months when Red throated diver (*Gavia Stellate*) and Common scoter (*Melanitta Nigra*) are overwintering on this frontage.	Beach management should take account of all nature conservation designations. NRW should be consulted on the need for a HRA and Assent to Work in a SSSI. Existing sand dunes may need to be monitored to ensure adequate sand supply. Excess sand could be used to support the dunes or to support management of the North Shore.
Option 2 Dune Regeneration	Option presents an opportunity to create more extensive sand dunes along the entire West Shore frontage, where they have previously been lost to past development and the construction of sea defences. The creation of new sand dune habitat, which is a UK BAP habitat, will be a significant positive development and provides the greatest opportunity of any option along this frontage to restore the coastal environment and enhance biodiversity.	New sand dunes will need to be managed accordingly and there may be opportunities to collaborate in partnership with NRW and local wildlife trust and groups.
Option 3 Concrete Wall and Periodic Beach Maintenance	This option would result in the direct and permanent loss of upper beach habitat and potentially some dune habitat within the SSSI for the construction of the new wall. The up to 1.5 m high wall will also restrict the supply of sand to the existing dune system backing the foreshore in this location at the North Wales Golf Club. Although, there would be no direct impacts on the SAC/SPA, the proposed works may still need to be screened for any potential likely significant effects, particularly if works are undertaken during the winter months when Red throated diver (*Gavia Stellate*) and Common scoter (*Melanitta Nigra*) are overwintering on this frontage.	NRW will need to be consulted as this option has the potential to result in the loss of habitat designated under the Aber Afon Conwy SSSI and may also require a HRA.
Option 4 Rock Cover Layer	This option would result in the direct and permanent loss of upper beach habitat and potentially some dune habitat within the SSSI for the construction of the new wall. Although shorter than the wall proposed under Option 3, the new retaining wall may still restrict the supply of sand to the existing dune system backing the foreshore in this location at the North Wales Golf Club. Although, there would be no direct impacts on the SAC/SPA, the proposed works may still need to be screened for any potential likely significant effects, particularly if works are undertaken during the winter months when Red throated diver (*Gavia Stellate*) and Common scoter (*Melanitta Nigra*) are overwintering on this frontage.	NRW will need to be consulted as this option has the potential to result in the loss of habitat designated under the Aber Afon Conwy SSSI and may also require a HRA.
Option 5 Sand Traps	The installation of sand traps would require only minimal construction works and no significant effects on marine or terrestrial ecological receptors or designations are predicted at this stage. There would also be no direct impacts on the SAC/SPA.	Beach maintenance operations should take account of the nature conservation designations that apply to West Shore. NRW should be consulted on the need for a HRA and Assent to Work in a SSSI.
Option 6 Removal of the existing 3 breakwaters	Removal of the three existing fish tail rock groynes may result in short term temporary adverse effects within the SSSI if not managed appropriately. In the long term the removal of the three groynes will reduce the biodiversity of the shoreline but would return the bay to a more natural state with less interrupted sediment movement, although adjustment of the shoreline is uncertain. Although, there would be no direct impacts on the SAC/SPA, the proposed works may still need to be screened for any potential likely significant effects, particularly if works are undertaken during the winter months when Red throated diver (*Gavia Stellate*) and Common scoter (*Melanitta Nigra*) are overwintering on this frontage.	Appropriate intertidal surveys would be required to assess the biological features present on the groynes. NRW should be consulted on the need for a HRA and Assent to Work in a SSSI.

Table 2 Ecological Risk Assessment West Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 7 Installation of a raised timber or plastic walkway	Although raising the walkway will reduce permanent loss of habitat potentially within the Aber Afon Conwy SSSI in comparison to Options 3 and 4, some habitat loss and temporary adverse effects cannot be avoided entirely. Although, there would be no direct impacts on the SAC/SPA, the proposed works may still need to be screened for any potential likely significant effects, particularly if works are undertaken during the winter months when Red throated diver (*Gavia Stellate*) and Common scoter (*Melanitta Nigra*) are overwintering on this frontage.	NRW will need to be consulted as this option has the potential to result in the loss of habitat designated under the Aber Afon Conwy SSSI and may also require a HRA.
Option 8 Undertake repairs / raise existing wall along the northern section of the frontage	Option maintains the current sea defence structures and would potentially increase the height of the northern sea wall, but without increasing its current footprint. No significant effects on marine or terrestrial ecological receptors or designations are predicted at this stage. Although, there would be no direct impacts on the SAC/SPA, the proposed works may still need to be screened for any potential likely significant effects, particularly if works are undertaken during the winter months when Red throated diver (*Gavia Stellate*) and Common scoter (*Melanitta Nigra*) are overwintering on this frontage.	This option does not involve any long term and regular maintenance or intervention along this frontage in addition to current arrangements.

Scope for Mitigation

Beach maintenance operations will need to take account of the features and management objectives of the nature conservation designations that apply to West Shore and where possible avoid any adverse effects. Where construction works are required there may be the need for a HRA and further consultation with NRW should be carried out to scope this and any application for Assent to Work in a SSSI, particularly where there may be development in the Aber Afon Conwy SSSI and potential loss of designated habitat. Further ecological surveys of habitat and the potential for protected species will be needed following standard methods and at the appropriate time of year as part of any Ecological Impact Assessment for this, or where the existing fish tail groynes may be removed. These might include ornithological surveys so that the potential for indirect likely significant effects on the Liverpool Bay SPA can be appraised. Monitoring may be required to ensure a sufficient sand supply to the existing sand dunes close the North Wales Golf course, especially for those options that seek to introduce barriers that may disrupt wind-blown sand supply (i.e. Options 3, 4 or 7).

Need for Further Assessment

It is recommended that a full ecological desk study is undertaken as options are developed. In addition, further ecological surveys are recommended including more detailed species analysis of the beach if there is a going to be a potential disturbance to the beach habitats. If offshore breakwaters are proposed further surveys to assess the bed substrate and species present may be required using underwater cameras and the analysis of grab samples. Finally, due to the proximity to the statutory sites it is recommended that a HRA should be undertaken.

Water and Sediment Quality

The following section considered the potential effects of the proposed beach management options on the water environment, including the mobilisation of sediment and any contamination that it may contain.

Environmental Baseline

North Shore

The Environment Agency's Catchment Data Explorer website provides information on the classification of WFD water bodies. The coastal waters out to one nautical mile adjacent to the Llandudno North Shore frontage are designated under the WFD as the North Wales coastal water body (GB641011650000). The North Wales coastal water body covers an area of 146 km^2 extending from the Dee Estuary in the east to the point of Great Orme's Head in the west. It is characterised by being moderately exposed, macro-tidal, and heavily modified due to coastal protection. It is currently only achieving Moderate Ecological Potential and failing to meet Good Chemical Status (due to dissolved inorganic nitrogen). No water or sediment quality data was available to inform this preliminary assessment.

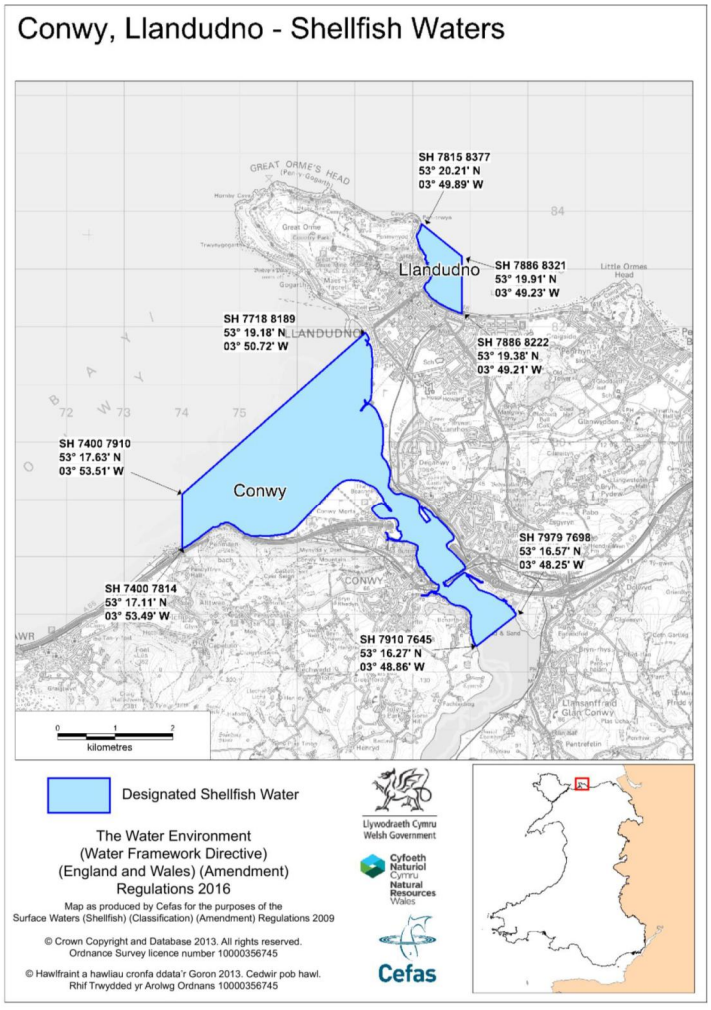
The North Shore has been designated a bathing water since 1988. Information and data on bathing water quality can be found on Natural Resources Wales' website (http://environment.data.gov.uk/wales/bathing-waters/profiles/). This includes bathing water profiles that describe the beach and the surrounding area, identifies any rivers and streams feeding into the site, and details about how Natural Resource Wales manage the risk of pollution at the site.

The profile for Llandudno North Shore describes the local environs and the beach as "*long and sandy, with a stony pebble foreshore, which extends over 2 kilometres. A concrete promenade runs the length of the beach to the rear. The sea area offshore is designated as the Menai Strait and Conwy Special Area of Conservation, whilst the Great Orme is also designated as a Special Area of Conservation. The water quality sample point is located opposite the St. George's Hotel*." Based on water quality sampling and analysis of faecal indicator organisms (i.e. bacteria) in the

water, the overall annual quality result for 2015 was good, and unchanged during the past four years.

Oil and tarry residues, and sewage debris has not been observed at this bathing water, with only trace amounts of animal faeces noted at the site on a minority of occasions. Trace amounts of litter were observed at the bathing water the majority of the time and in greater amounts on more than an additional twenty per cent of occasions. The bathing water is also not significantly affected by any inflowing streams or rivers and has no history of large amounts of seaweed (macroalgae) or algal (phytoplankton) blooms.

The westernmost part of North Shore and the entire West Shore are included within the Conwy, Llandudno commercial shellfish waters designated under the Water Environment (Water Framework Directive) (England and Wales) (Amendment) Regulations 2016 which came into force on 3 March 2016:



Shellfish waters are designated to protect the quality of water and the environment to support healthy commercial shellfish beds that are suitable for human consumptions. Further consultation with the Environmental Health Officers at Conwy County Borough Council, Natural Resources Wales and potentially local organisations is required to determine the precise location of farmed shellfish beds and how these may be affected by the proposed options in terms of loss or indirect effects during construction and operation.

West Shore

The outer bay is a coastal water body, and the inner bay is included in the Conwy Estuary transitional water body, and both are designated under the WFD. Some designated features of nature conservation designations that apply to Conwy Bay may depend on good water quality in the bay.

The Conwy Transitional Water Body (GB541006614800) is a partly mixed, meso-scale estuary that covers 15.57 km^2 and extends from the tidal limit some distance in land near Trefriw to the coastal waters off West Shore. It is heavily modified for flood protection and is currently only meeting Moderate Ecological Potential and failing to meet Good Chemical Status (due to invertebrate and not all mitigation measures being in place.

The outer Conwy Bay between Great Orme's Head, the southeastern point of Anglesey and the Menai Strait in the west is designated as the Conwy Bay coastal water body (GB6710104000000). This coastal water body covers 49.67 km^2 and is characterised as sheltered and macro-tidal. It is heavily modified due to coast protection and only meeting Moderate Ecological Potential (due to invertebrates) and failing to meet Good Chemical Status.

Conwy Bay is a designated shellfish water where there are important commercial shellfish beds (see insert above). It has also been designated a bathing water, which has generally achieved the highest standards since2011 bathing season, although the most recent sample was a failure.

The West Shore has also been designated a bathing water since 1988. Information and data on bathing water quality can be found on Natural Resources Wales' website (http://environment.data.gov.uk/wales/bathing-waters/profiles/). The profile for this bathing water describes the local environs and the beach as "*long and sandy with a stony pebble foreshore, backed by a concrete promenade. The sea area offshore is designated under the Menai Strait and Conwy Special Area of Conservation, whilst the Great Orme is designated as the Great Orme's Head Special Area of Conservation. The bathing water also lies in the Aber Afon Conwy Site of Special Scientific Interest. The water quality sample point is located in-line with the north of the paddling pool*." Based on water quality sampling and analysis of faecal indicator organisms (i.e. bacteria) in the water, the overall annual quality result for 2015 was excellent, unchanged since 2014 before which it was projected to be poor.

Oil and tarry residues, and sewage debris has not been observed at this bathing water, with only trace amounts of animal faeces noted at the site on a minority of occasions. Trace amounts of litter were observed at the bathing water the majority of the time and in greater amounts on more on less than ten per cent of occasions. The bathing water has no history of large amounts of seaweed (macroalgae) or algal (phytoplankton) blooms. However, it is situated on the Conwy estuary at the end of the River Conwy and is subject to short term pollution (i.e. when heavy rainfall washes faecal material into the sea from livestock, sewage and urban drainage via rivers and streams).

The West Shore bathing waters are potentially impacted by a number of storm and emergency overflows, both along the immediate foreshore and River Conwy. The storm sewage from the Ganol Wastewater Treatment Works, further up the Conwy is disinfected before being discharged into the Conwy estuary. The scheme is designed to comply with the requirements of the Shellfish Waters Directive and has strict rules regarding storage and the number of spills allowed.

There are two existing emergency storm water pipelines that are initially buried beneath the beach in front of the seawall, but which emerge at approximately 400 m from the sea wall. The two pipelines run parallel to each other a few metres apart and in a westerly direction for ~1200 m. The southernmost pipeline is a 500 mm diameter pipe that is redundant. The northernmost pipeline is a 700 mm diameter pipe that operates as an Emergency Sewer Overflow. Dwr Cymru Welsh Water have now repaired a breach in the long sea outfall for the intermittent storm discharge and are planning to reduce the frequency of spills by reducing surface water runoff into the foul and combined sewer networks. Based on aerial images and site survey the outfalls also influence local beach geomorphology with the formation of a deeper channel to the south of the pipes that remains flooded even at low tide.

There are two further treated sewage outfalls to the north of the emergency storm water outfall and there may be others preventing sewer flooding of the low lying urban areas that back West Shore.

No water or sediment quality data was available to inform this preliminary assessment. If dredging of the sea bed is required for any option sediment samples may need to be collected for

investigation of their physical and chemical properties to determine the risk of contamination of the water column and to determine their suitability for re-use or waste disposal.

Potential Environmental Effects

During construction, there is the potential for short term and temporary adverse impacts on the water environment from spillages of chemicals and fuel. There is also the potential for the mobilisation of fine sediment. Although high suspended sediment conditions may occur occasionally in the bay and habitats and species will be adapted to these conditions, the chemical composition of sediment may need to be investigated to determine if any contamination is present.

In the long term, the beach management options may have a permanent impact on shellfish beds off the North Shore if these are found to be close to areas of works or depending on changes to sediment transport and depositional processes in the bay. However, no permanent or long term adverse effects on water quality, and therefore the WFD and bathing water designations, is predicted.

Risk Assessment

Table 3 provides a summary of the options risk assessment for water environment receptors for the North Shore options, and Table 4 for the West Shore:

Table 3 Water Environment Risk Assessment for the North Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1A Emerged detached breakwaters and beach nourishment	The location of new development could impact upon existing commercial shellfish beds subject to confirmation of their location. Without appropriate mitigation measures to control pollution risk construction works may result in temporary adverse effects from the mobilisation of suspended sediment and chemical spillages.	Commercial shellfish beds should be avoided and indirect impacts minimised. The risk can be reduced by applying good practice construction techniques with pollution prevention measures.
Option 1B Submerged detached breakwater and beach nourishment	The location of new development could impact upon existing commercial shellfish beds subject to confirmation of their location, but to a lesser extent than Option 1A. Without appropriate mitigation measures to control pollution risk construction works may result in temporary adverse effects from the mobilisation of suspended sediment and chemical spillages.	Commercial shellfish beds should be avoided and indirect impacts minimised. The risk can be reduced by applying good practice construction techniques with pollution prevention measures.
Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment	The location of development may have an impact on existing commercial shellfish beds subject to confirmation of their location, but to a lesser extent than Options 1A and 1B. Without appropriate mitigation measures to control pollution risk construction works may result in temporary adverse effects from the mobilisation of suspended sediment and chemical spillages. In the long term this option is unlikely to result in significant adverse effects on the water environment, and may enhance beach based recreational activities.	Good practice construction techniques with pollution prevention measures should be implemented.
Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment	Without appropriate mitigation measures to control pollution risk construction works may result in temporary adverse effects from the mobilisation of suspended sediment and chemical spillages. In the long term improved beach management may support recreational activities.	Good practice construction techniques with pollution prevention measures should be implemented.
Option 3 Traditional Groynes and beach nourishment	Construction works would be of a relatively small scale and duration and would not require any dredging of the sea bed. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	Good practice construction techniques with pollution prevention measures should be implemented.
Option 4 Beach Nourishment only	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.
Option 5 Periodic beach nourishment at ‘Children’s Corner’ (from Pier wall to Trevor Street slipway)	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.
Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	Good practice construction techniques with pollution prevention measures should be implemented.

Table 4 Water Environment Risk Assessment West Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1 Periodic Beach Maintenance	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.
Option 2 Dune Regeneration	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.
Option 3 Concrete Wall and Periodic Beach Maintenance	Without appropriate mitigation measures to control pollution risk construction works may result in temporary adverse effects in the short term from the mobilisation of suspended sediment and chemical spillages. No permanent long term effects on water quality are predicted.	Where possible pre-cast concrete wall sections should be used to avoid the use of wet concrete close to the foreshore and sand dunes. Standard best practice mitigation measures to prevent water pollution should be adopted.
Option 4 Rock Cover Layer	Without appropriate mitigation measures to control pollution risk construction works may result in short term, temporary adverse effects from the mobilisation of suspended sediment and chemical spillages. No permanent long term effects on water quality are predicted.	Where possible pre-cast concrete wall sections should be used to avoid the use of wet concrete close to the foreshore and sand dunes. Standard best practice mitigation measures to prevent water pollution should be adopted.
Option 5 Sand Traps	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.
Option 6 Removal of the existing 3 breakwaters	Without appropriate mitigation measures to control pollution risk construction works may result in short term, temporary adverse effects from the mobilisation of suspended sediment and chemical spillages. No permanent long term effects on water quality are predicted.	The risk can be reduced by applying good practice construction techniques with pollution prevention measures.
Option 7 Installation of a raised timber or plastic walkway	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.
Option 8 Undertake repairs / raise existing wall along the northern section of the frontage	Limited construction / maintenance works. Option is unlikely to result in significant adverse effects on the water environment. In the long term improved beach management may support recreational activities.	No further comments.

Scope for Mitigation

Where possible, any new development should avoid direct or indirect effects on any commercial shellfish beds. Measures will also be required to ensure that there are no significant adverse effects on water quality during construction, in order to protect the WFD, shellfish, bathing water and nature conservation sites (where features depend on good water quality). These measures could be described in Construction Method Statements and a Construction Environmental Management Plan. Providing these measures are implemented it is anticipated that any significant adverse effects during construction could be avoided or effectively managed.

Need for Further Assessment

Further desk study is required to determine the locations of any commercial shellfish beds within the zone of influence of the proposed management options. In addition, the scope of further WFD assessment should be discussed and agreed with NRW. Finally, appropriate pollution prevention mitigation measures should be developed alongside Construction Method Statements to support future planning and licencing applications.

Geology and Geomorphology

The following section considers potential effects on geology and geomorphology.

Environmental Baseline

The site is underlain by superficial geology comprises Coastal Zone Deposits (undifferentiated) comprising sand, silt and clay. The solid geology comprises Dolostone of the Llanarmon Limestone Formation of the Asbian – Holkerian ages beneath the eastern area of the site and Mudstone of the Lower Palaeozoic Rocks (undifferentiated) of the Silurian – Cambrian ages beneath the western area of the site. Tidal Flat deposits comprising clay, silt and sand run along the shoreline to the east.

The proposed site is underlain by a Secondary Undifferentiated Superficial Aquifer, and a Principal (Limestone) and a Secondary B (Mudstone) bedrock aquifer. However, the site is not located within a Source Protection Zone and it is likely that groundwater will be saline intruded. The outfall is located in a SSSI, which relates to a biological not geological designation. The closet area of geological importance is Great Ormes Head SSSI approximately 215 m to the north east.

No significant current or historical sources of contamination have been identified, although at this stage a full and comprehensive geotechnical and contaminated land desk study has not been undertaken. Further desk study and possibly site investigation (depending on the preferred option(s) may be required at a later stage.

Coastal Engineering UK Ltd prepared a Llandudno Beach Management Natural Processes and Shoreline Baseline assessment in February 2017. This provides a detailed overview of the development of both shorelines and an understanding of the prevailing coastal processes based on available data.

The following summarises the key points from this assessment for North Shore:

- Present day natural upper beach geomorphology is similar along both shores which shows a fringe of present day or older storm gravel beach deposits from reworked glacial deposits. Lower down the beach, generally from mid tide level, beach deposits comprise fine to medium sand deposits with the lower foreshore underlain by boulder clay;
- The North Shore is starved of new material with existing material being recycled and small annual inputs from erosion of the adjacent resistant rocky headlands. The bay has therefore recessed into a pocket beach between two headlands, controlled naturally by the juxtaposition of the headlands, the tide and wave regime, and the nature of the shoreline material;

- Prior to the development of Llandudno from the mid-1800's a natural ridge separated the land from the sea. The construction of artificial coastal defences (e.g. stepped revetment, sea walls, groynes and sand nourishment between Trevor Street slipway and Llandudno Pier which is otherwise known as 'Children's Corner' with wind-blown sand from West Shore) along the North and West Shore frontages in the 20C has interrupted natural processes and fixed the shoreline in its current position. The upper beaches have since become strongly influenced by these linear defences as they have altered the hydraulic regime and natural erosion, transportation and deposition processes. The overall trend is one of erosion, although little evidence of significant changes over the past 60-70 years;
- In 1996 approximately 40,0000 cubic metres (m^3) of natural gravel cobbles was placed on the upper beach between the amenity boating pool at Craig-y-Don and the timber slipway and Vaughan Street. Further works to widen the lifeboat slipway at Trevor Street and the addition of a further 12,000 m^3 of cobbles was undertaken in 2000. Finally, a further 30,000 m^3 of cobbles was added to the upper beach following the winter storms of 2013-14;
- Re-cycling of material and re-profiling of the beach along the Llandudno Promenade and Craig-y-Don frontages was undertaken between 2000-2013 typically annually prior to the summer season together with some limited replenishment of sand;
- At the western edge of the North Shore the Great Orme headland provides shelter from wave directions west of north, with increasingly more exposed conditions the further east. Northwest and northerly fetches are also limited by the Isle of Man;
- Liverpool Bay has a large tidal range, significant surges, and relatively strong nearshore currents and fetch limited storm waves from the west through to the north;
- Within the eastern Irish Sea the flood flow is dominant such that the strongest flows are towards the shoreline and sediment typically moved in that direction. The effects of the Great and Little Orme Headlands are to induce an 'eddy' or clockwise circulation in currents on the eastern side of the headlands, creating local flow reversals. This means that the general drift of sediment in this bay is from east to west, contrary to the overall west to east trend along the North Wales coastline; and
- A review of historical data suggests that on-offshore movement contributes more to sediment losses than longshore change.

The following summarises the key points from this assessment for North Shore:

- Up to the 1980s contemporary foreshore conditions applying along the coast between Deganwy and West Shore, generally comprised, across the upper intertidal zone, a thin veneer of superficial deposits of sand, gravel, cobbles and boulders overlying variable boulder clay, which were the remnants of nearshore deposits of glacial material left by the retreat of the ice sheets during the last glacial period;
- In places where the smaller deposits were winnowed out larger boulder beds remain and the boulder clay was exposed, such as at Cerrig Duon, before the breakwater was constructed. These deposits are thought to be the remains of extensive moraine deposits, which may have choked the present mouth of the Conwy valley before the river broke through;
- The natural backshore conditions applying across the frontage is a belt of sand dunes that used to stretch from the Great Orme to Deganwy. Historically these dunes developed and have been subsequently fed by sand blowing across the wide expanse of Conwy Bay;
- On the Great Orme the intertidal zone width decreases to northwards with the foreshore becoming coarser of cobble and boulder composition;
- In 1950's a stepped concrete revetment with wave return wall and steel sheet pile toe was constructed, although as beach levels fell the foundations have been increasingly exposed;

- In 1991/92 three cross-shore, shore connected rock 'fishtail' groynes were constructed at West Shore together with a mixture the introduction of a mixture of quarried limestone cobble, shingle and sand on the upper beach. These have been successful in reducing exposure conditions across the shore but have inadvertently increased the potential for wind-blown sand which is a local nuisance and generated localised dune features;
- In 2006, as part of the West Shore to Deganwy cycle path works, the southernmost section of the dunes frontage was reinforced with additional imported quarried cobble and section of rock revetment was built immediately to the south of Cerrig Duon. Despite erection of fencing, on-going clearance of wind-blown sand and maintenance of the track surface, the section in front of the dunes has been overwhelmed by wind-blown sand;
- The Great Orme headland provides shelter to West Shore from wave directions north of northwest, and Anglesey from directions south of west-north-west meaning that this shoreline is sheltered and only exposed to longer fetches (e.g. 160 km) when wave come from a west-north-west to northwest direction. Furthermore, offshore banks also help to dissipate wave energy;
- In addition to the information presented for the North Shore, according to the SMP2 "*Drift along the Gogarth frontage will be towards Llandudno West Shore. Prior to construction of the fishtail breakwaters there was a relatively rapidly dropping foreshore in front of the sea wall. The breakwaters and subsequent recharge have slowed this process. With the breakwaters in place, the shoreline has adapted to a relatively stable orientation. The backshore in the centre of the frontage between the north and central breakwater is still in advance of the fully developed bay shape, but is capable of retaining a good width of shingle beach;*"
- Behaviour is cyclical within sections and overall across the frontage but generally the upper sections of beach are showing are stable/ modestly accreting trend, whilst the lower sections of beach are showing losses. Some of these losses will be associated with aeolian transport of sand from the lower beach into the upper sections, which has been a direct contributor of the dune development at the root of the Gogarth and Lloyd Street groynes and along the North Wales Golf Club frontage; and
- Generally, as identified in the SMP2, the construction of the breakwaters and associated fishtail groynes has stabilise upper beach conditions across the frontage intercepting waves from the predominant direction that previously would have been incident on the sea wall and blocking wave induced southerly longshore sediment transport across the frontage.

Potential Environmental Effects

New physical interventions and changes to management of a beach frontage can result in geomorphological changes to the beach such as the redistribution of sand and shingle, changes in beach material type, building up of material or scour and changes in beach profile. Changes to beach processes can indirectly effect the supply of wind-blown sand needed to support healthy dune systems and can alter their equilibrium (i.e. maintain state, degrade where sand supply is reduced or advance inland where there is an increase in supply).

There may be impacts associated with the construction of new structures, especially where these use piled foundations that may create preferential pathways for contaminants to migrate to underlying strata. However, at this stage no significant sources of contamination have been identified along either shore frontage and the importance of geological and groundwater receptors is currently considered to be low.

Risk Assessment

Table 5 provides a summary of the options risk assessment for geological and geomorphological receptors for the North Shore options, and Table 6 for the West Shore:

Table 5 Geological and Geomorphological Risk Assessment for the North Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1A Emerged detached breakwaters and beach nourishment	Geomorphology of the upper beach will be altered by the import of sand beach recharge, which will be more mobile than the current shingle. Breakwaters will provide shelter and control on the movement of material between them and the shoreline, potentially creating salients or tombolos. The impacts on beach morphology will diminish moving easterly as the shoreline moves out of the shelter provided by the breakwaters. To seaward of the structures there will be some change in behaviour due to the interaction of waves and tides with the breakwater structures. Structures will limit offshore losses of material. At this stage no geotechnical and contaminated land desk study or site investigation has been carried out and so the nature of underlying ground conditions is uncertain.	Geotechnical and contaminated land investigation may be required to inform foundation design and to support future planning and marine licence applications. See 'Water Environment' for consideration of contaminated marine sediments. Further assessment and potentially modelling of the preferred option(s) will be required to determine the effect on beach geomorphology. It is assumed that clean beach material from a suitable source will be used. This will need to be agreed with NRW as part of the Marine Licencing application.
Option 1B Submerged detached breakwater and beach nourishment	Geomorphology of the upper beach will be altered by the import of sand beach recharge, which will be more mobile than the current shingle. Breakwaters will provide some shelter and lesser control on the movement of material in between the breakwaters and the shoreline as some wave and tidal energy will pass over the breakwaters. As in 1a, the affects will diminish moving easterly as the shoreline moves out of the shelter provided by the breakwaters. To seaward of the breakwaters there will be some change in behaviour due to the interaction of waves and tides with the breakwaters. Breakwaters will limit offshore losses of material. At this stage no geotechnical and contaminated land desk study or site investigation has been carried out and so the nature of underlying ground conditions is uncertain.	As above.
Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment	Geomorphology of the upper beach will be altered by the import of sand beach recharge, which will be more mobile than the current shingle. Shore connected structures will exert some local control on wave and tide conditions which will impact on the movement of the recharged beach. Groynes will generally prevent longshore movement of beach material but will do little to prevent losses if beach is drawn down to seaward beyond the zone of influence of the groynes. If beach is unmanaged some overspill of groynes would be expected. Nearshore geomorphology would remain largely unaltered. At this stage no geotechnical and contaminated land desk study or site investigation has been carried out and so the nature of underlying ground conditions is uncertain.	As above.
Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment	Behaviour would be broadly as for 2a with slight difference expected at western end due to different groyne arrangements. At this stage no geotechnical and contaminated land desk study or site investigation has been carried out and so the nature of underlying ground conditions is uncertain.	As above.

Table 5 Geological and Geomorphological Risk Assessment for the North Shore Options continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 3 Traditional Groynes and beach nourishment	Geomorphology of the upper beach will be altered by the import of sand beach recharge, which will be more mobile than the current shingle. The structures will control the longshore movement of material but beach draw down under certain conditions will lead to losses of material once it moves to seaward of the groyne extents. Nearshore geomorphology would remain largely unaltered. No significant impact on ground conditions anticipated at this stage. This assumes that only small foundations will be required to support the new traditional groynes.	It is assumed that clean beach material from a suitable source will be used. This will need to be agreed with NRW as part of the Marine Licencing application.
Option 4 Beach Nourishment only	Geomorphology of the upper beach will be altered by the import of sand beach recharge, which will be more mobile than the current shingle. Longshore and cross-shore movement of material would be expected leading to higher magnitude/frequency losses and more regular management and/or topping up. No significant impact on ground conditions anticipated at this stage.	It is assumed that clean beach material from a suitable source will be used. This will need to be agreed with NRW as part of the Marine Licencing application.
Option 5 Periodic beach nourishment at 'Children's Corner' (from Pier wall to Trevor Street slipway)	Minor change dependant on area covered with sand. On-going losses of material expected as material is drawn down beach and lost within bay/offshore requiring periodic topping up. No significant impact on ground conditions anticipated at this stage.	It is assumed that clean beach material from a suitable source will be used, which may be recycled material from West Shore. This will need to be agreed with NRW as part of the Marine Licencing application.
Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don	Incorporation of wave wall along seaward edge would increase potential wave reflection, under extreme storm condition when beach is overtopped, and increase risk of localised scour of beach immediately to seaward. At this stage no geotechnical and contaminated land desk study or site investigation has been carried out and so the nature of underlying ground conditions is uncertain.	Geotechnical and land quality investigation may be required to infirm foundation design and to support future planning and marine licence applications. See 'Water Environment' for consideration of contaminated marine sediments.

Table 6 Geological and Geomorphological Risk Assessment West Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1 Periodic Beach Maintenance	Option 1 will introduce regular supply of new shingle and recycling of sand within the frontage to maintain beach levels. In between nourishment natural processes will move material to form a natural beach profile. No significant impact on geomorphology or ground conditions is predicted at this stage.	It is assumed that clean beach material from a suitable source will be used. This will need to be agreed with NRW as part of the Marine Licencing application.
Option 2 Dune Regeneration	Local geomorphological conditions will change along backshore as dunes are encouraged to develop, increasing potential for aeolian transport of sand landward. To seaward beach morphology will be largely unchanged. No significant impact on beach geomorphology and ground conditions are expected. This option will result in a more naturalised back beach dune environment similar to what would have existing prior to the development of Llandudno.	No comments.
Option 3 Concrete Wall and Periodic Beach Maintenance	The concrete wall will interfere with the natural interaction between the beach and the dunes reducing, to a degree, aeolian sand supply to the existing dune systems, which although mature and vegetated, may be degraded over time. Without regular maintenance the wall would be expected to be covered over. Notwithstanding this, no significant impact on geomorphology or ground conditions are predicted at this stage.	Geotechnical and land quality investigation may be required to infirm foundation design and to support future planning and marine licence applications.
Option 4 Rock Cover Layer	No significant impact on ground conditions. The rock cover layer will interfere but not entirely prevent natural interaction between the beach and the dunes, initially reducing the aeolian transport of sand into the hinterland/dunes. The effectiveness of the system will diminish over time as the cover layer becomes clogged with conditions reverting to those that currently exist. The impact on overall geomorphological processes will be minimal.	Geotechnical and land quality investigation may be required to infirm project design and to support future planning and marine licence applications.
Option 5 Sand Traps	Sand traps will lead to a gradual change in backshore geomorphological conditions as dunes develop along frontage with associated aeolian sand transport issues, as currently exist at the root of Lloyd St groyne. The sand traps will help to improve upper beach conditions and reduce the risk from storm events. No significant impact on ground conditions.	No comments.
Option 6 Removal of the existing 3 breakwaters	The three existing fishtail shore connected breakwaters and associated beach recharge has helped to stabilise the frontage and prevent further lowering of the upper beach. Removal of the breakwaters would lead to adjustment of beach conditions along the frontage to different degrees dependant on the type of beach material, with an increased drift of material southerly towards the mouth of the Conwy estuary. Over time it would be expected that this would lead to increased mixing of natural and imported beach material, a lowering of beach levels along the developed West shore frontage, an increased flood risk, but a reduction in aeolian transport of sand into the hinterland. Across the dune frontage beach lowering would see a reduction in aeolian transport of sand and potentially increased risk of erosion of the dunes along the golf club frontage.	Further assessment and potentially modelling of the preferred option(s) will be required to determine the effect on beach geomorphology.

Table 6 Geological and Geomorphological Risk Assessment West Shore Options continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 7 Installation of a raised timber or plastic walkway	Provision of a raised walkway would have no significant impacts on geomorphological processes and/or ground conditions other than to provide a minor interference to aeolian transport of sand	Geotechnical and land quality investigation may be required to infirm foundation design and to support future planning and marine licence applications.
Option 8 Undertake repairs / raise existing wall along the northern section of the frontage	No significant impact on beach morphology or ground conditions.	Geotechnical and land quality investigation may be required to infirm foundation design and to support future planning and marine licence applications.

Scope for Mitigation

At this stage it is difficult to set out the scope for mitigation as little is known about the quality of underlying ground conditions. However, where options require construction works care will need to be taken to ensure that new preferential pollutant pathways to underlying strata and groundwater are not crested and that adequate chemical spillage prevention measures are adopted during construction. In the long term no mitigation is expected to be required.

Need for Further Assessment

Further assessment and potentially modelling of the preferred option(s) will be required to determine the effect on beach geomorphology.

Further desk study and potential site investigation may be required depending on the preferred option(s).

Landscape Setting

Llandudno's North Shore forms a developed coastline and occupies a curving bay lying between the limestone headlands of the Great Orme in the west and the Little Orme in the east (See Figure 1). These features form distinctive backdrops to the setting of the seaside town. The North Shore is characterised by largely Victorian properties, which form the frontage to the sea front and contrast with the setting of the sand duned West Shore, which looks out towards the Conwy Estuary, Anglesey and Conwy Bay (See Figure 1 and 2).

Llandudno's West Shore looks out towards the Conwy Estuary, Anglesey and Conwy Bay. Characterised by sand dunes to the south, the beach at low tide reveals a large expanse of sand backed by the West Parade. In general, the beach is quieter than the North Shore with views available to Great Orme's Head in the north.

Environmental Baseline

North Shore

The National Seascape Assessment for Wales (2015) identifies the inshore waters at Llandudno North Shore as lying within Marine Character Area (MCA) 2: Colwyn Bay and Rhyl Flats. Characterised by gently shelving beaches with an extensive network of offshore sandbanks and flats, the MCA extends from the shallow coastal waters of Colwyn Bay to the Rhyl Flats. The carboniferous limestone headlands of the Little Orme and the Great Orme extend into the sea forming steep sea cliffs and a backdrop to this MCA. Long sandy beaches and shingle storm beaches form 'key characteristics' of the coastline. Coastal defence mechanisms such as groynes, rock armour, walls and traditional promenades are also common features.

MCA 3: Red Wharf and Conwy Bays adjoins MCA 2 and defines the bay area to the west of the North Shore, from Great Orme's Head in the east to Moelfre headland on the eastern Anglesey coast in the west. This MCA is characterised by sand flats and low-lying sandy beaches, punctuated by rugged cliffs and prominent limestone headlands. The Great Orme's Head is prominent in many land-to-sea views within this MCA and forms an iconic coastal feature and the largest headland in North Wales. The varied coastal geology of cliffs and rocky or sandy beaches are described as a 'key characteristics' of this area. In addition, the mountains of Snowdonia National Park form a spectacular landscape setting to this MCA, providing dramatic and distinctive elevations when viewed from the sea.

Identified by NRW, National Landscape Character Areas (NLCAs) form the terrestrial equivalent to the MCAs and together form a complete suite of information on national character spanning both land and sea. The identification of NLCAs is underpinned by information from LANDMAP – Wales' national programme of landscape assessment. The coastal boundary of MCA 2: Colwyn Bay and Rhyl Flats adjoins NLCA 8: Colwyn and Northern Coastline as it extends towards the coast. This NLCA includes the coastal fringe and forms a narrow, low-lying strip of land between the Great Orme and the Point of Ayr.

The distinctive foothills of Snowdonia National Park are located approximately 4.6 km south-west of Llandudno's North Shore. This landscape is acknowledged by definition as an extensive tract of country protected by law in view of its natural beauty and the opportunities offered for outdoor recreation. Although not encompassing the North Shore itself, the wider setting includes landscape considered to be of the highest quality and value at a national scale.

Land defined as the Great Orme and Creuddyn Peninsular Special Landscape Area (SLA) within the Conwy Local Development Plan (2007-2022) lies at both the eastern and western extent of Llandudno North Shore. The objective of this policy (NTE/4) is to ensure that the local character of the area is not altered by inappropriate forms of development and that features which contribute to local distinctiveness are preserved. Land at Great Orme is of significant cultural, historic and ecological interest and is designated as Heritage Coast in virtue of the requirement for the conservation, protection and enhancement of the undeveloped coastline. Land lying immediately south of the B5115 Colwyn Road, separating Llandudno from Craigside, is also designated as Green Wedge within the Proposals Map of Conwy Borough Council. The purpose of this policy is to prevent coalescence of settlements and retain the open character of an area.

Conservation Areas, whilst not specific landscape designations, reflect landscape and architectural quality and contribute to the townscape setting. The Llandudno Town Centre and Seafront Conservation Area encompass the coastal frontages of both the northern and western shores, connected by the carriageway of the A546 Gloddaeth Avenue. The North Wales Coast Path (long distance footpath) follows the length of the coastline, accommodated on the promenade at Llandudno's North Shore. Listed by CADW, Happy Valley Historic Park and Garden adjoins the North Parade with direct paths leading from Llandudno's North Shore. Haulfre Gardens, an Historic Park and Garden situated on steep ground on the west side of the Great Orme, also lies approximately 650 m west of the North Shore. Policy CTH / 2 within the Conwy Local Development Plan (2007-2022) states that development proposals which affect a heritage asset or its setting shall preserve or, where appropriate, enhance that asset.

The 25 No. turbines of Rhyl Flats Offshore Wind Farm form a prominent offshore feature, approximately 8.0 km from the coast in the shallow waters around Constable Bank. The character description for MCA 2: Colwyn Bay and Rhyl Flats states that 'the presence of the turbines reduces the overall sense of tranquillity and remoteness but does not affect the feeling of exposure associated with the vast open beaches'.

West Shore

The National Seascape Assessment for Wales (2015) identifies the inshore waters at Llandudno West Shore as lying within Marine Character Area (MCA) 3: Red Wharf and Conwy Bays. This MCA encompasses the extensive inter-tidal areas around Great Orme's Head in the east to Moelfre headland on the Anglesey coast in the west. Broad sand flats and low lying sandy beaches are identified as 'key characteristics' of this MCA with shelter provided by the Great Orme headland which is prominent in many land-to-sea views. The rising foothills of Snowdonia National Park also form a spectacular backdrop to the MCA and contribute to a sense of containment in Conwy Bay.

The MCA is described as a 'generally busy seascape' and comprises several coastal settlements which form popular tourist destinations for traditional family beach recreation. Sailing and water sports contribute towards a busy marine environment with dive sites also evident along the coast. The MCA also contains the Great Orme Tramway which forms Britain's only cable-hauled public road tram. Despite these features, the MCA does retain a sense of wildness and remoteness in places due to the changing coastal orientation, rugged cliffs and prominent limestone headlands.

In terms of NLCAs, the coastal boundary of MCA 3: Red Wharf and Conwy Bays Bay adjoins NLCA 8: North Wales Coast at its western extent. This NLCA includes the coastal fringe and forms a narrow, low-lying strip of land between the Great Orme and the Point of Ayr. NLCA 3: Arfon also lies within close proximity of Llandudno's Western Shore, broadly following the boundary of Snowdonia National Park at its northern limit.

Land at the Little Orme's Head and Llandudno Bay is designated as a Landscape of Outstanding Historic Interest in virtue of the area's rich historic past, forming part of the medieval commote of Creuddyn. Contained within the Conwy Local Development Plan (2007-2022), the frontage to Llandudno's West Shore lies within land defined as the Great Orme & Creuddyn Peninsular Special Landscape Area (SLA).The objective of this policy (NTE/4) is to ensure that the local character of the area is not altered by inappropriate forms of development and that features which contribute to local distinctiveness are preserved. The boundary of Snowdonia National Park also lies approximately 3.2 km south of Llandudno's West Shore. This landscape is acknowledged by definition as an extensive tract of country protected by law in view of its natural beauty and the opportunities offered for outdoor recreation. Although not encompassing the West Shore itself, the wider setting includes landscape considered to be of the highest quality and value at a national scale.

Land at Great Orme is of significant cultural, historic and ecological interest and is designated as Heritage Coast by virtue of the requirement for the conservation, protection and enhancement of the undeveloped coastline. The boundary of this designation lies at the northern extent of Llandudno's West Shore. Great Orme itself is also designated as a Country Park. Land lying immediately south of Llandudno West Shore, including North Wales Golf Club, is designated as Green Wedge 2: Deganwy, Llandudno and Llanrhos within the Proposals Map of Conwy Borough Council. The land is dissected by the corridor of the Conwy Valley Rail Line and includes the seafront immediately west of Deganwy. The purpose of this policy is to prevent coalescence of settlements and retain the open character of an area.

The Llandudno Town Centre and Seafront Conservation Area encompass the coastal frontage of Llandudno West Shore, connected to the North Shore by the carriageway of the A546 Gloddaeth Avenue. The North Wales Coast Path (long distance footpath) follows the alignment of Marine Drive immediately north of Llandudno's West Shore before moving south where it is accommodated on the beach promenade, and beyond on the beach itself. Residential land use characterises much of the built land use at Llandudno West Shore and forms the frontage to West Parade. Residential properties / holiday cottages at Gogarth also run parallel to the route of Marine Drive.

Potential Environmental Effects

North Shore

The potential scheme options have been reviewed and the following potential townscape / seascape and visual effects resulting from the four options for the Beach Zone may be summarised as follows:

- Direct but temporary change in landscape character during construction arising from the presence of heavy machinery required to construct the scheme and import the sand;
- Indirect but temporary changes in landscape character within the surrounding area during construction as a result of views of machinery and traffic movements and potential ancillary impacts such as lighting (depending on time of year and agreed working hours);
- Permanent change in landscape character during operation as a result of the increased height of the secondary sea wall (Options 1-4), creation of offshore breakwaters (Option 1), and introduction of shore connected breakwaters (Option 2) or the construction of traditional groynes (Option 3).
- Permanent change in visual amenity arising from views of the proposals. The presence of these features has the potential to have an effect on the visual amenity of PRoW (including the North Wales Coastal Path) and the occupants of buildings lining the promenade and forming the coastal frontage.
- Permanent change in visual amenity associated with the availability of far reaching views from the Great Orme and the Little Orme. The Conservation Appraisal for Llandudno Town Centre and Seafront Conservation Area identifies views into the conservation area as a key feature of the locality.

West Shore

Potential townscape / seascape and visual effects resulting from the five options for the Beach Zone may be summarised as follows:

- Direct temporary change in landscape character during construction arising from the presence of heavy machinery required to construct the scheme;
- Indirect temporary changes in landscape character within the surrounding area during construction as a result of views of machinery and traffic movements and potential ancillary impacts such as lighting;
- Permanent change in landscape character during operation as a result of the potential introduction of wind traps or measures to reduce wind movement;
- Permanent change in visual amenity arising from views of the proposals. The presence of these features has the potential to have an effect on the visual amenity of PRoW (including the North Wales [Coastal] Path) and the occupants of buildings lining the West Parade;
- Permanent change in both landscape and visual amenity arising from the potential over provision of engineering features which would detract from the existing landscape setting and nature of views from receptors; and
- Permanent change in visual amenity associated with the availability of far reaching views from the Great Orme and the Little Orme. The Conservation Appraisal for Llandudno Town Centre and Seafront Conservation Area identifies views into the conservation area as a key feature of the locality. However, these works are not anticipated to change the nature of views into the conservation area.

Risk Assessment

Table 7 provides a summary of the options risk assessment for landscape setting for the North Shore options, and Table 8 for the West Shore:

Table 7 Landscape Setting Risk Assessment North Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1A Emerged detached breakwaters and beach nourishment	Construction works may result in short term, reversible and temporary adverse visual effects on local residents or visitors to the North Shore. Views of the engineered breakwaters in the operational phase are not considered to form an entirely incongruous addition to the existing seaside context and would over time be colonised by marine flora and fauna. Views of the detached breakwaters would be most evident at MLWST, although significant adverse landscape / visual effects are not predicted.	Potential mitigation may include ensuring suitable form and choice if materials for the beach nourishment and emerged detached breakwaters.
Option 1B Submerged detached breakwater and beach nourishment	Construction works may result in short term, reversible and temporary adverse visual effects on local residents or visitors to the North Shore. Operational effects would be of lesser magnitude than Option 1A due to the submerged nature of the detached breakwaters at MHWST. Like Option 1A, over time the breakwaters would be colonised by marine flora and fauna. The overall proposals are not anticipated to result in significant landscape and visual effects due to the existing beach context.	Potential mitigation may include ensuring suitable form and choice if materials for the beach nourishment and emerged detached breakwaters.
Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment	Construction works may result in short term, reversible and temporary adverse visual effects on local residents or visitors to the North Shore. Views of the proposals, including the fishtail groynes, would remain visible at MHWS as they will extend to the upper beach. However, these features would not form incongruous components due to the similar appearance of existing structures within the baseline view and over time the breakwaters within the intertidal zone would be colonised by marine flora and fauna. This option is unlikely to result in significant adverse landscape and visual effects.	Potential to advise on the height, form and suitability of materials for conventional groynes to minimise adverse effects on coastal landscape character.
Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment	Construction works may result in short term, reversible and temporary adverse visual effects on local residents or visitors to the North Shore. Views of the proposals, including the fishtail groynes, would be visible at MHWS as they will extend to the upper beach. These features would not form incongruous components due to the similar appearance of existing structures within the baseline view and over time the breakwaters within the intertidal zone would be colonised by marine flora and fauna. This option is unlikely to result in significant adverse landscape and visual effects.	Potential to advise on the height, form and suitability of materials for conventional groynes to minimise adverse effects on coastal landscape character.
Option 3 Traditional Groynes and beach nourishment	Views of the operational scheme (traditional groynes and beach nourishment) would not be incongruous within the seaside context due to the similar appearance of existing structures within the baseline view. This option is unlikely to result in significant adverse landscape and visual effects. Construction works may result in temporary adverse visual effects on local residents or visitors to the North Shore.	Potential to advise on the height, form and suitability of materials for conventional groynes to minimise adverse effects on coastal landscape character.
Option 4 Beach Nourishment only	Beach nourishment, in both construction and operation, is not anticipated to result in significant landscape and visual effects due to the existing beach context.	Mitigation measures not considered appropriate.
Option 5 Periodic beach nourishment at ‘Children’s Corner’ (from Pier wall to Trevor Street slipway)	Beach nourishment is not anticipated to result in significant landscape and visual effects due to the existing beach context. The works would involve limited construction activity due to the small scale nature of the works.	Mitigation measures not considered appropriate.

Table 7 Landscape Setting Risk Assessment North Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don	The small scale nature of the works is not anticipated to result in significant landscape and visual effects.	Mitigation measures not considered appropriate.

Table 8 Landscape Setting Risk Assessment West Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1 Periodic Beach Maintenance	Limited construction / operational works which are unlikely to result in significant adverse landscape or visual effects.	Mitigation measures not considered appropriate.
Option 2 Dune Regeneration	Limited construction / operational works which are unlikely to result in significant adverse landscape or visual effects.	Mitigation measures not considered appropriate.
Option 3 Concrete Wall and Periodic Beach Maintenance	Construction works may result in temporary adverse visual effects on local residents or visitors to the West Shore. The concrete wall would form an engineered component within a seaside context detracting from the aesthetic character and amenity of the beach. However, the scale and proposed height of the wall is not anticipated to result in significant landscape and visual effects due to the existing beach context.	Potential to optimise design through the use of materials to provide proposals which complement the local vernacular.
Option 4 Rock Cover Layer	The retaining wall and rock cover layer would form an engineered component within a seaside context, detracting from the aesthetic character and amenity of the beach. However, the construction and operational phases are unlikely to result in significant adverse landscape and visual effects.	Potential to optimise design through the use of materials to provide proposals which complement the local vernacular.
Option 5 Sand Traps	Limited construction / operational works which are unlikely to result in significant adverse landscape or visual effects.	Mitigation measures not considered appropriate.
Option 6 Removal of the existing 3 breakwaters	This option would result in short term construction effects through the removal of the three existing breakwaters. No long term landscape and visual effects are anticipated and the resulted frontage would have a more natural appearance.	Mitigation measures not considered appropriate.
Option 7 Installation of a raised timber or plastic walkway	Limited construction / operational works which are unlikely to result in significant adverse landscape or visual effects.	Mitigation measures not considered appropriate.
Option 8 Undertake repairs / raise existing wall along the northern section of the frontage	Limited construction / operational works which are unlikely to result in significant adverse landscape or visual effects.	Mitigation measures not considered appropriate.

Scope for Mitigation

North Shore

Based on the current scheme and baseline information none of the options are likely to result in significant effects and landscape character or visual receptors. However, effects on landscape and visual receptors will depend on the potential over provision of engineering features within the landscape, which is likely to detract from the amenity of the beach. As the design develops landscape and visual effects will need to be taken into account to optimise the design and ensure it is incorporated into the wider landscape setting as much as possible (e.g. the height, form, materials and façade of any new sea walls is yet to be determined).

Mitigation measures will be proposed if considered appropriate subject to a suitable level of impact assessment and consultation with NRW and Conwy County Borough Council. These may include ensuring a suitable choice of materials (e.g. for the traditional groynes within Option 3) to complement local vernacular.

West Shore

Mitigation measures will be proposed if considered appropriate. These may include ensuring a suitable choice of materials to complement the local vernacular.

Need for Further Assessment

North Shore

Further assessment would be based on the principles of the Guidelines for Landscape and Visual Impact Assessment (2013). This would include the identification of representative viewpoints (if required) by Conwy County Borough Council. Any future assessment would need to consider the construction and operational phases of the proposals and would be aligned to the scope of environmental assessment required to support future planning and marine licence applications, that may or may not require a statutory Environmental Impact Assessment.

Further study would also be required to assess the effect on the townscape and neighbouring NLCAs / MCAs. For the purpose of identifying the composition and relative sensitivity of the baseline of the urban area, it would also be beneficial to group the immediate setting of the North Shore into broadly homogeneous Townscape Character Areas (TCAs). Detailed visual assessment and site survey would be required to assess the effect on identified visual receptors.

West Shore

Further assessment would be based on the principles of the Guidelines for Landscape and Visual Impact Assessment (2013). This would include the identification of representative viewpoints (if required) by Conwy Borough Council. Any future assessment would need to consider the construction and operational phases of the proposals.

Further study would also be required to assess the effect on the townscape and neighbouring NLCAs / MCAs. For the purpose of identifying the composition and relative sensitivity of the baseline of the urban area, it would also be beneficial to group the immediate setting of the North Shore into broadly homogeneous TCAs. Detailed visual assessment and site survey would be required to assess the effect on identified visual receptors.

Archaeology and Cultural Heritage

Introduction

Data has been collected from the online Gwynedd Archaeological Trust (GAT) Historic Environment Record (HER) (http://www.cofiadurcahcymru.org.uk/arch/gat/english/gat_interface.html) and Coflein (http://map.coflein.gov.uk/) to inform the options of the draft Beach Management Plan, based upon their perceived impacts upon the historic landscape.

Environmental Baseline

North Shore

The online information from the GAT HER contains 39 records covering the project study area, while a number of historic ship wrecks are recorded on Coflein. In addition, the Llandudno Town Centre and Seafront Conservation Area also lies within the study area and is covered within the Llandudno Town Centre and Seafront Conservation Area Appraisal (Conwy County Borough Council n.d.).

Evidence exists for a prehistoric landscape, in the form of a record of a submerged forest (PRN 60884) at Llandudno Beach. However, despite extensive evidence for prehistoric activity in the wider area, little is recorded in close proximity to the proposed development site.

There are no records of Roman, early medieval or medieval date.

A single Grade II* listed structure, the Llandudno Pier (PRN 12712), completed in 1876 and extended in 1884, lies to the west of Llandudno North beach.

The remaining recorded heritage assets primarily comprise post-medieval Grade II listed buildings, and, along with the pier, reflect the nineteenth century development of Llandudno from a village with an economic base in mining and fishing to a Victorian sea-side resort. The architect Owen Williams had been fundamental in this development, presenting plans to the landowner Lord Mostyn in 1848 for the development of the marshlands behind Llandudno Bay. Development ensued, particularly between 1857 and 1877 under the surveyor and architect George Felton. The 37 Grade II listed buildings which face onto Llandudno Beach and the proposed development site consist of buildings and associated structures from this era of Llandudno's development. They are mostly made up of hotels and residential houses.

The Llandudno Town Centre and Seafront Conservation Area's designation covers the heart of the planned resort, which was completed from the 1850s to 1914, for its historical, cultural and architectural quality. All of the listed buildings discussed above lie within the Conservation Area and are a reflection of the character for which the Conservation Area was established to preserve and enhance.

West Shore

The online information from the GAT HER contains 21 records covering the project study area, while a number of historic ship wrecks are recorded on Coflein. In addition, the Llandudno Town Centre and Seafront Conservation Area also lies within the study area and is covered within the Llandudno Town Centre and Seafront Conservation Area Appraisal (Conwy County Borough Council n.d).

The prehistoric period is represented by a number of individual finds of flint tools and stone axes. Shell middens (i.e. a refuse heap of discarded shells), which are likely to date to the prehistoric period, are also recorded in this area. It is likely that these sites are linked to the caves on the Great Orme where evidence of early human occupation has been recorded. The early settlement in this area is believed to be linked to the copper mining which has been dated to the Bronze Age, although there is little to suggest this continued into the Iron Age.

There are only two recorded sites of Roman date within the study area. Roman activity is limited to an Aurelian coin collected from the Penmorfa Adit (see below) and the supposed site of a Roman causeway across the Conwy Bay area, although its exact location is not known. In the wider area evidence shows that the Roman continued to utilise the mineral deposits in the area.

There are no recorded assets from the early medieval within the study area. It is known that during the medieval period the area around Llandudno continued to be a focus of settlement and agriculture. Fishing was also an important supplement to agriculture and within the study area the remains of two medieval fish traps / weirs and a possible third are recorded. The importance of the fish traps can be seen from details recorded from as early as the thirteenth century when two traps /

weirs in the area, named Gorad Maelgwn and Gorad Wyddno, were reported to be worth 40 shillings a year in 1284[1]. The fish traps were examined as part of a thematic study undertaken in 2000[2].

The importance of farming and fishing continued into the post-medieval period with the copper mining not taking a big role in the economy until the late seventeenth century when the acts that had made the mining of metals a crime were repealed in 1688 (Smith 1988[1]). This resulted in limited mining operations commencing, and further changes were made in 1692. All of the assets recorded within the study area dating to the post-medieval relate to the mining practices and the developing town. Gravel pits are recorded on the coast and a series of drains, the Penmorfa Adit, were intended to keep the mine work free from water.

There is one Grade II listed building within the study area dating to the post-medieval period, a toll lodge on a pedestrian path on the Great Orme constructed in the 1850s. The growth of Llandudno as a beach resort saw the growth of attractions for visitors.

During the early years of the twentieth century the West Shore area was prone to flooding and altered little in the twentieth century. Three assets from this period are recorded. The first is a Grade II listed building is The White Rabbit Memorial dedicated to the family of Alice Liddell, upon whom Lewis Carroll based Alice in Wonderland, who spent several summers in Llandudno. There are also two gun emplacements dating from the Second World War.

The Llandudno Town Centre and Seafront Conservation Area's designation covers the heart of the planned resort, which was completed from the 1850s to 1914, for its historical, cultural and architectural quality. All of the listed buildings discussed above lie within the Conservation Area and are a reflection of the character for which the Conservation Area was established to preserve and enhance.

Potential Environmental Effects

North Shore

Several of the options may have a direct adverse impact upon the site of the prehistoric submerged forest. The potential extent of this effect is unknown at this stage as the historic significance of the remains is not well understood. Options 1A and 1B would potentially have a physical effect on the Grade II* listed pier if the breakwater is tied into the structural supports of the pier. Where secondary sea walls are proposed there may be permanent adverse impacts on the on the setting of listed buildings. There may also be adverse impacts from the construction or nourishment activities on previously unrecorded heritage assets and archaeological deposits.

West Shore

Several of the options would have no or only limited adverse impacts on the historic environment. Only one of the options may have a direct adverse impact upon the medieval fish traps / weirs, which are an important local heritage asset. Some options may also adversely impact upon the setting of the listed buildings in the area by the introduction of the proposed secondary sea walls. Finally, there may also be limited adverse impacts derived from the construction or maintenance activities on previously unrecorded heritage assets and archaeological deposits.

[1] Draper, C. (2007) *Llandudno Before the Hotels: 10,000BC to 1854AD,* Llyyad Gwalch: Pwllheli.
[2] Hopewell, D. (2000) *An Assessment of Coastal Fish Weirs and Traps (G1589)* Gwynedd Archaeological Trust. Unpublished Report Number 363, Prepared for Cadw: Welsh Historic Monuments.

Table 9 Archaeology and Cultural Heritage Risk Assessment for the North Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1A Emerged detached breakwaters and beach nourishment	Option 1A includes a section of breakwater adjacent to the Grade II* listed pier. Should the design require the breakwater to physically tie into the foundations and supports of the pier there would be an adverse, physical effect on the pier. Any works physically affecting the pier would require listed building consent. The beach nourishment and construction activity may adversely impact upon the site of the prehistoric submerged forest due to a physical effect on the remains. There may also be adverse impacts derived from the construction of the offshore breakwaters. However, the effect on the setting of the listed buildings will be limited as the proposed breakwaters will be located just off shore within the sea and will form part of the seascape.	The detailed design of the breakwater should try and remove or limit the physical effect on the Grade II* listed pier. The risk could be reduced to green if the potential physical effect is removed completely. The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed.
Option 1B Submerged detached breakwater and beach nourishment	Option 1B includes a section of breakwater adjacent to the Grade II* listed pier. Should the design require the breakwater to physically tie into the foundations and supports of the pier there would be an adverse, physical effect on the pier. Any works physically affecting the pier would require listed building consent. The beach nourishment and construction activity may adversely impact upon the site of the prehistoric submerged forest due to a physical effect on the remains. There may also be adverse impacts derived from the construction of the offshore breakwaters. No effect on the setting of the listed buildings.	The detailed design of the breakwater should try and remove or limit the physical effect on the Grade II* listed pier. The risk could be reduced to green if the potential physical effect is removed completely. The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed.
Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment	The beach nourishment and construction activity may adversely impact upon the site of the prehistoric submerged forest due to a physical effect on the remains. There may also be adverse impacts derived from the construction of the fishtail groynes. There will also potentially be an adverse effect on the setting of the listed buildings from the fishtail groynes on the beach.	The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed. The potential effect on the setting of the listed building cannot be mitigated.
Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment	The beach nourishment and construction activity may adversely impact upon the site of the prehistoric submerged forest due to a physical effect on the remains. There may also be adverse impacts derived from the construction of the fishtail groynes. There will also potentially be an effect on the setting of the listed buildings from the fishtail groynes on the beach.	The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed. The potential effect on the setting of the listed building cannot be mitigated.

Table 9 Archaeology and Cultural Heritage Risk Assessment for the North Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 3 Traditional Groynes and beach nourishment	The beach nourishment and construction activity may adversely impact upon the site of the prehistoric submerged forest due to a physical effect on the remains. There may also be limited adverse impacts derived from the construction of the traditional groynes. There will also potentially be a limited effect on the setting of the listed buildings from the traditional groynes on the beach.	The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed. The potential effect on the setting of the listed building cannot be mitigated.
Option 4 Beach Nourishment only	The beach nourishment may adverse impact upon the site of the prehistoric submerged forest.	The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed.
Option 5 Periodic beach nourishment at 'Children's Corner' (from Pier wall to Trevor Street slipway)	There would be no effect on heritage assets from this option.	No change
Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don	The construction activity may adversely impact upon the site of the prehistoric submerged forest due to a physical effect on the remains. There will also potentially be an effect on the setting of the listed buildings in the area by the introduction of the proposed wave return wall, although these are unlikely to be significant.	The extent of the remains of the prehistoric submerged forest can only be determined through further survey. If the construction works can be undertaken without extensive excavation the risk will be removed. The potential effect on the setting of the listed building cannot be mitigated.

Table 10 Archaeology and Cultural Heritage Risk Assessment West Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1 Periodic Beach Maintenance	Option 1 will maintain the current situation by only removing excess sand, which could then be used elsewhere on this frontage (for example to support sand dunes) or at the North Shore. There would be no effect on previously recorded heritage assets.	No change.
Option 2 Dune Regeneration	The regeneration of the sand dunes would have no effect on previously recorded heritage assets. Construction activity may adversely impact upon previously unrecorded assets if excavation of ground level is required.	If the construction works can be undertaken without extensive excavation the risk will be removed.
Option 3 Concrete Wall and Periodic Beach Maintenance	There would be no effect on previously recorded heritage assets from Option 3. There is limited potential for physical effect on previously unrecorded archaeological deposits from the construction of the wall. There will potentially be an effect on the setting of the listed buildings and other non-designated heritage assets from the construction of the wall.	The potential effect on the setting of heritage assets cannot be mitigated
Option 4 Rock Cover Layer	There would be no effect on previously recorded heritage assets from Option 4. There will potentially be an effect on the setting of the listed buildings and other non-designated heritage assets from the construction of the wall.	The potential effect on the setting of heritage assets cannot be mitigated
Option 5 Sand Traps	There would be no effect on previously recorded heritage assets.	No change.
Option 6 Removal of the existing 3 breakwaters	There is the potential for direct adverse impacts on the remains of the medieval fish weirs which lie adjacent to the existing fishtail rock groynes. The change in the flow of the tide may also affect the erosion of the remains of the fish weir.	A detailed methodology from the removal of the existing breakwaters may prevent an adverse effect on the fish weirs. Archaeological investigation may be possible to ensure their current condition is recorded
Option 7 Installation of a raised timber or plastic walkway	There would be no effect on previously recorded heritage assets.	No change.
Option 8 Undertake repairs / raise existing wall along the northern section of the frontage	There would be no effect on previously recorded heritage assets.	No change.

Scope for Mitigation

Mitigation measures could include the use of materials sympathetic to vernacular material choices for the construction of walls and walkways. Further investigation into the effect of the options on the submerged forest (North Shore) and the medieval fish traps / weirs (West Shore) will also be required, along with recording of any affected remains.

The detailed design of the breakwater should try and remove or limit the physical effect on the Grade II* listed pier. The risk could be reduced to green if the potential physical effect is removed completely.

Need for Further Assessment

North Shore

It is recommended that further assessment of the effect of the proposed options on the setting of listed buildings and of the effects on the submerged forest should be undertaken.

West Shore

It is recommended that further assessment of the effect of the proposed options on the setting of listed buildings and other heritage assets. In addition, an assessment and review of the remains of the medieval fish weir should be undertaken and appropriate mitigation developed.

Amenity Issues

Introduction

The following section considers a range of topic broadly grouped under 'amenity issues' including noise, air quality (and dust), socio-economic, access and recreation.

Environmental Baseline

Noise and Vibration

Along the North Shore Noise Sensitive Receptors (NSR) may include primarily residential properties and secondary local businesses (e.g. hotels and guest houses) along South Parade, St Georges Crescent, Gloddaeth Crescent, and Mostyn Crescent.

The northern part of the West Shore is backed by residential properties along Trinity Crescent, West parade, Abbey Road and Marine Drive, but further south there are no receptors where the North Wales Golf Club is located. The North Wales Path runs along the back of West Shore and walkers along this could be transient receptors to construction noise adverse impacts. The frontage from low water is also included with a SPA designated for over wintering bird populations.

Air Quality and Dust

There are no Air Quality Management Areas on or close to the site. Potential air quality and dust receptors include local residential properties, business, and those enjoying the beach and promenade for recreation. It is also possible that some local terrestrial or backshore habitats may be sensitive to dust effects.

Socio-Economics (including public amenity, access and recreation)

While Llandudno is medium in scale in comparison to other UK resorts it represents the busiest coastal resort in Wales[3]. The resident population in 2011 was approximately 20,000 people but can increase threefold to approximately 60,000 people in the peak summer tourist months (i.e. July and August). The average year-round employment directly supported by seaside tourism in the wider

Llandudno, Conwy and Colwyn Bay area was 4,600 between 2006 and 2008 which represents around 14% of all jobs[3].

Llandudno is located on the central low lying section of the Creuddyn Peninsula and therefore has a coastline on either side. The vast majority of development and leisure activities are focused on the North Shore including the town promenade, pier, bandstand, the focus for sailing and other water sports, larger scale hotels and guest houses, restaurants and a number of other regular town services (See Appendix C). As a result the majority of tourists are accommodated by this side of the town.

The west shore in contrast is less commercialised and provides a beach area backed by green space can be divided into three sections. The southern section is adjoined by the North Wales Golf Club. Access to this section is gained from a point off Trinity Crescent and car parking is provided for users off Dale Road .There are also several tracks connecting the Golf Course to the beach, although it is assumed these may not be open to the general public. Next the central section is adjoined by the western edge of Llandudno town (which is characterised by low density housing, guest houses, open space, beach access, and car parking, children's playground and a model boat pond, but few or no shops or commercial premises). Access to this section is gained from a point off Trinity Crescent and car parking is provided for users off Dale Road. The northern-most section (north of the stormwater outfall) has very little development overlooking it and is backed by a coastal road in front of the Great Orme's Head Special SAC, and further north approximately 35 medium to large beach front residences with gardens leading onto the upper back shore.

The sandy beaches along this north coast of Wales have long been popular with visitors from the industrial towns of north-west England and from across Wales. The coastal towns of Llandudno (known as 'The Queen of Resorts'), Colwyn Bay, Rhyl and Prestatyn provide a wealth of traditional seaside recreational opportunities and attractions including the Grade II Listed Victoria Pier at Colwyn Bay and the Grade II* Llandudno Pier – the longest in Wales, opened in 1877 as a major draw for Victorian holiday-makers.

Recreational activities at the North Shore as noted above include water sports such as jet skiing and speed boating. Tourist pleasure trips run from the pier at Llandudno, usually heading westwards around Great Orme's Head. The North beach is accessed mainly from access points along the promenade between South Parade and the pier area. It is noted that this is directly opposite the main bus stop and it is presumed that member of the public gaining access to the area by public transport would want to access the beach at this location. The Wales Coast Path runs along the promenade.

Recreational activities at the West Shore are similar although not as formal. The main recreational activities in this area are the golf courses, public use of green space, children's playground and model boat pond. The Wales Coast Path also runs along the back of West Shore.

Potential Effects

Noise and Vibration

There are potential temporary short term noise and vibration adverse impacts during the construction phase on residential and other noise sensitive properties along the North Shore and the West Shore. Noise may also be a disturbance to local fauna (e.g. birds) and this is considered more under 'Ecology and Fisheries.'

The magnitude of the impacts will depend upon the construction methods and times. For example, the greatest noise and vibration would be expected from any piling works, but the use of pneumatic tools, high turret excavators or excavators operating from moored barges, and the operation of other plant and heavy goods vehicles could be significant sources of noise along a foreshore. Where possible works should avoid peak holiday seasons, although only where this is compatible with over-wintering bird activity. Night time working should also be avoided and minimised

[3] *The Seaside Tourist Industry in England and Wales - Employment, economic output, location and trends* (CRESR June 2010)

wherever possible, although this may not always be possible depending on the need to work at low tide. Although local disturbances due to construction noise may be significant at times, they are likely to be short-term occurring only when construction works are occurring. The construction noise and vibration impacts can be mitigated using the guidance in BS 5228 'Code of Practice for noise and vibration control on construction and open sites'.

It is anticipated that there would be no change to the existing situation for noise or vibration impacts in the long term.

Air Quality and Dust

Construction work may result in short term temporary adverse impacts on air quality from dust nuisance (e.g. from the spreading of beach nourishment material, vehicles tracking across exposed sand) and an increase in emissions from construction vehicles. The potential for adverse impacts depends on the scale and duration of construction works, especially where there is greater works in upper levels of the beach. Due to the urban location of the with North Shore, close to the busy area of Llandudno and sensitive receptors, appropriate mitigation measures will need to be in place to prevent the spread of dust during construction. In the long term it is unlikely that any new sources of dust will be created and no permanent impacts on air quality are predicted.

Socio-Economics (including public amenity, access and recreation)

Potential temporary adverse effects to local residents, businesses and visitors may include noise, air pollution and traffic disruption during construction works. Collectively, these adverse impacts may deter visitors and temporarily effect local businesses (although visitors are likely to use other services and resorts). At the same time there may be temporary beneficial socio-economic impacts to the local economy through construction-related employment opportunities and worker spending. Options that involve the most significant construction works (e.g. Options 1A, 1B, 2A and 2B for the North Shore, and Options 3, 4 and 6 for the West Shore) will have the greatest impact on socio-economics. Construction works along the West Shore are also less significant that along the West Shore due to the proximity to local businesses and tourism activities. Beach nourishment only options will have the least temporary impacts. Overall, due to the nature and scale of the proposed options and also the relatively small exposure of the local population and economy to temporary adverse effects during construction socio-economic effects are unlikely to be significant.

Both shores are utilised by local residents and visitors and although there may be some temporary disruption, local services will be maintained in the long term. It is not anticipated that any options for beach management would result in changes to the labour force, skills and unemployment, industry and the economy or availability of land for other uses and the current land use will not change. However, without control structures to retain imported sand, replenishment activities will be required more frequently and thus this may not be seen as the most sustainable long term option. In addition, some of the options have the potential to create / facilitate beneficial socio economics effects in the operational phase. The overarching aim of the proposals of the options is for the management of the beach in the long term. By having a beach management plan in place in will promote the beaches continued and enhanced use in a sustainable way so it can be enjoyed by local residents and hopefully improve the number of visitors and visitor experiences. Therefore, in the long term all options will have a beneficial socio-economic effect.

Risk Assessment

Table 11 provides a summary of the options risk assessment for amenity issues for the North Shore options, and Table 12 for West Shore:

Table 11 Amenity Issues Risk Assessment for the North Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1A Emerged detached breakwaters and beach nourishment	Noise, Dust and Air: Without appropriate mitigation measures to noise and dust during construction works may result in temporary adverse effects on local residents or visitors to the North Shore (e.g. effective dust or particulate matter suppression).	The risk can be reduced by applying good practice construction techniques with noise reduction/ prevention measures (e.g. Adhering to 'standard' hours for noisy construction activities where possible (although to fit in with tides this may not always be possible) and ensure that best practicable means are used to mitigate noise and vibration impacts on neighbours or dust prevention measures e.g. effective dust or particulate matter suppression.
	Socio Economics, Access and Recreation Use: Without maintenance (which may have financial implications) the emerged breakwaters may encourage build-up of debris (e.g. seaweed and offshore rubbish on the upper beach). This may be unsightly for users of the beach and require removal. This may however provide long-term ecological benefits (creation of new habitats).	Potential mitigation may include having a maintenance programme for removal of debris. A similar programme may already be in place for the beaches and could be adapted.
Option 1B Submerged detached breakwater and beach nourishment	Noise, Dust and Air: As per Option 1A above for construction. No operational air quality issues anticipated.	As per option above.
	Socio Economics, Recreation Use: This may result in changes to suitability of the beach for certain recreational activities but in the long term improved beach management may support additional recreational activities.	These recreational activities may be adapted or may be facilitated elsewhere within the area and careful consideration to location and design of the solution would be required.
Option 2A 3 No. fishtail, 4 No. conventional groynes and beach nourishment	Noise, Dust and Air: As per option 1A and 1B for construction phase effects. No operational air quality issues anticipated	As per Options above
	Socio Economics, Recreation Use and Access: Option may result in segmentation of the beach zone within this area but not to the same extent as Option 3 A & B below. This may result in changes to suitability of the beach for certain activities or may affect access points to the beach. In the long term improved beach management may support additional recreational activities. It is not anticipated that this option would change the number of visitors to the North Shore as although the option would segment the beach area there are still large areas of beach that can be utilised.	Provision of suitable access to all current and future users of the beach during construction (where safe to do so) and during operation.

Table 11 Amenity Issues Risk Assessment for the North Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 2B 2 No. fishtail groynes, 4 No. conventional groynes and beach nourishment	Noise, Dust and Air: As per options above for construction phase effects. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option may result in long term segmentation of the beach zone within this area but not to the same extent as Option 3. This may result in changes to suitability of the beach for certain activities or may affect access points to the beach. In the long term improved beach management may support recreational activities. It is not anticipated that option would change the number of visitors to the north shore as although the option would segment the beach area there are still large areas of beach that can be utilised.	Provision of suitable access to all current and future users of the beach during construction (where safe to do so) and during operation.
Option 3 Traditional Groynes and beach nourishment	Noise, Dust and Air: As per Options above for construction phase effects. No long-term air quality impacts expected.	As per Options above.
	Socio Economics, Recreation Use and Access: Option will result in segmentation of the beach zone within this area. This will segment the beach zone into 4 distinct sections. From photos available there appears to be traditional timber groynes currently at this location. Changes in the location or number of these may result in changes to suitability of the beach for certain activities or may affect access points to the beach. However, in the long term improved beach management may support enhanced or even additional recreational activities. There may be a visual effect from the traditional groynes. This may discourage users of the beach in this area although unlikely, however it result in redistribution of users to other beaches within the area.	Provision of suitable access to all current and future users of the beach during construction (where safe to do so) and during operation. Through design reduce the visual impact of the groynes (e.g. less visually intrusive design, using local materials in keeping with the Limestone within the area or other suitable materials).

Table 11 Amenity Issues Risk Assessment for the North Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 4 Beach Nourishment only	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Option is unlikely to result in significant adverse effects on socio economics in short term. In the long term improved beach management may support recreational activities. This option would result in the requirement for continuous nourishment and would may not address ongoing long term erosion issues facing this frontage, which would have ongoing financial implications.	Programme for re nourishment to ensure the longevity of the beach area in the long term.
Option 5 Periodic beach nourishment at 'Children's Corner' (from Pier wall to Trevor Street slipway)	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option is unlikely to result in significant adverse effects on socio economics in the short term. In the long term improved beach management may support recreational activities. It will facilitate the continued use of this section of beach as 'Children's Corner' an area historically well known to be used by children for sandcastle building. This would cause periodic short term disturbance of its use as a recreational resource but would increase its longevity. This option would result in the requirement for continuous nourishment in the long-term which would have ongoing financial implications.	Programme for re nourishment would be required to ensure the longevity of this area of the beach area in the long term and fulfil its purpose as sandcastle building area as used by the public..
Option 6 Wave return wall along the seaward edge of the paddling pool at Craig-y-Don	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option is unlikely to result in significant adverse effects in the short term. In the long term this option may support recreational activities. It will facilitate the continued use of the paddling pool by local residents and visitors. This may cause short term disturbance of its use (during construction) as a recreational resource but would improve it in the long-term.	Unlikely to discourage users of the paddling pool. Appropriate design to mitigate any visual effects.

Table 12 Amenity Issues Risk Assessment for the West Shore Options

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 1 Periodic Beach Maintenance	Noise, Dust and Air: Without appropriate mitigation measures to noise and dust during construction works may result in temporary adverse effects on local residents or visitors to the North Shore (e.g. effective dust or particulate matter suppression).	The risk can be reduced by applying good practice construction techniques with noise reduction/ prevention measures e.g. Adhering to 'standard' hours for noisy construction activities and ensure that best practicable means are used to mitigate noise and vibration impacts on neighbours or dust prevention measures e.g. effective dust or particulate matter suppression.
	Socio Economics, Recreation Use and Access: Due to its location Option is unlikely to result in significant adverse effects on socio economics. In the long term improved beach management may support recreational activities. This option would result in the requirement for continuous nourishment in the long-term which would have ongoing financial implications.	Programme for re nourishment will be required to ensure the longevity of the beach area in the long term.
Option 2 Dune Regeneration	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option is unlikely to result in significant adverse effects on socio economics in short term. There may be impacts to users of the model boating lake however through disruption during construction activities however this would be temporary and short term in nature. Access may be affected if dune regeneration is proposed at points where users of the beach currently gain access whether through designated Public Right of Way or just through the dunes themselves. Newly installed dunes should not be used as a point of access so therefore temporary or permeant diversions may be required. This is not considered significant once an alternative route is provided. Option may result in segmentation of the beach zone within this area but not to the same extent as Option 3 A & B below. This may result in changes to suitability of the beach for certain activities or may affect access points to the beach. In the long term improved beach management may support additional recreational activities. In the long term improved beach management may support recreational activities. In particular, this option provides the greatest opportunity for nature conservation and biodiversity.	Minimise disruption to users of the boating lake. Facilitate access to the beach. Appropriate design to mitigate any visual effects.

Table 12 Amenity Issues Risk Assessment for the West Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 3 Concrete Wall and Periodic Beach Maintenance	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Option is unlikely to result in significant adverse effects on socio economics in short term. In the long term improved beach management may support recreational activities. This option would result in the requirement for continuous nourishment in the long-term which would have ongoing financial implications	Programme for re nourishment will be required to ensure the longevity of the beach area in the long term.
	Socio Economics, Recreation Use and Access: Access may be affected by the installation of a 1.5 m high wall between the footpath and the beach. It is assumed this will affect points where users of the beach currently gain access whether through designated Public Right of Way or just through the dunes themselves. Temporary or permeant diversions may be required. This is not considered significant once an alternative route of access is provided. Option is unlikely to result in significant adverse effects on socio economics in short term. In the long term improved beach management may support recreational activities. However, this option would require continuous beach nourishment which would have ongoing financial implications.	Facilitate access to the beach. Appropriate design to mitigate any visual effects.
Option 4 Rock Cover Layer	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: may be affected by the installation of the rock layers. It is assumed this will affect points where users of the beach currently gain access whether through designated Public Right of Way or just through the dunes themselves. Temporary or permeant diversions may be required. This is not considered significant once an alternative route of access is provided Option will reduce the aesthetic appearance of the beach backshore. Option may change the suitability of the beach for certain activities, however in the long term improved beach management may support additional recreational activities. Overall the option is unlikely to result in significant adverse effects on socio economics in the long term.	Facilitate access to the beach. Appropriate design to mitigate any visual effects Mitigation measures as listed above.

Table 12 Amenity Issues Risk Assessment for the West Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 5 Sand Traps	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option will result in segmentation of the beach zone within this area. This will segment the beach zone into 2 sections. This may result in changes to suitability of the beach for certain activities or may affect access points to the beach .Option is unlikely to result in significant adverse effects on socio economics in short term. In the long term improved beach management may support additional recreational activities. This option would potentially avoid the need for regular beach nourishment in the long term.	Facilitate access to the beach. Appropriate design to mitigate any visual effects Mitigation measures as listed above.

Table 12 Amenity Issues Risk Assessment for the West Shore Options - continued

Option	Environmental Risk Classification – without mitigation	Environmental Risk Classification – taking potential mitigation into account
Option 6 Removal of the existing 3 breakwaters	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option may result in changes to suitability of the beach for certain recreational activities. Option is unlikely to result in significant adverse effects in short term. In the long term improved beach management may support additional recreational activities.	Further assessment of the potential effects on coastal processes and beach geomorphology is required, and how this may affect recreational activities.
Option 7 Installation of a raised timber or plastic walkway	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: Option may result in changes to suitability of the beach for certain activities or may affect access points to the beach. Option is unlikely to result in significant adverse effects in short term. In the long term improved beach management may support recreational activities. Option would provide enhanced public access, assuming the North Wales Path (PRoW) is maintained or routed along the new walkway.	Facilitate access to the beach and ensure design in in keeping with the surroundings.
Option 8 Undertake repairs / raise existing wall along the northern section of the frontage	Noise, Dust and Air: As per options above for construction phase. No long term air quality issues anticipated.	As per Options above.
	Socio Economics, Recreation Use and Access: There may be a visual effect from the raising of the wall next to the footpath. This may reduce immediate visibility of the sea however the level of visual disturbance would be dependent on the design of the structure. Option is unlikely to result in significant adverse effects on socio economics in short term. In the long term improved beach management may support recreational activities. Repairs only to the existing wall would not be considered to cause any significant effects.	No comments at this stage.

Scope for Mitigation

There are effective options for mitigating potential dust issues from construction works and these will be developed with the design of the scheme. It is considered that with the implementation of an appropriate Dust Management Plan and mitigation of vehicle emissions (e.g. appropriate access routes and no idling of engines) there will be no significant residual impacts on air quality.

The timing of construction works is important given the importance of tourism to the local economy and avoidance of peak periods is likely to be a pre-requisite. However, this will need to be balanced against other factors such as the presence of designated bird species over winter months typically between October and March. Cumulatively, it may also be prudent to avoid undertaking works on both the North Shore and West Shore concurrently, in order that space for recreational activity is maintained at all times. Either way, careful co-ordination of the works with local businesses is important to avoid, minimise and reduce the potential for short term and temporary adverse effects during construction works.

Depending on the construction programme it may be necessary to provide diversions to access to the beach. Works should aim to avoid busy periods and facilitate continued access where feasible and safe to do so. Any temporary or permanent diversions to Public Rights of Way will need prior consent from Conwy County Borough Council's Public Rights of Way officer. Where access to the beach is altered, provision for disabled people should be provided in accordance with the Well-Being of Future Generations Act (Wales) 2015.

Need for Further Assessment

It is recommended that an appropriate level of assessment is carried out of amenity impacts as options are developed. This is to ensure that appropriate mitigation measures to managed potential short term and temporary construction effects (e.g. dust, noise and disruption) are determined and included in future Construction Method Statements. Specifically, further assessment could be undertaken in consultation with Conwy County Borough Council's Environmental Health Department of the need to determine noise limits for construction noise or if necessary the construction noise and vibration impacts can be controlled by a Section 61 consent under the Control of Pollution Act 1974. It is also recommended that local businesses and residents are consulted on proposals to ensure that the preferred option takes into account local needs and wishes.

Summary and Conclusions

The following provides a summary of the main conclusions of this environmental pre-feasibility study.

North Shore

Directly adjacent to the North Shore is the Menai Strait and Conwy Bay SAC and Liverpool Bay SPA, with other SACs, SSSIs, and NNRs in the local vicinity. The beach is a designated bathing water and the coastal waters are covered by the Water Framework Directive and on the west of SH 7886 8222 the Shellfish Directive for commercial shellfish beds. The North Shore also backs on to the main Llandudno Promenade occupied by residential properties, hotel and business premises and the foci for local tourism activities, with slipways for boat trips and the life boat, and further west Llandudno Pier, which is Grade II* listed. Residential properties, businesses and visitors may be receptors to construction effects (e.g. dust and noise etc.). The North Wales Coast Path is routed along the promenade. Finally, there are numerous local heritage records in the study area, which includes numerous listed buildings along the promenade. The study area is also within the Llandudno Town Centre and Sea Front Conservation Area and the Happy Valley Historic Park and Garden overlooks the frontage from the west side of the Great Orme Headland.

There is a potential high risk to the environment from Options 1A and 1B in respect to the potential adverse impacts on biodiversity, commercial shellfish beds, water pollution, and on the Grade II* Listed Llandudno Pier. Options 1A and 1B (and to a lesser extent Options 2A, 2B, 3A, 4 and 5) could result in a temporary net loss of species diversity. However, it is difficult to fully determine the risk at this stage and further ecological survey and assessment as part of a HRA will be required.

With time it is possible that the creation of new breakwaters may increase the local diversity of intertidal and sub-tidal habitat.

Similarly, Options 1A and 1B, and to a lesser extent Option 2A (by virtue of its smaller physical footprint) may impact upon potential commercial shellfish beds and result in significant temporary adverse effects on water quality during construction, close to a designated bathing water. The location of commercial shellfish beds within the designated shellfish waters is not known at this stage and through design direct and indirect effects should be avoided. Appropriate mitigation measures should also be developed to control construction pollution risks.

Finally, Options 1A and 1B includes a section of breakwater adjacent to the Grade II* listed pier. Should the design require the breakwater to physically tie into the foundations and supports of the pier there would be an adverse, physical effect on the pier. Any works physically affecting the pier would require listed building consent. The detailed design of the breakwater should try and remove or limit the physical effect on the Grade II* listed pier. The risk could be reduced to green if the potential physical effect is removed completely.

Option 2A, 2B and 3 will increase beach segregation which may result in a moderate environmental risk due to the adverse impact on beach access and recreational uses. This may be mitigated by ensuring the design provides appropriate access to the beach and along it for future users. All options have the potential for short term, temporary adverse impacts on local amenities and socio-economics, although the risk is greatest where construction works would be more extensive, complex and take longer to complete (such as for Options 1A and 1B).

No significant landscape or heritage impacts have been predicted at this stage, although through further design of the preferred options measures to minimise potential adverse effects should be considered through appropriate height and form of structures and the use of materials. Through good design it should be possible to ensure that new structures are most in keeping with local landscape character and the setting of listed buildings. There is also the potential to impact on the submerged prehistoric forest and further survey may be required to determine the extent of this and to avoid and minimise potential adverse impacts where practically possible.

Finally, at this stage no ground investigation has been undertaken or sediment sampling so it is not possible to determine what if any contamination exists and what risk this may pose to human receptors or controlled waters. Depending on which option is preferred ground investigation may be required as the scheme develops.

The unmitigated and potential mitigated risk profiles for options for beach management for the North Shore are presented below (for amenity issues the worst case is reported):

Table 13 Environmental Risk Profiles for North Shore Options

West Shore

The entire West Shore is included within the Aber Afon Conwy SSSI and within the Menai Strait and Conwy Bay SAC and Liverpool Bay SPA below MLW. There are also other nature conservation sites in the vicinity of the site and the local sand dunes are a UK BAP habitat. The beach is a designated bathing water, the coastal waters are covered by the Water Framework Directive, and to the south there are commercial shellfish beds at the mouth of the Conwy Estuary that are designated under the Shellfish Directive. West Shore also backs on to a pedestrian promenade, which although less developed provides opportunities for recreational walks, cycling, and exercise, beyond which there are sea facing residential properties and further south the North Wales Golf Course. The study area is also within the Llandudno Town Centre and Sea Front Conservation Area, with numerous local heritage records including up to three medieval fish traps / weirs and the Grade II listed Toll Lodge at the base of the eastern flank of the Great Orme Headland. Finally, the North Wales Coast Path runs along the promenade and between the upper beach and sand dunes.

There is a potential high risk to the natural environment from Options 3, 4, 6 and 7 due to the potential direct and permanent changes to beach geomorphology (and potential increase in flood risk) and the potential loss of upper beach and dune habitat within a SSSI, and particularly in the case of Options 3 and 4 the potential to disrupt the supply of wind-blown sand to existing sand dunes resulting in future habitat degradation. On the other hand, Option 2 would promote the creation of new sand dunes, a UK BAP Habitat, and it may be possible to form partnerships with NRW and local wildlife groups for the sustainable future management of this new habitat. Option 6 would also require the removal of the existing fishtail groynes which may result in some short term, temporary adverse effects within the SSSI due to construction works and the risk of pollution. Any works in the SSSI will require permission from NRW and suitable mitigation measures will be required if this becomes the preferred option. In the longer term, there would be a reduction in the

biological diversity of the bay by the removal of rocky substrate, although the bay would be returned to a more natural state. The geomorphic impact of removing the rock groynes is also uncertain and further assessment would be required. Finally, although none of the options would result in direct impacts on the Liverpool Bay SPA or the Menai Straits and Conwy Bay SAC, all options except Option 2 should be screened to determine any likely significant effects and the need for a future HRA.

No significant heritage impacts have been predicted other than for Option 6. Option 6 would involve the removal of the three existing rock fishtail groynes, which may result in direct and indirect adverse impacts on the remains of medieval fish traps / weirs which lies adjacent to them. Potential adverse impacts may be avoided, minimised and reduced by agreeing a suitable and detailed removal methodology informed by further archaeological investigation and recording of their current condition.

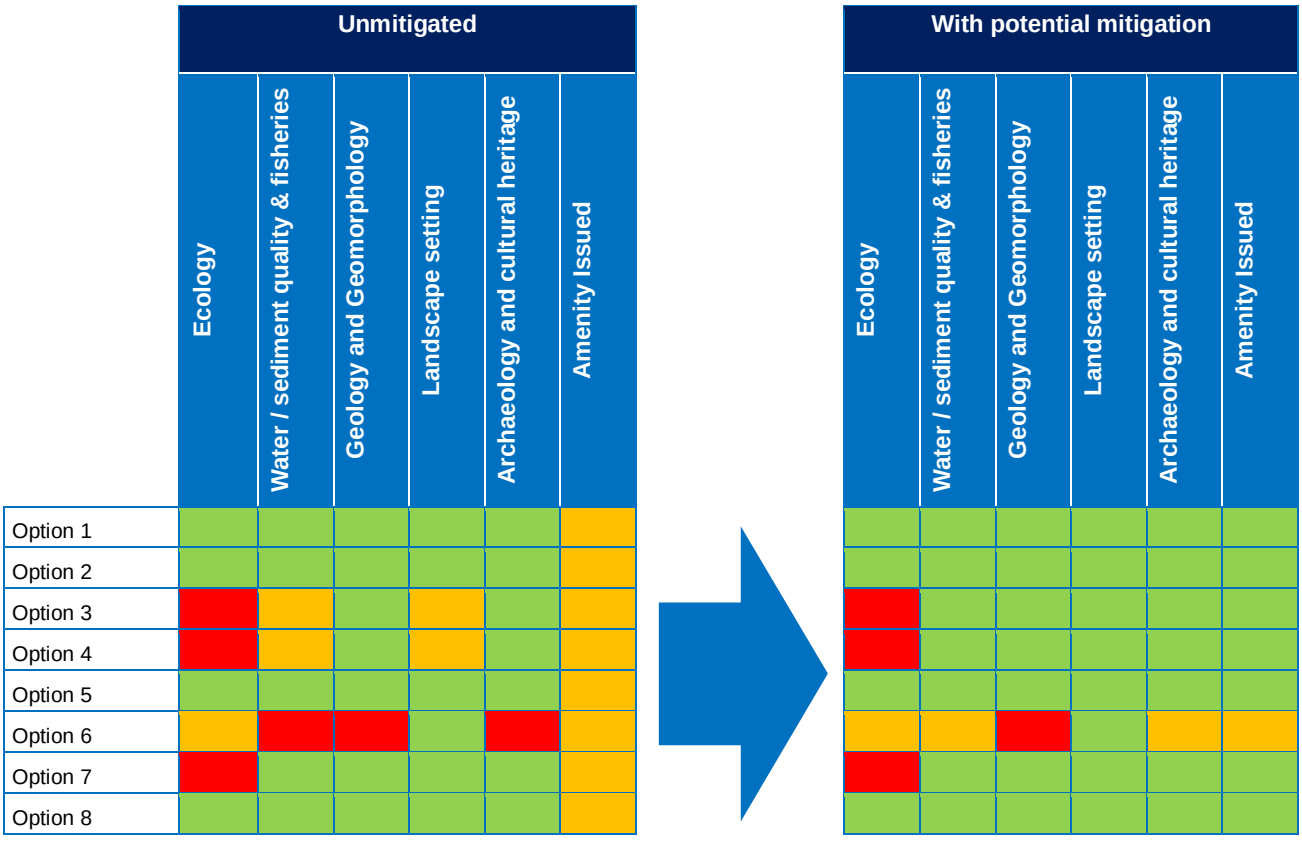
No significant landscape impacts have been predicted at this stage, although through further design of the preferred options measures to minimise potential adverse effects should be considered through appropriate height and form of structures and the use of materials. Through good design it should be possible to ensure that new structures are most in keeping with local landscape character and the setting of listed buildings. There is also the potential to impact on the submerged prehistoric forest and further survey may be required to determine the extent of this and to avoid and minimise potential adverse impacts where practically possible.

All options have the potential for short term, temporary adverse impacts on local amenities and socio-economics, although the risk is greatest where construction works would be more extensive, complex and take longer to complete (such as for Options 3, 4 and 6). This assumes that appropriate access arrangements are provided.

Finally, at this stage no ground investigation has been undertaken or sediment sampling so it is not possible to determine what if any contamination exists and what risk this may pose to human receptors or controlled waters. Depending on which option is preferred ground investigation may be required as the scheme develops.

The unmitigated and potential mitigated risk profiles for options for beach management for the West Shore are presented below (for amenity issues the worst case is reported):

Table 14 Environmental Risk Profiles for West Shore Options



Recommendations

The scope for further surveys and assessment should be determined in consultation with planners and statutory consultees as part of the process of applying for planning permission and a marine licence. This may include an Environmental Impact Assessment, depending on the scale and nature of the proposed development and the potential for significant environmental effects). The following represents initial surveys and assessments that are likely to be required, depending on the options that are taken forward for further consideration:

- The need for a HRA needs for options along both the North and West Shores should be determined in consultation with NRW. The HRA could be undertaken alongside further terrestrial / marine ecological and ornithological surveys and assessment that will be required.
- Options along the West Shore would be within the Aber Afon Conwy SSSI and will need Assent to Work in a SSSI from NRW. NRW will require the preferred option to be compliant with current conservation and management objectives for the SSSI.
- It is recommended that a full ecological desk study is undertaken as options are developed. In addition, further ecological surveys are recommended including more detailed species analysis of the beach if there is a going to be a potential disturbance to the beach habitats. Specifically, if structures affecting sub-tidal habitat are proposed (North Shore) further surveys to assess the bed substrate and species present may be required using underwater cameras and the analysis of grab samples.
- Some options (i.e. West Shore Options 3, 4 and 7) may directly interrupt the transport of wind-blown sand from West Shore feeding existing sand dunes. For these options long term monitoring of the condition of these sand dunes linked to an action plan may be required so as to avoid future degradation of this UK BAP habitat locally.

- Where possible, any new development should avoid direct or indirect effects on any commercial shellfish beds. Any shellfish beds in close proximity to the proposed options should be identified and taken into account during further design. The scope of any WFD assessment should also be discussed and agreed with NRW.
- Pollution prevention measures will be required relevant to the option to ensure that there are no significant adverse effects on water quality during construction, in order to protect the WFD, shellfish, bathing water and nature conservation sites (where features depend on good water quality). Measures will also be required to manage the risk of air or land pollution, noise, vibration, visual intrusion, and traffic effects. These measures could be described in Construction Method Statements and Construction Environmental Management Plan (incorporating other topic specific plans, e.g. Dust Management Plan).
- Further assessment and potentially modelling of the preferred option(s) may be required to determine the full effect on beach geomorphology, depending on which option is selected.
- Further desk study and potential site investigation may be required depending on the preferred option(s). Sediment sampling and chemical analysis may also be required to support future marine licence applications.
- Further investigation into the effect of the options on the submerged forest (North Shore) and the medieval fish traps / weirs (West Shore) will be required, along with recording of any affected remains. Further assessment if the potential direct and setting impact on Listed Buildings and heritage assets may be required for some options, particularly for the North Shore and where these might impact Llandudno Pier.
- As the design develops landscape and visual effects will need to be taken into account to optimise the design and ensure it is incorporated into the wider landscape setting as much as possible (e.g. the height, form, materials and façade of any new sea walls is yet to be determined). Mitigation measures could include the use of materials sympathetic to vernacular material choices for the construction of groynes, walls and walkways. Further assessment would be based on the principles of the Guidelines for Landscape and Visual Impact Assessment (2013). This would include the identification of representative viewpoints (if required) by Conwy County Borough Council. It would also assess the effect on the townscape and neighbouring NLCAs / MCAs.
- Further assessment could be undertaken in consultation with Conwy County Borough Council's Environmental Health Department of the need to determine noise limits for construction noise or if necessary the construction noise and vibration impacts can be controlled by a Section 61 consent under the Control of Pollution Act 1974. It is also recommended that local businesses and residents are consulted on proposals to ensure that the preferred option takes into account local needs and wishes.
- Finally, depending on the construction programme it may be necessary to provide diversions to access to the beach. Works should aim to avoid busy periods and facilitate continued access where feasible and safe to do so. Any temporary or permanent diversions to Public Rights of Way will need prior consent from Conwy County Borough Council's Public Rights of Way officer.

Planning Policy Context

All options for beach management along the North Shore frontage are in keeping with the SMP2 policy of hold the line in the short to long term. The SMP2 policy for West Shore is to hold the line in the short to medium term and to allow managed retreat in the longer term. Clearly, should existing stabilising structures be removed (e.g. West Shore Option 6) the effects on the frontage need to be carefully assessed to ensure that this action is compliant with the SMP2 policy. Although the longer term is beyond the expectation of the design life for beach management options being proposed now, options to remove structures or are offer a more natural and sustainable coastal defence would be more in keeping with the policy for future managed retreat.

All options seek to support healthy and sustainable beaches at the North Shore and West Shore and are thus in keeping with local planning policy, albeit there may be some short term temporary adverse effects during any necessary construction works. The potential impact on local human sensitive receptors and the tourism economy could be mitigated by timing the works to avoid the peak holiday periods. However, should works be restricted to late autumn to early spring they may conflict with over wintering birds that are designated under the Liverpool Bay SPA. Other local policies seek to protect and enhance the natural and built environment including nature conservation sites, historic features and buildings, landscape character and the coastal zone in terms of preventing land, air and water pollution. Appropriate assessments of the short listed and preferred option will be required as part of future planning and marine licence applications to ensure that these matters are adequately considered and where required the necessary mitigation measures are provided. In particular, Option 2 for the West Shore proposes significant enhancement of sand dunes along the back of the beach that is a UK BAP habitat and would support local planning policy NTE/3.

The following section provides details of the potential permissions, consents and licences that may be required depending on which options are preferred.

Permissions, Consents and Licences

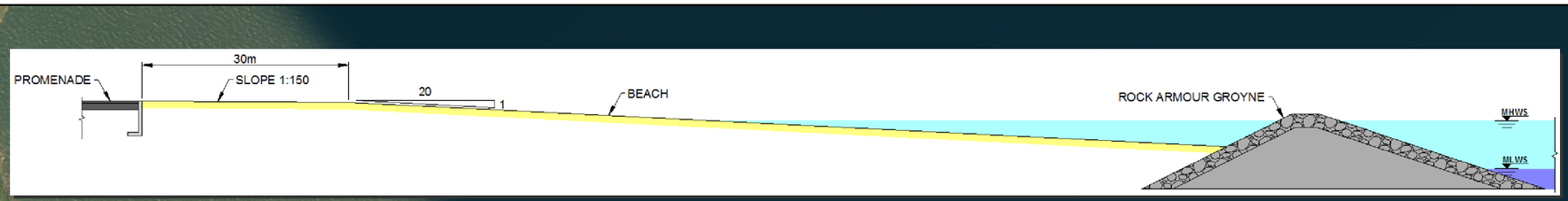
New development at the coastline will require certain consents in order for them to be constructed and operated. The requirements of these should be established at an early stage and in consultation with the relevant regulators and planning authorities so that a programme for delivery of the project can be determined. Table 15 summarises those that are potentially relevant to the long list of beach management options:

Table 15 Potential Permissions, Consents, and Licences

Permission / Consent	Authorising Body	Legislation	Comment
Planning Permission, including possible EIA and Listed Building Consent and permission	Conwy County Borough Council (Planning Department)	The Town & Country Planning Act 1990 (as amended), the Town and Country Planning (EIA) (England and Wales) Regulations 1999 (as amended), The Town and Country Planning (General Permitted Development) Order 1995 (as amended), Planning (Listed Building and Conservation Areas) Act 1990 and the Marine Works (EIA) Regulations 2007 (as amended).	Planning permission would be required from Conwy County Borough Council for any works that fall outside of permitted development above the low water mark. Depending on the scale, type and location of the proposed development an EIA be required. Where works may directly affect a listed building additional consent may be required. Planning permission may also need to consider permission for works affecting a Conservation Area.
Marine Licence	Natural Resources Wales	The Marine and Coastal Access Act 2009, the Marine Licensing (Exempted Activities) (Amendment) Order 2013 and the Marine Licensing (Exempted Activities) Order 2011	A Marine Licence will be required for any regulated activities below MHWST as defined by paragraph 66 (1) of the Act, unless exemptions apply. For works that affect marine sediments, chemical testing will be required to support the application. See also 'Waste Permit.'
Crown Estate Landowner's Permission	The Crown Estate	The Crown Estate Act 1961	Activities such as intrusive site investigations and any physical work on, over or under the foreshore out to 12 nautical miles requires permission from the Crown Estate where they are the default landowner.
Habitats Regulation Assessment	Natural Resources Wales	Conservation of Habitats and Species (Amendment) Regulations 2011.	An Appropriate Assessment is required where there is the potential for significant effects on European designated sites (e.g. SACs and SPAs).
Water Activity Permits (Flood Defence Activity)	Natural Resources Wales	The Environmental Permitting (England and Wales) Regulations 2016.	Depending on the nature of the works it might be necessary to apply for various consents relating to works that have discharges to controlled waters or affect existing flood defences. However, where a separate Marine Licence is to be applied for a separate Water Activity Permit may not be required, subject to confirmation by Natural Resources Wales.
Waste Permit	Natural Resources Wales	The Environmental Permitting (England and Wales) Regulations 2016.	The 2008 Waste Framework Directive (2008/98/EC) defines 'waste' as "…any substance or object which the holder discards or intends or is required to discard…" Any waste generated by the construction of beach management options, including potentially marine sediments that need to be dredged, will need to be managed in accordance with prevailing waste legislation in the UK. The use, disposal, storage or treatment of waste may require an Environmental Permit unless an exemption applies.
Control of Construction Noise	Conwy County Borough Council (Environmental Health Department)	Control of Pollution Act (COPA) 1974	Noise nuisance from construction works is controlled by Section 60 Control of Pollution Act 1974 and Section 61 Control of Pollution Act 1974. Section 61 Control of Pollution Act 1974 allows a contractor or promoter to approach the local authority to gain consent to carry out construction works. The local authority has the power to amend or condition any consent.
Assent to Work in a SSSI	Natural Resources Wales	Part II of the Wildlife and Countryside Act 1981, as amended by the Countryside and Rights of Way Act 2000,	It is a legal requirement to give written notice to Natural Resources Wales for any works proposed in a SSSI that may affect the features of that site. The upper backshore at West Shore is within the Aber Afon Conwy SSSI.

Figures

Appendix A Scheme Options



Project Management Initials: RR Designer: BM Checked: DC Approved: RR

Scale: 1:8,000 @ A3

AECOM

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Breakwater
- Beach Nourishment

PROJECT NUMBER

60525387

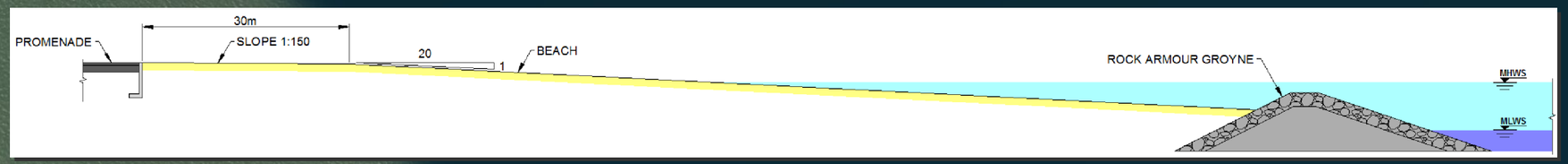
SHEET TITLE

NORTH BEACH: OPTION 1A. BREAKWATERS

DRAWING NUMBER

60525387-SKE-00-0000-C-1150

Project Management Initials: RR Designer: BM Checked: DC Approved: RR



N

MARINE ZONE
BEACH ZONE
160m
152m
SUBMERGED DETACHED BREAKWATER
160m
145m
160m
60m
145m
BEACH ZONE
BOATING ZONE
BOATING ZONE
FISHING ZONE
FISHING ZONE
MARINE ZONE

0 200 400 Metres

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Scale: 1:8,000 @ A3

AECOM

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Breakwater
- Beach Nourishment

PROJECT NUMBER

60525387

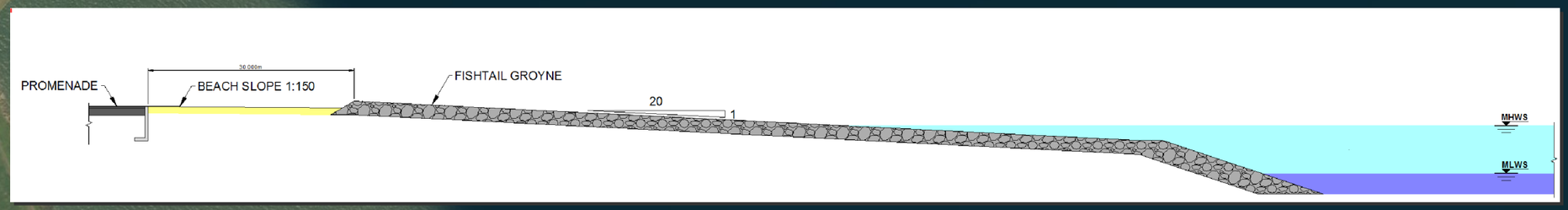
SHEET TITLE

NORTH BEACH: OPTION 1B. BREAKWATERS

DRAWING NUMBER

60525387-SKE-00-0000-C-1151

Project Management Initials: RR Designer: BM Checked: DC Approved: RR



AECOM

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Fishtail Groyne
- Beach Nourishment

PROJECT NUMBER

60525387

SHEET TITLE

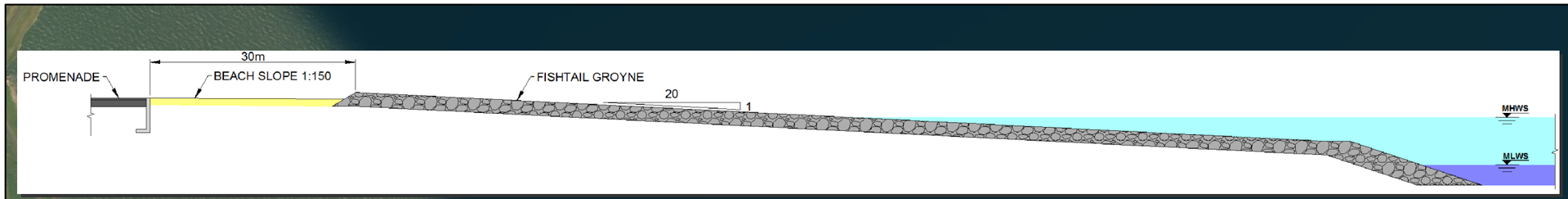
NORTH BEACH: OPTION 2A.
FISHTAIL GROYNES

DRAWING NUMBER

60525387-SKE-00-0000-C-1152

Scale: 1:8,000 @ A3

Project Management Initials: RR Designer: BM Checked: DC Approved: RR



AECOM

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Fishtail Groynes
- Beach Nourishment

PROJECT NUMBER

60525387

SHEET TITLE

NORTH BEACH: OPTION 2B.
FISHTAIL GROYNES

DRAWING NUMBER

60525387-SKE-00-0000-C-1153

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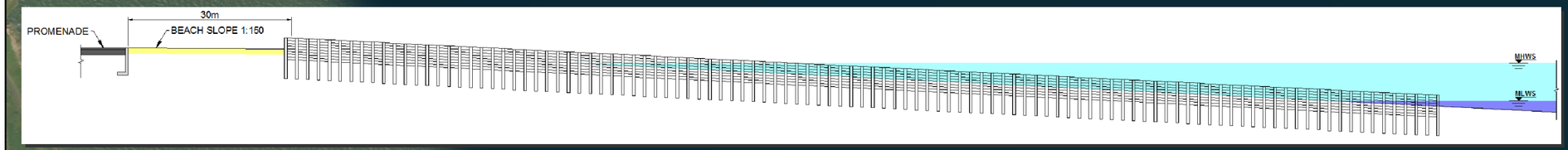

AECOM

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Traditional Groynes
- Beach Nourishment

PROJECT NUMBER

60525387

SHEET TITLE

NORTH BEACH: OPTION 3.
TRADITIONAL GROYNES

DRAWING NUMBER

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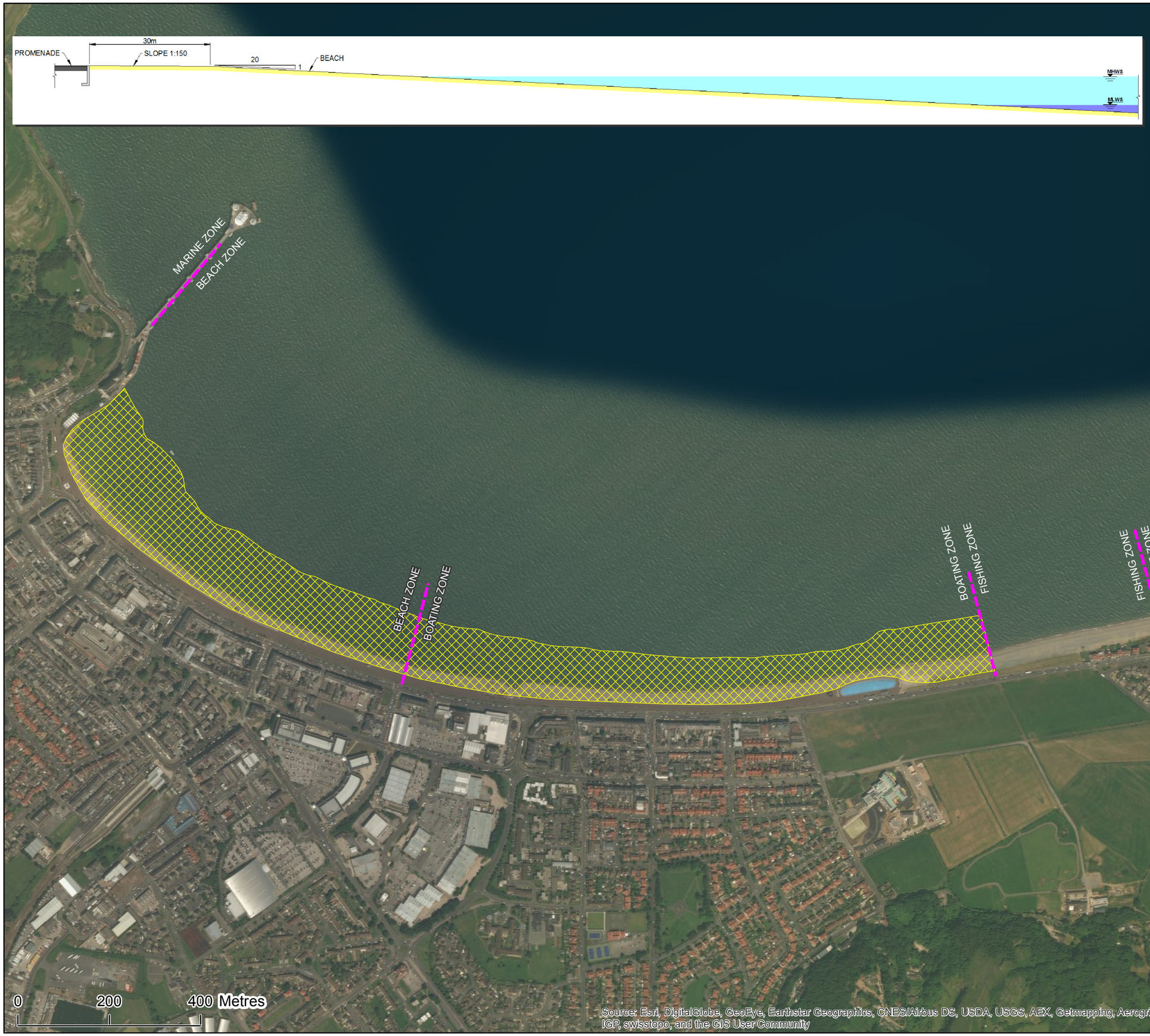

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AECOM

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

Beach Nourishment

PROJECT NUMBER

60525387

SHEET TITLE

NORTH BEACH: OPTION 4.
BEACH NOURISHMENT

DRAWING NUMBER

60525387-SKE-00-0000-C-1155

Project Management Initials: RR Designer: BM Checked: DC Approved: RR

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Zones
- Beach_Nourishment

PROJECT NUMBER

60525387

SHEET TITLE

NORTH BEACH: OPTION 5.
BEACH NOURISHMENT - CHILDREN'S CORNER

DRAWING NUMBER

60525387-SKE-00-0000-C-1156

Scale: 1:8,000 @ A3

Project Management Initials: RR Designer: BM Checked: DC Approved: RR

PROJECT

LLANDUDNO BMP AND CTFRA UPDATE

CLIENT

CONWY COUNTY BOROUGH COUNCIL

LEGEND

- Concrete Wall
- Zones

PROJECT NUMBER

60525387

SHEET TITLE

NORTH BEACH: OPTION 6.
BEACH NOURISHMENT - WAVE RETURN WALL

DRAWING NUMBER

60525387-SKE-00-0000-C-1157

Scale: 1:8,000 @ A3

LEGEND

Periodic beach maintenance

Client: CLIENT

Project: PROJECT

Title: WEST BEACH: OPTION 1. PERIODIC BEACH MAINTENANCE

AECOM
Sunley House
4 Bedford Park
Croydon
CR0 2AP
Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

Drawn:	BM	Chk'd:	DC
App'd:	XX	Date:	10/11/2016
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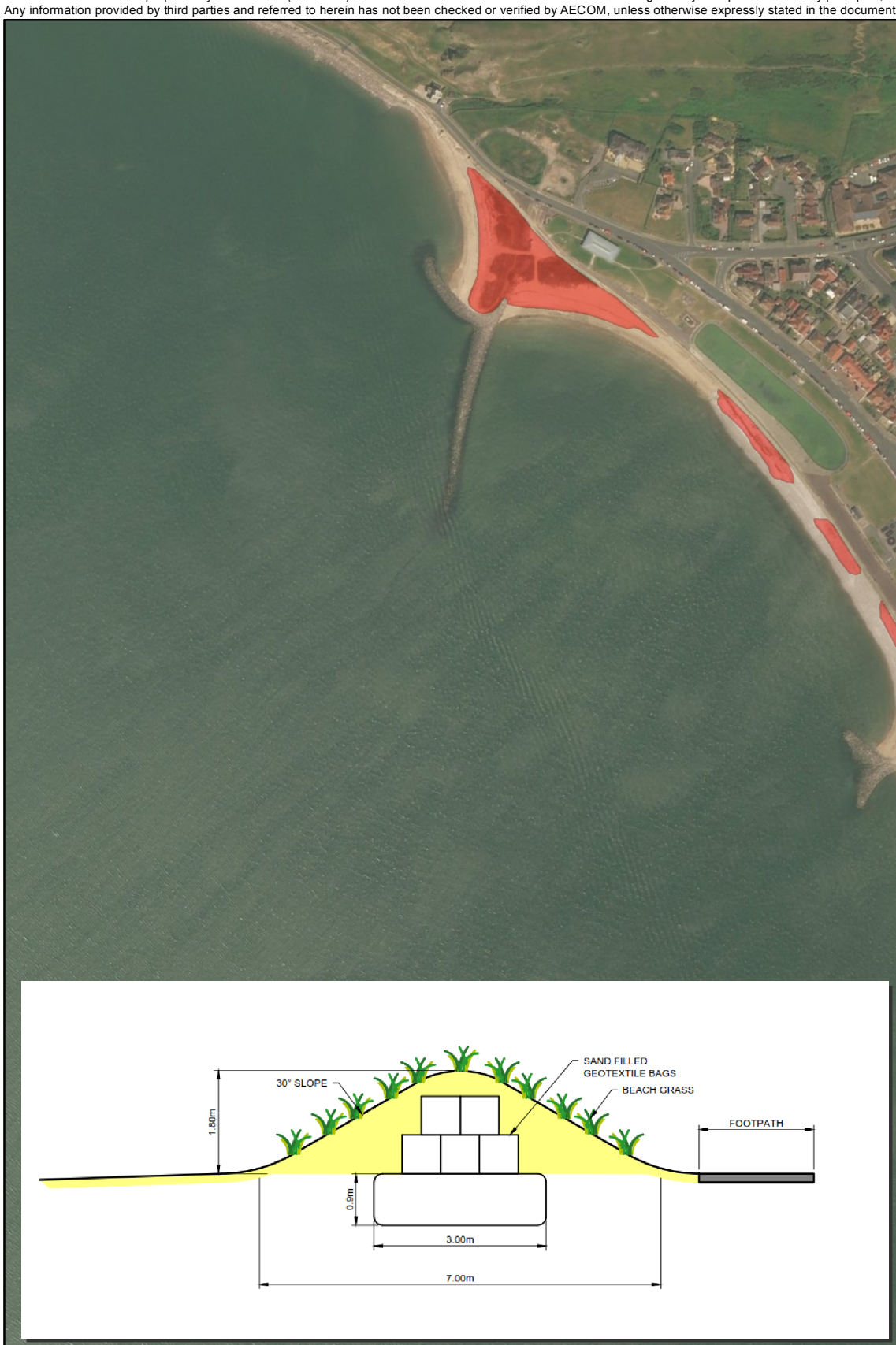

N

LEGEND

Dune Regeneration

0 100 200 Metres

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 2. DUNE REGENERATION

AECOM
Sunley House
4 Bedford Park
Croydon
CR0 2AP
Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

Drawn:	BM	Chk'd:	DC
App'd:	RR	Date:	10/11/2016
Scale at A3:	1:5,000		

Client: CLIENT

Project: PROJECT

Title: WEST BEACH: OPTION 3. CONSTRUCTION OF PATH WALL & PERIODIC BEACH MAINTENANCE

AECOM
Sunley House
4 Bedford Park
Croydon
CR0 2AP
Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

Drawn:	BM	Chk'd:	DC
App'd:	XX	Date:	10/11/2016
Scale at A3:	1:5,000		

Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 4. ROCK COVER LAYER

AECOM
Sunley House
4 Bedford Park
Croydon
CR0 2AP
Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

Drawn:	BM	Chk'd:	DC
App'd:	RR	Date:	10/11/2016
Scale at A3:	1:5,000		

Typical Sand Trap

Source: http://www.standard.net.au/story/2999114/port-fairy-east-beach-erosion-control-hailed-a-success/

LEGEND

- Sand Traps

0 100 200 Metres

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 5. SAND TRAPS

AECOM
Sunley House
4 Bedford Park
Croydon
CR0 2AP
Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

Drawn:	BM	Chk'd:	DC
App'd:	RR	Date:	10/11/2016
Scale at A3:	1:5,000		

Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 6. BREAKWATER REMOVAL

AECOM
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Croydon
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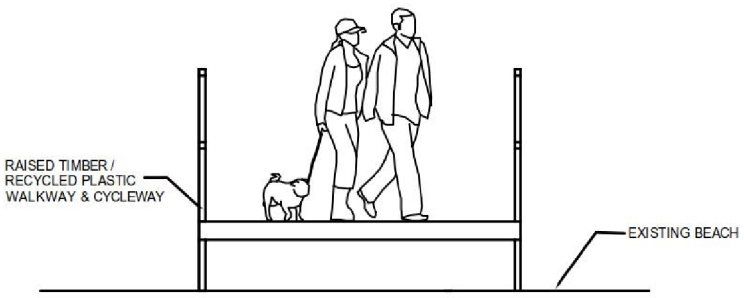
Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

Drawn: NC	Chk'd:
App'd:	Date:
Scale at A3: 1:5,000	

N

EXAMPLE CROSS SECTION THROUGH RAISED WALKWAY



LEGEND

Raised Pathway

0 95 190 Metres

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 7. RAISED WALKWAY

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Croydon
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Drawn: NC | Chk'd:
App'd: | Date:
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Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 8. EXISTING WALL REPAIRS / RAISING

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Croydon
CR0 2AP
Tel: +44 (0)20 8639 3500
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www.aecom.com

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App'd: | Date:
Scale at A3: 1:6,389

Client: CONWY COUNTY BOROUGH COUNCIL

Project: LLANDUDNO BMP AND CTFRA UPDATE

Title: WEST BEACH: OPTION 9

AECOM
Sunley House
4 Bedford Park
Croydon
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Tel: +44 (0)20 8639 3500
Fax: +44 (0)20 8639 3599
www.aecom.com

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Appendix B Site Photos

North Shore

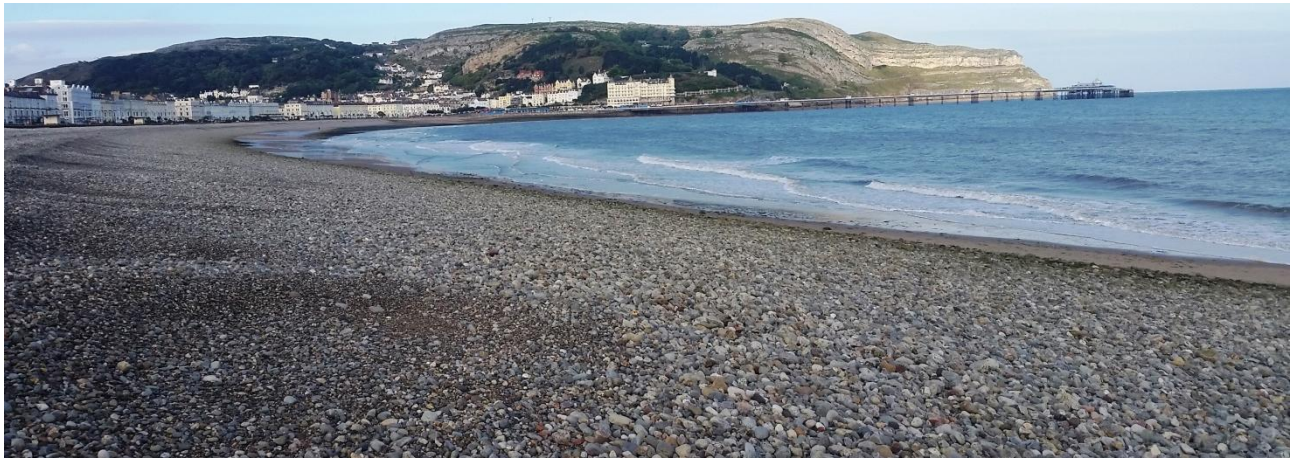

Photo 1 View looking west towards Llandudno and the Great Orme Headland and Llandudno Pier.

Photo 2 View looking east towards the Little Orme Headland with the raised cobble/shingle berm pushed up to the Llandudno promenade on the right hand side.

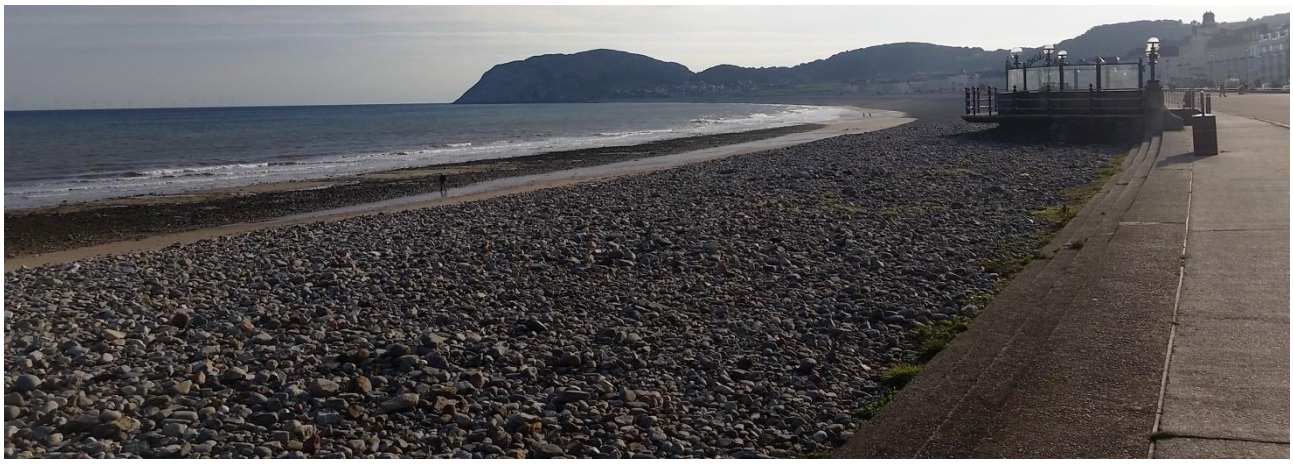

Photo 3 View looking east towards the Little Orme Headland with the Craig-y-Don paddling pool and concrete stepped revetment up to the Llandudno promenade on the right hand side.

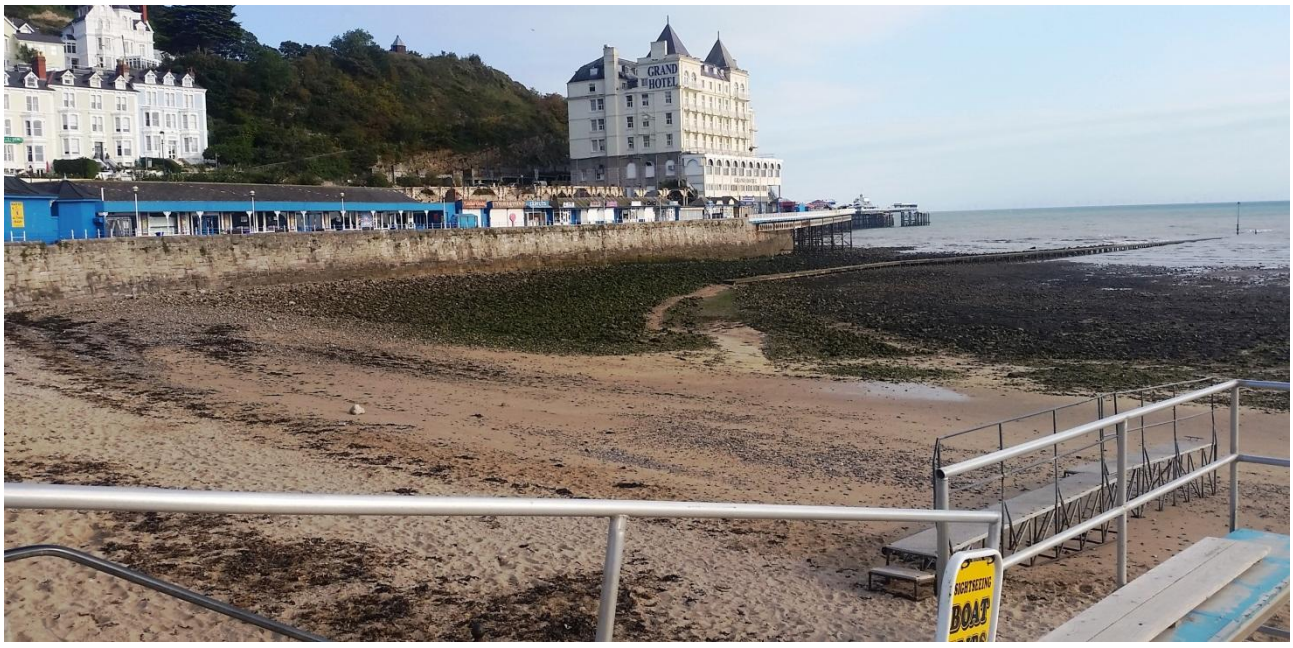

Photo 4 View west across ‘Children’s Corner’ from boat trip landing stage with stone sea wall, traditional groyne and Llandudno Pier in the background.

Photo 5 Timber slip way with little evidence of any interruption of drift sediment transport.

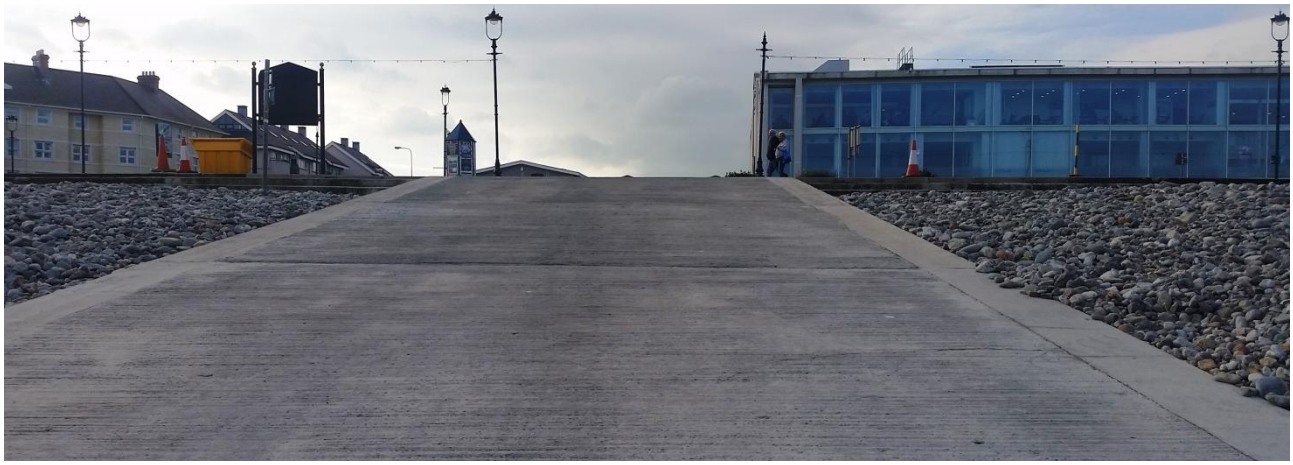

Photo 5 Existing concrete slip way.

West Shore

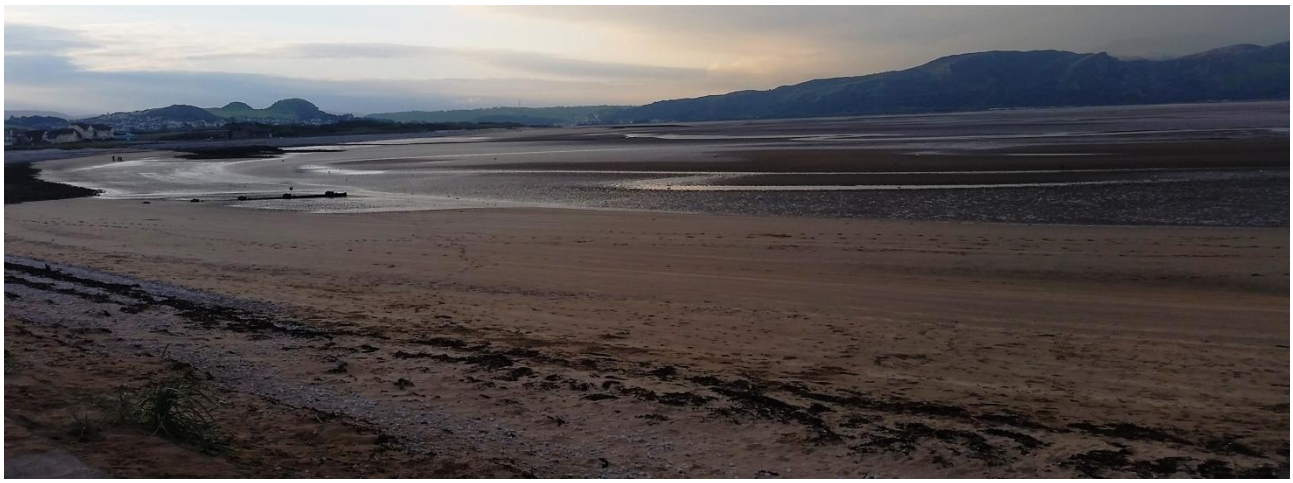

Photo 6 View southeast across West Shore at low tide showing the upper remnants of the West Shore Storm Water Outfall, existing fishtail breakwaters and the Conwy Estuary in the middle back ground.

Photo 7 Close up view of a rock groyne showing colonisation of the intertidal zone by algae.

Photo 8 View looking northwest across coastal footpath, remnant degraded sand dunes and upper shingle beach towards fishtail groyne and with the Great Orme Headland (SAC) on the right hand side.

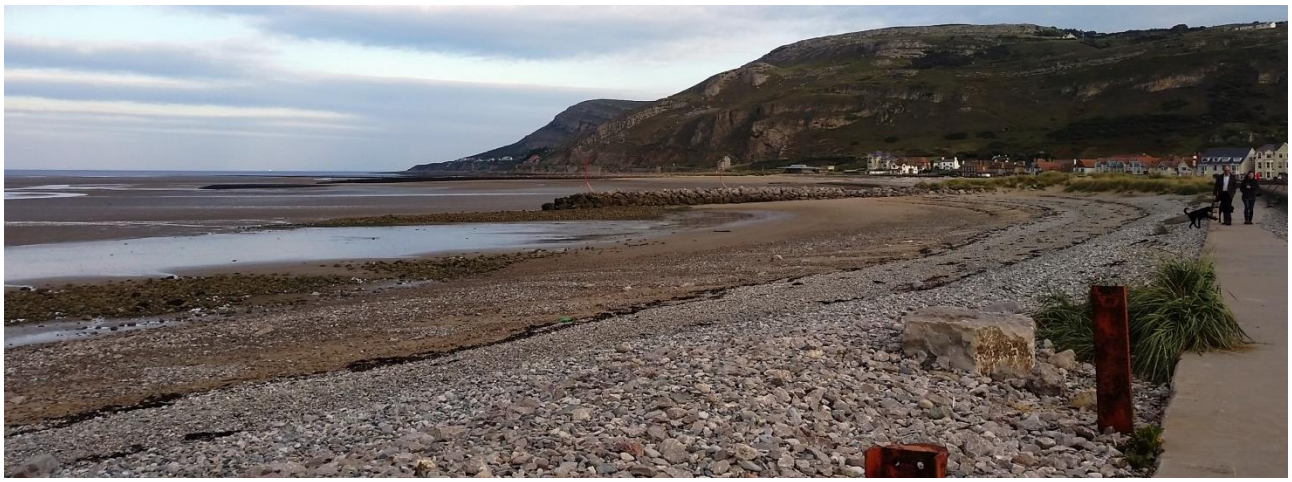

Photo 9 View looking northwest towards the Great Orme Headland (SAC) across concrete revetment and upper shingle/cobble beach.

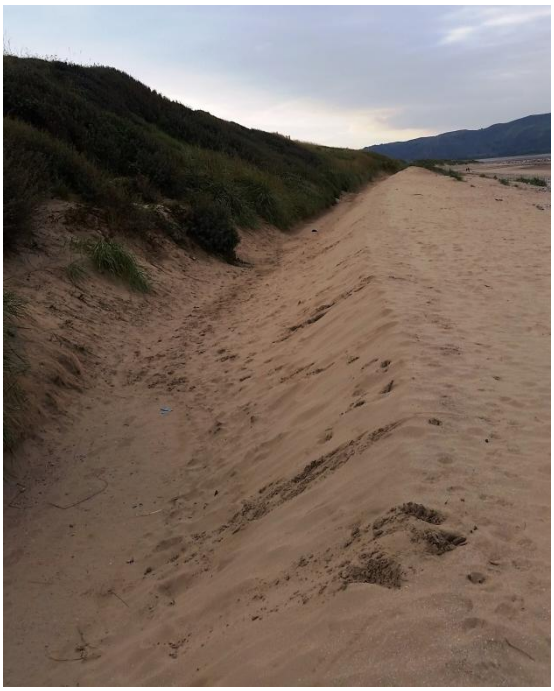

Photo 10 Build-up of fine sand on the seaward side of existing sand dunes toward the southern extent of the West Shore frontage.

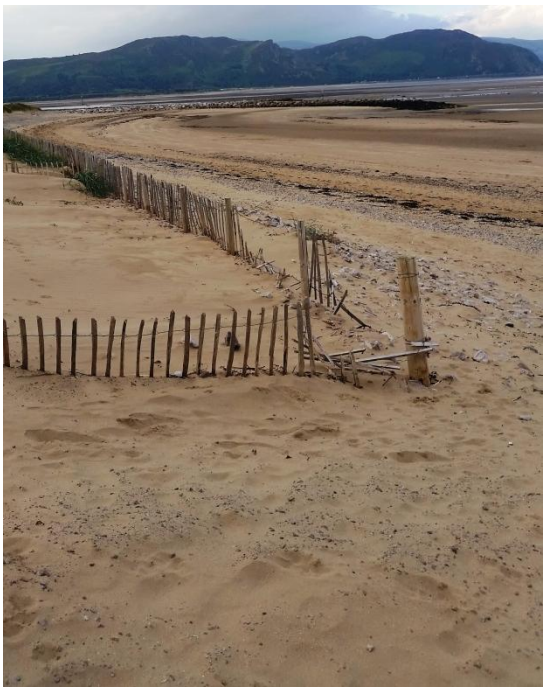

Photo 11 Existing and degraded sand traps in the southern half of the West Shore frontage.

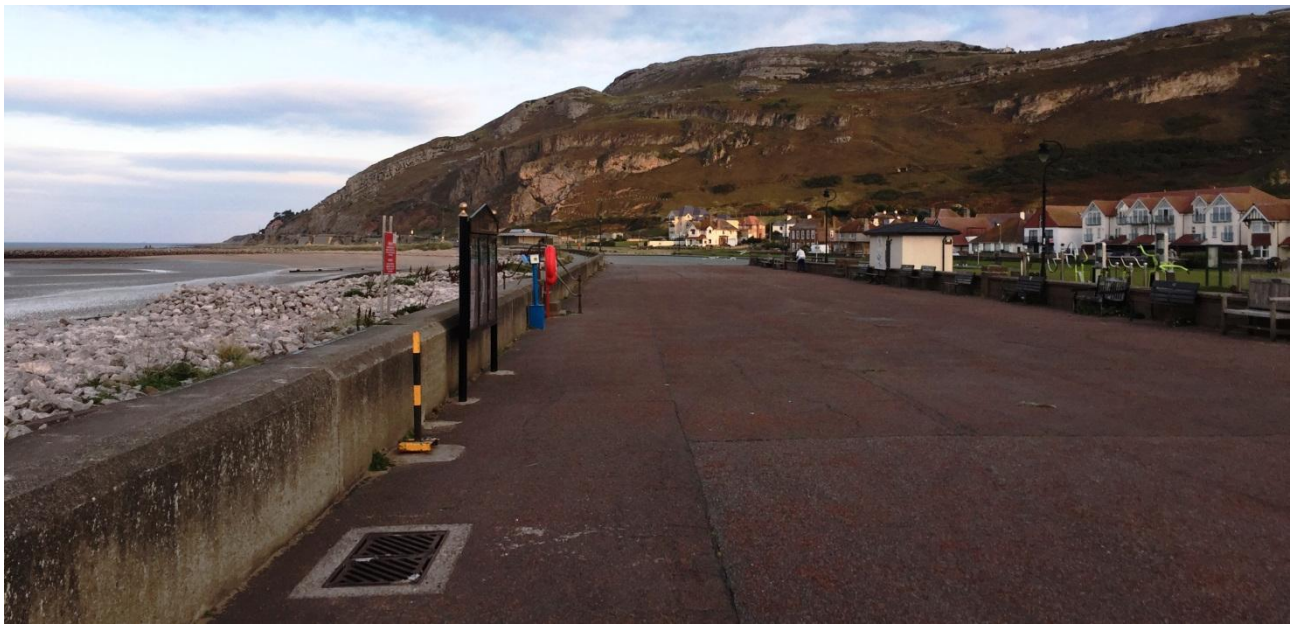

Photo 12 Existing flood wall (with excess sand on the landward side in places), promenade, recreational open space with outdoor exercise equipment and sea fronting residential properties.

Photos 13 Amenity pond adjacent to promenade and sea view residential properties.

Appendix C Socio-economic uses along North Shore

LAND USES

- 8th Nov 2016

- HOTEL / B&B
- RESTAURANT / PUB
- RESIDENTIAL
- LEISURE / CONFERENCE CENTRE
- RETAIL / COMMERCIAL
- CHURCH

Quality information

Prepared by	Checked by	Approved by
Owen Tucker, BSc (Hon) MSc CEnv MCIWEM Principal Environmental Scientist - Environment and Planning	Kathryn Thorp, BSc MSc DIC Regional Director – Environment, Environment and Planning	Alan Forster Principal Coastal Specialist, Infrastructure and Environment

Revision History

Revision	Revision date	Details	Authorized	Name	Position
First Draft	08.03.2017	-			

Distribution List

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Prepared by AECOM, AECOM House, 179 Moss Lane, Altrincham, WA15 8FH, UK (www.aecom.com)
Project Number: **60525387**

Appendix B. Coastal development history and processes appraisal

Llandudno Beach Management Plan

Natural Processes and Shoreline Baseline

Conwy County Borough Council

Project Number: 60525387

February 2017

Quality information

Prepared by	Checked by	Approved by
Alan Williams Principal Coastal Specialist		

Revision History

Revision	Revision date	Details	Authorized	Name	Position
1	19/06/17			Alan Williams	Principal Coastal Specialist

Distribution List

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Owen Conry

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T: (0151) 558 1956

Table of Contents

Table of Figures

List of Tables

1. Introduction

AECOM have been commissioned by Conwy County Borough Council to produce an options evaluation report for preparation of a beach management plan for the North and West Shore frontages at Llandudno.

The basis for producing an appropriate strategy for future coastal management is an understanding of coastal and geomorphological processes, how they are likely to change and what impact this will have on the shoreline in the future.

In order to achieve this, the following document provides information on the geomorphology, historical development of the shoreline, behaviour of coastal processes and condition of current coastal defence arrangements applying across the two frontages.

2. Summary of Current Data and Knowledge

2.1 Geomorphological Overview

2.1.1 Local Geology

The geology of the Llandudno area is dominated by the two Dyserth limestone group outcrops of the carboniferous period, at the extremities of the North Shore frontage - the Little Orme at the eastern end and the Great Orme at the western end. In between the underlying geology comprises sedimentary rocks, primarily mudstones of the Silurian and Cambrian Periods (formed 416 to 542 million years ago) or siltstone of Ordovician Period (451 to 479 million years ago). The mudstones were formed in deep seas from infrequent slurries of shallow water sediments which were then re-deposited as graded beds. Conversely the siltstones were formed in shallow seas with mainly siliciclastic sediments (comprising of fragments or clasts of silicate minerals) and deposited as mud, silt, sand and gravel[1].

The solid geology of the area is shown on figure 2.1(a).

Superficial or drift deposits comprise primarily blown sand deposits or tidal flat deposits of clay, silt and sand formed up to 2-3 million years ago in the Quaternary period in a local environment previously dominated by shorelines[1].

The built up area of Llandudno is primarily built on sand deposits and marshland.

The drift geology across the Llandudno area is shown on figure 2.1(b)

2.1.2 Geomorphological Evolution of the Llandudno area

The present day geomorphological features of the shoreline across the Llandudno area have been shaped by events that have occurred over the past 2-3 million years, however it is occurrences over the past ten thousand years (the Pleistocene era), and more recently in the past two hundred years that have largely influenced current behaviour.

Before the last ice age it is believed that the present Conwy estuary, on the west side of the Great Orme, was blocked by a low volcanic ridge linking Conwy Mountain on the west side of the town of Conwy and the Vadre, a rock outcrop above Deganwy. The course of the River Conwy at this time is thought to have followed the route of the present Afon Ganol valley from the RSPB nature reserve in the Conwy via Dolwyd, Bron-y-Nant and across the golf course to Penrhyn Bay, where it flowed into the sea, albeit some distance further seaward than at present.

During the last glacial period, two main ice sheets affected the Conwy region - the Irish Sea ice sheet moving from the north, and the North Wales ice sheet moving from the south. During a period of ice sheet retreat, it is believed that the meltwater from both glaciers caused a breach in the low volcanic ridge establishing the course of the river that is evident today[2].

[1] BGS, 2017. Geology of Britain Viewer (http://mapapps.bgs.ac.uk/geologyofbritain/home.html)
[2] TH Technology, 1990. Conwy Estuary Feasibility Study of Tidal Power. Report for the Department of Energy

The coastlines of both bays have been modified following the last ice age with the interaction of glacial erosion, rising sea levels and underlying geology resulting in a coastline characterised by rocky shores interspersed with sandy bays[3].

Present day natural upper beach geomorphology is similar along both shores, as can be seen by reference to Figure 2.1 (b)[1], which shows a fringe of present day or older storm gravel beach deposits along the upper parts of each shoreline.

The 1956 Council Engineer's Report[4] identified that "the beach consists of a steep shingle bank extending about 100 feet (30 metres) seaward beyond which stretches a gently sloping beach".

The natural gravel material forming the upper beaches is largely a product of erosion of the shoreline and the remnants of nearshore deposits of glacial material left by the ice sheets. Lower down the beach, generally below mid tide level, beach deposits comprise fine to medium sands. The sand deposits on the lower foreshore are underlain by boulder clay[5].

Prior to the diversion of the River Conwy, the North Shore would have been fed with material that was transported seaward by the river and then longshore by wave action. Over time during the post glacial period, with the course of the river changing this source ceased and the shoreline stopped receiving any fresh sediment inputs. The headlands being rock erode only slowly and provide little material to the beaches. This resulted in the shoreline within the bay recessing to form a pocket beach between the two headlands, controlled naturally by the juxtaposition of the headlands, the tide and wave regime and the nature of the shoreline material.

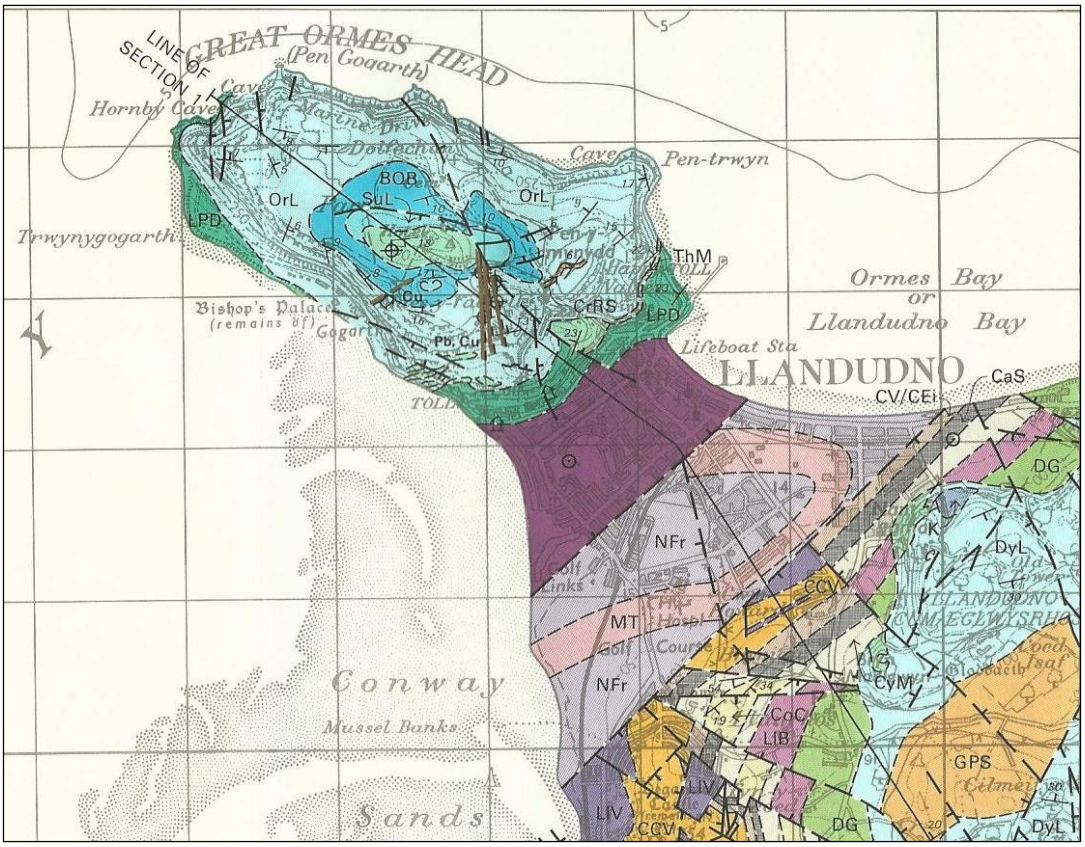
Prior to the development of Llandudno from the mid 1800s onwards, these deposits formed a natural ridge that separated the land from the sea. With the construction of artificial coastal defences along both frontages during the 20th century, as described in section 2.2 below, the natural interaction between the shoreline and the sea was interrupted and the location of the shoreline was fixed. The upper beaches became strongly influenced by linear artificial coastal structures which alter the shoreline hydraulic regime and disrupted the natural processes of erosion, transport and deposition.

In 1991, in association with the construction of three rock fishtail groynes a mixture of quarried limestone cobble, shingle and sand were introduced to the upper beach at West Shore between Gogarth at the north end and Cerrig Duon.

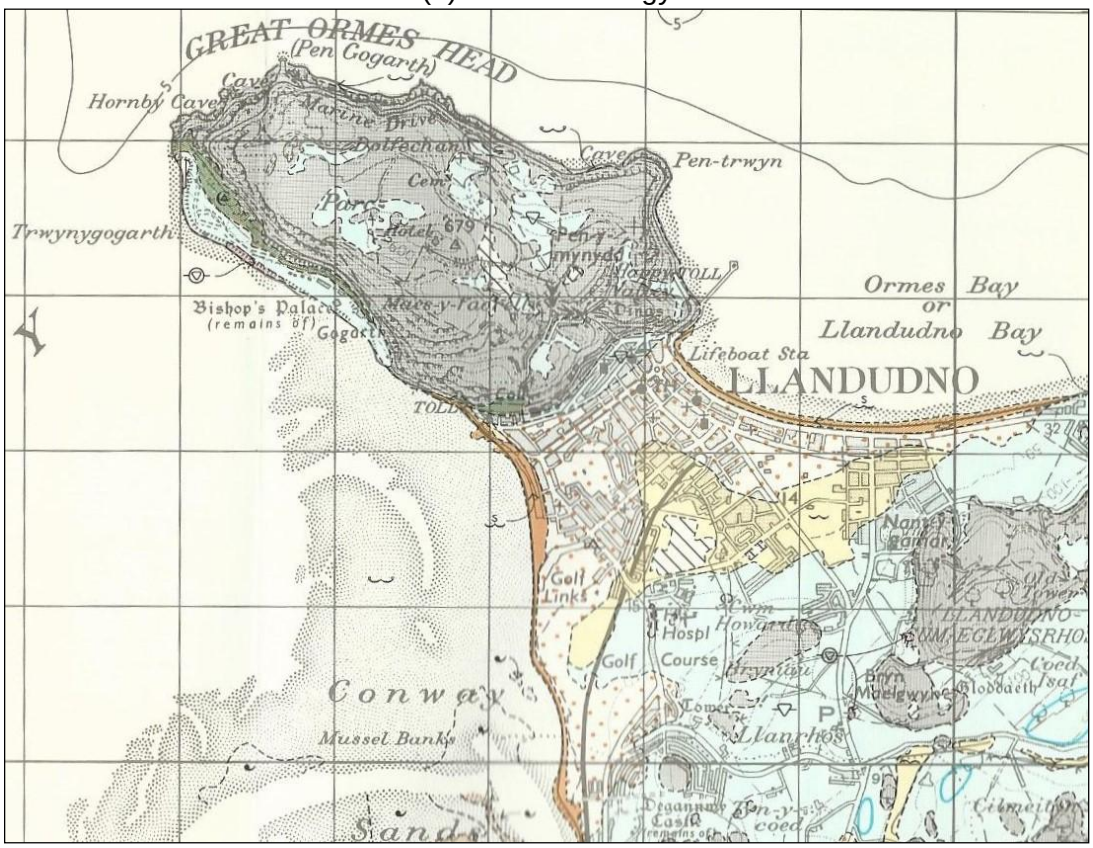
In 1996 on the North Shore, approximately 40,000m^3 of natural gravel cobbles were placed along the upper beach between the amenity boating pool at Craig-Y-Don and the then timber slipway at Vaughan St. At the same time a temporary rock groyne was constructed just to the east of the timber slipway to control easterly movement of the cobble and a low level crib groyne was constructed at the east end of the amenity pool. In 2000, the temporary rock groyne was removed, the lifeboat slipway at Trevor St was widened and extended and a further 12,000m^3 of cobble material was placed between Vaughan St and Trevor St.

[3] Conwy County BC, 2001. Ynys Enlli to Great Orme Shoreline Management Plan.
[4] Llandudno Urban DC, September 1956. Coast Protection Works, North Shore, Llandudno – Engineer's Report.
[5] LRDC International Ltd, 1986. Aberconwy Breakwater Design Study – Report on Preliminary Foreshore Site Investigation and Surveys.

Following the winter storms of 2013-14 a further 30,000m^3 of natural gravel cobbles were placed along the upper beach between the amenity boating pool at Craig-Y-Don and the slipway at Trevor St to replace material that



(a) – Solid Geology



(b) – Drift Geology

Figure 2.1 – Solid and Drift Geology (reproduced from BGS Sheet 94 – Llandudno)

2.2 Historical Development & Current Conditions

2.2.1 North Shore

The natural shoreline form applying across Llandudno Bay, or North Shore as it is more usually known, is an upper shingle bank which merges into a lower sand foreshore. As on the West Shore material forming the upper beaches is largely a product of erosion of the shoreline and the remnants of nearshore deposits of glacial material left by the ice sheets. This supply of sediment from the shoreline has been reduced and almost halted as a result of the construction of artificial coastal defence structures, with the upper beaches now strongly influenced by these coastal structures which alter the shoreline hydraulic regime and disrupt the natural processes of erosion, transport and deposition.

The changes from a natural undefended shoreline system to a defended one are linked to the development of the town as a seaside resort rather than a port. In the mid 19th century Llandudno was vying with Holyhead and Porthdinllaen to be the port for trading with Ireland. A storm on the 25th October 1859 destroyed the original pier, which had only been completed a year earlier and with it plans to rival the other two locations as the port for North Wales. The development of the town was closely linked to the completion of the North Wales coastal railway, which reached the town in 18??.

In 1875 a new pier was constructed, which was extended to join the newly constructed Pavilion in the mid 1880s. At this time a vertical Pier wall was constructed, from the Pavilion to Gloddaeth Avenue, which is still in service today.

The earliest artificial defences to protect the shoreline from erosion were constructed at the end of the 19th century/beginning of the 20th century. The Llandudno surveyor at the time noted in 1893 that beach material was being lost and, anticipating that this would threaten the town, decided that artificial protection would be required. As a result a set of concrete steps were constructed from South Parade, west of Trevor St, to Carmen Sylva Rd. The works were constructed between 1894 and 1906 but their shape and form were such that levels reduced further and three areas had to be extended seaward during the period.

The profile of the defences was not conducive to holding the beach and whilst the defences fixed the shoreline position they did not prevent and indeed contributed to further loss of the beach.

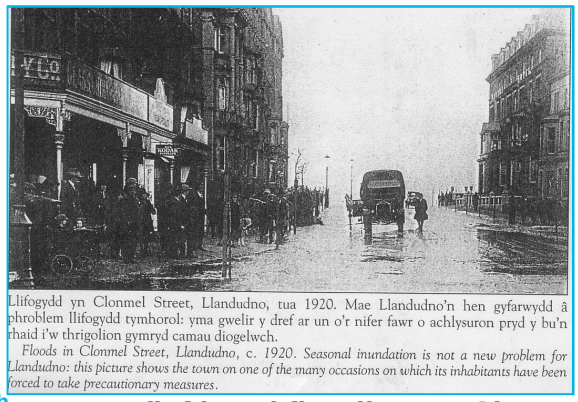
In Autumn 1927 high tides and onshore winds in October caused flooding of Nant y Gamar Road and Queens Road together with houses in Victoria Street and Pleasant Street at Craig-y-Don. A month later a further storm overtopped the defences causing flooding of Llandudno to Mostyn Street (see below right), estimated at 4 feet (1.22 metres). During this time underground toilets at North Western Gardens were submerged, trapping people inside[6].

There is also anecdotal evidence that on one of these occasions overtopping waters from both West Shore and North Shore flooded inland along Gloddaeth Avenue, meeting in the middle.

Following a further storm in February 1937, which destroyed sections of the original steps, a new stepped revetment was constructed St Georges's Crescent and Craig-

[6] HR Wallingford, May 2004. Conwy Tidal Flood Risk Assessment, Stage 1 Report. Report EX4667;

Y-Don, together with nine timber groynes between the bandstand west of Vaughan St and Gwynedd Road. Following further storm damage in the 1950s, the new stepped revetment was extended westwards to the junction with the vertical pier wall and a further four groynes were added to the west of those originally installed[7]. By the mid 1980s the groyne field was in poor condition probably due to a combination of abrasion of the timber by the foreshores sediments and lack of maintenance.



Llifogydd yn Clonmel Street, Llandudno, tua 1920. Mae Llandudno'n hen gyfarwydd â phroblem llifogydd tymhorol: yma gwelir y dref ar un o'r nifer fawr o achlysuron pryd y bu'n rhaid i'w thrigolion gymryd camau diogelwch.

Floods in Clonmel Street, Llandudno, c. 1920. Seasonal inundation is not a new problem for Llandudno: this picture shows the town on one of the many occasions on which its inhabitants have been forced to take precautionary measures.

Figure 2.2 – Original Defences early 20th century (left) and flooding on Clonmel St in 1920s

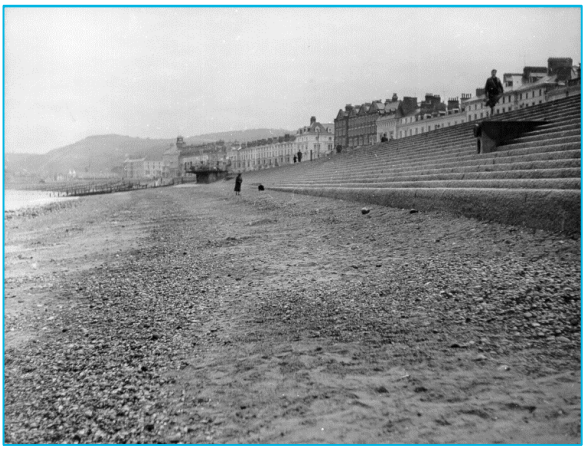


Figure 2.3 – Mid 20th century defences – Original steps repaired following 1937 storm at west end of frontage (left) and new stepped revetment to east with new groynes in background (right)

[7] Llandudno Urban DC, September 1956. Coast Protection Works, North Shore, Llandudno – Engineer's Report.

Figure 2.4 – Stepped Revetment, Beach and Groynes 1987 (left) and 1995 (right)

The natural upper beach at North Shore is not sand but coarser material. Any sand that finds its way onto the beaches is as result of material brought into the bay from offshore by tide and wave action. Accordingly sand only exists at lower levels where the beach slackens in gradient.

The beach has been showing a trend of erosion since the first development and the covering up of the natural shingle bank with construction of the artificial defences, whilst providing a coastal defence function that was necessary for the town, restricting the interaction of coastal processes and the natural shoreline features and exacerbated the erosion trend.

In the 1990s following extensive studies, numerical and physical modelling, public consultation and second opinions from eminent consulting engineers, a new approach to coastal defence was adopted across the Llandudno Promenade and Craig-y-Don frontages with the importation of gravel cobble (D_{50}= 80-125mm) to recharge the beach levels in front of the defences, as well as carrying out repair works to the existing defences, reconstruction of the promenade (which was in poor condition) and provision of a new secondary flood wall at the rear of the promenade between Clarence Rd and the Craig-y-Don pool and increasing the elevation of the existing dwarf wall over the remainder of the frontage. This work was carried out in two phases – Craig-Y-Don Boating pool to Vaughan St in 1996-97 and between Vaughan St and Trevor St in 1999/2000. The second phase also included widening and extending the lifeboat slipway.

The section of frontage between the Trevor St slipway and the Pier wall, aka “Children’s corner” was not modified as part of the arrangements undertaken in 1996-2000. Wind blown sand retrieved from the West Shore has been intermittently tipped on the lower beach in the intervening period. In addition cobble and shingle material that has been moved westerly across the slipway has been separated out from the sand and recycled to areas east of the slipway. Generally across this area although cyclical change has taken place, overall conditions are not markedly different than 60-70 years ago (ref Figure 2.5).

Figure 2.5 – Children's Corner – Mid 20th century (top Left); 1987 (top right); 2003 (bottom left) and 2012 (bottom right)

Present day intertidal geomorphology typically comprises a mixture of the original natural shingle, generally to the east of the Craig-y-Don boating pool, and a mixture of the natural shingle and the imported cobble deposits further to the west on higher beach sections, with consequent steep beach gradients, and lower sand beaches of flatter gradients.

A cross shore concrete crib groyne constructed at the eastern end of the Craig-Y-don boating pool frontage during the 1996/97 scheme, provides a degree of control on the movement of the upper beach material across the frontage, although some by-passing of material can occur.

Re-cycling of material and re-profiling of the beach along the Llandudno Promenade and Craig-Y-Don frontages has been carried out , typically on an annual basis, from 2000-2013 with the beach being generally re-profiled prior to the summer season. Local replenishment exercises of a few thousand tonnes at a time were carried out during that period.

Past flood events have occurred due to low beach levels allowing high energy waves to reach the promenade and overtop the defences. The lack of beach protection to the defences has also caused significant damage most notably in 1937 and 1990. Since the completion of the 1996/2000 coast protection works the defences have been protected from significant damage and wave energy is decreased by the shingle bank. Storm events in 2005, 2010 and over the winter of 2013-14 caused flooding of the promenade and the movement of shingle and cobble onto the promenade. Wave energy is therefore converted into movement of the shingle

allowing any residual overtopping of the shingle bank to be contained by the secondary defences at the rear of the promenade. In spite of this the December 2013 storm was close to overtopping the secondary sea wall, particularly near the paddling pool due to the west / northwest wind direction.

Following on from the winter 2013-14 storms, approximately 30,000m^3 of new beach cobble was imported to replace material that had been lost since the scheme was implemented.

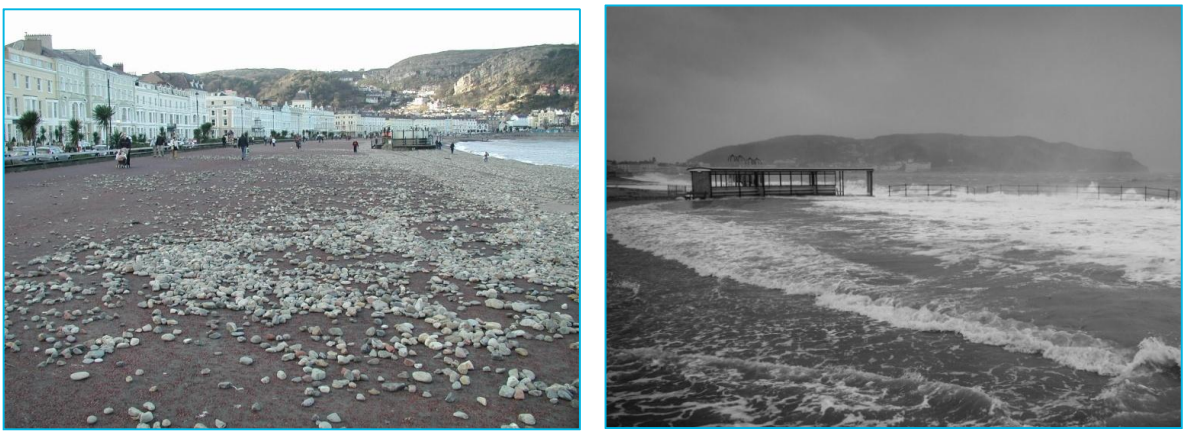


Figure 2.6 – Storm Impacts – March 2005 (left) and December 2013 (right)

2.2.2 West Shore

Up to the 1980s contemporary foreshore conditions applying along the coast between Deganwy and West Shore, generally comprised, across the upper intertidal zone, a thin veneer of superficial deposits of sand, gravel, cobbles and boulders overlying variable boulder clay[8], which were the remnants of nearshore deposits of glacial material left by the retreat of the ice sheets during the last glacial period.

In places where the smaller deposits were winnowed out larger boulder beds remain and the boulder clay was exposed, such as at Cerrig Duon, before the breakwater was constructed. These deposits are thought to be the remains of extensive moraine deposits, which may have choked the present mouth of the Conwy valley before the river broke through[9].

The main channel of the River Conwy turns westward after it passes the Deganwy Narrows with the majority of the shoreline on the east bank up to the Great Orme fronted by the wide expanse of the Conwy Sands. Historic plans confirm that this has been the case over the past 200 years although there always appear to have been potential swatches or minor channels acting as conduits for tidal waters across the sands.

The natural backshore conditions applying across the frontage is a belt of sand dunes that used to stretch from the Great Orme to Deganwy. Historically these dunes developed and have been subsequently fed by sand blowing across the wide expanse of Conwy Bay.

[8] LRDC International Ltd, 1986. Aberconwy Breakwater Design Study – Report on Preliminary Foreshore Site Investigation and Surveys.
[9] British Maritime Technology, 1987. Aberconwy Coastal Study, Part IV.

On the Great Orme the intertidal zone width decreases to northwards with the foreshore becoming coarser of cobble and boulder composition.

The first intervention works at West Shore, Llandudno took place in 1905 before any notable development existed. These works were relatively minor in nature and were breached on many occasions in the late 1920's and 1930's requiring major remedial works in 1936 (below left). Specifically in October 1927 high tides and winds caused damage and flooding of the hinterland with driftwood and seaweed found as far inland as Maelgwyn Road. In the 1950's a stepped concrete revetment with wave return wall and steel sheet piled toe was constructed (below right), however in the following decades beach levels fell, exposure conditions worsened and the loadings on the structure and risk of overtopping increased.

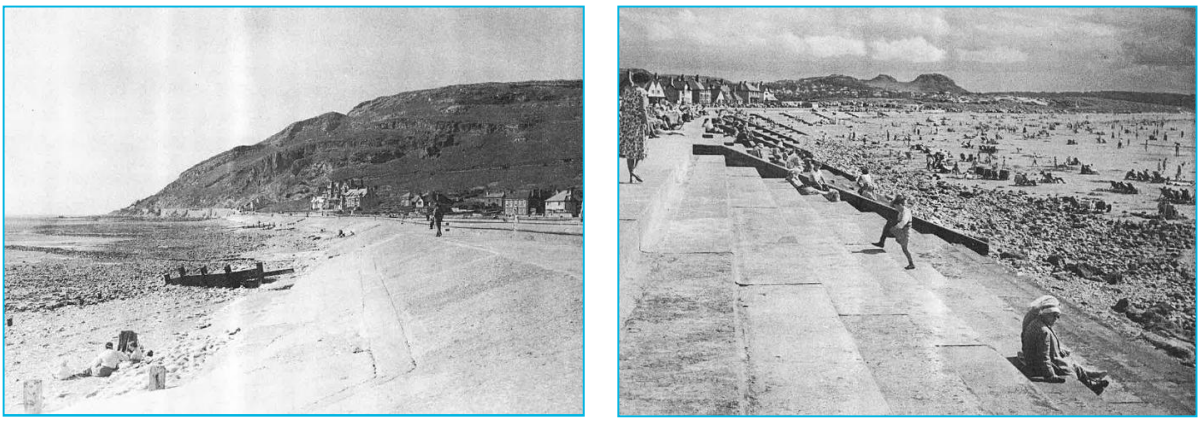


Figure 2.7 – Historical Coastal Defences at West Shore (pre 1950 – left, 1960's right)

By the 1980s however beach levels had fallen and the increasing exposure conditions were damaging the structural integrity of the defences. In 1991/92 three cross-shore, shore connected rock "fishtail" groynes were constructed at Cerrig Duon, opposite Lloyd St and at Gogarth and the upper beach was reinforced with a variety of graded materials, as follows:

- On the north side of the Gogarth breakwater: Quarried limestone shingle;
- Between the Gogarth and Lloyd St breakwaters: A mixture of sand, quarried limestone shingle and quarried limestone cobble. Coarser material in the centre of the frontage becoming gradually finer closer to the breakwaters;
- On the south side of the Lloyd St breakwater up to the southerly limit of the sea wall: Washed gravel shingle;
- West Shore Shingle Bank, between the end of the sea wall and the start of the golf club dune frontage: No recharge. The shingle here is the remains of the natural shingle ridge that exists along the frontage.
- In front of the North Wales Golf Club Dunes: A mixture of sand, quarried limestone shingle and quarried limestone cobble. Coarser material at the northern end of the section becoming gradually finer towards the Cerrig Duon groyne;

As a result of summer floods in June 1993, the sand beach on the south side of the Gogarth breakwater was washed away by pumping of flood waters from the hinterland, and was replaced in 1994 with marine dredged aggregate from Liverpool Bay.

The breakwaters and recharge have been successful in reducing exposure conditions along the shoreline but have produced a perceived unwanted side effect of increasing wind blown sand from the upper beach across the immediate hinterland, which became a nuisance to property owners. This has produced localised dune features at the root of the Lloyd St and Gogarth breakwaters.

Figure 2.8 – Development of dune features at West Shore (top – Lloyd St Groyne; bottom – Gogarth groyne)

In 2006, as part of the West Shore to Deganwy cycle path works, the southern most section of the dunes frontage was reinforced with additional imported quarried cobble and section of rock revetment was built immediately to the south of Cerrig Duon. The upper beach was reinforced with additional imported quarried cobble along the North Wales Golf club dune section, north of the Cerrig Duon breakwater, and an unbound cycle track was constructed along the crest of the beach across this section and across the section of natural shingle bank. Despite erection of fencing, on-going clearance of wind blown sand and maintenance of the track surface, the section in front of the dunes has been overwhelmed by wind blown sand.

Figure 2.9 – Cycle path on upper beach in front of NWGC dunes (Left – 2009; Right – 2016)

2.3 Coastal Processes

The evolution and development of a shoreline is linked to the interaction between the natural processes applying offshore and, more significantly, inshore and the geological/geomorphological form and profile of natural shoreline features and the form/profile of artificial coastal defence structures.

Natural processes may be split into two categories. Those that cause change in shoreline features and those that constitute the changes that are taking place.

Causation processes are the actions of wind, waves, tides, currents, freshwater flows, etc.

Reaction processes are those effects that occur as a result of the causation processes – sediment movement, foreshore profile and bank/channel changes, erosion, accretion etc.

2.3.1 Wind

Wind is the fundamental providing force for locally generated sea waves and for the aeolian transport of fine sediments (wind blown sand). Changes in wind patterns within Liverpool Bay affect the overall wave climate generated and therefore how waves will ultimately impact the shoreline.

The following key data relate to the wind climate in Liverpool Bay[10]:

- The predominant wind direction is from the West, with approximately 70% of wind occurring from the SE to NW sectors [135-315 Whole Circle Bearing (WCB)];
- The most frequent wind strength is 5-10 m/s;
- The most extreme wind conditions (wind speed greater than 20 ms^{-1}) are most frequent from the West. These high winds occur for some 0.75% of the time, typically about 65hrs/year.

Whilst consideration of long term data sets provides a good indication of long term averages and general conditions applying, consideration of shorter term data sets can show major differences, which potentially could have significant effects at the shoreline.

2.3.2 Waves

Waves in Liverpool Bay are generally locally wind generated or as a result of longer period swell waves that have propagated into the Irish Sea from the Atlantic Ocean via the St Georges Channel and Cardigan Bay to the south or the north channel between Scotland and Northern Ireland, to the north.

Direct exposure conditions on the North and West Shores at Llandudno are different and heavily influenced by adjacent, nearby and remote land masses.

At the western end of the North Shore frontage, the Great Orme provides shelter from directions west of north with direct exposure limited to directions between north and ENE (0-065° WCB) and fetches of between 50 and 150km). Moving easterly, the shoreline gradually moves out of the shelter of the Great Orme such that at the

[10] Coastal Engineering UK Ltd, July 2006. Conwy Local Monitoring Report 1997-2005.

Craig-Y-Don pool the sector of exposure is wider (NW to ENE, 315-065° WCB), although fetch distances remain the same. Also over much of the sector between NW and N fetches are limited to about 100km by the Isle of Man.

Across the West Shore the southern flank of the Great Orme provides shelter from wave directions north of NW whilst Anglesey does the same from directions south of WNW, limiting fetches to < 30 kilometres. Accordingly there is only a small window of exposure (WNW to NW) exposed to waves generated by winds blowing across fetches of up to 160km.

Waves entering Conwy Bay are constrained by the Ynys Mon, Penmon Peninsula and by the shelter afforded by the Great Orme. As such the net wave energy around the shoreline typically tends to spread in from the northwest, over the southern section, to more westerly in the shelter of the Great Orme in the north[11].

There are currently no specific measured or modelled wave climates directly relevant to either of the sites. Offshore wave conditions in Liverpool Bay that have historically been used in the recent past to derive wave climates at the shoreline were based on work carried out following the "Towyn" event in February 1990. This work which was commissioned to investigate the simultaneous occurrence of waves and water levels utilised a numerically modelled hindcast wave climate, from wind data collected at Blackpool Airport (Squire's Gate), which was calibrated against approximately 15 months data from an offshore wave rider buoy, situated approximately 10km north of Rhyl[12].

The Met Office European Waters (MOEW) wave model archive (1988-2006) provides modelled wave climates on a regular 0.25° lat/long (approx 30 km) grid. However its results in Liverpool Bay need to be treated with caution as the coarseness of the grid means that features such as Anglesey and the Isle of Man are not represented within the model and accordingly wave heights from these directions are likely to be overestimated.

A more recent update of the MOEW model – Wave watch 3 (2008 →) provides improved predictions but such data is not currently available for this project.

As waves approach the shoreline they will be modified by a number of processes, e.g. refraction, shoaling, friction, diffraction, due to the changing bathymetry and generally decreasing water depths.

Of particular relevance in this respect are the following:

- Constable Bank - An offshore sand and gravel bank, approximately 15km in length, 1-4km in width and located 6km offshore of the North Wales coast (see Figure 2.10). The level of the bank is typically -10 to -16m ODN. Constable Bank currently acts to protect the North Wales coast from the predominant storm and normal waves by shoaling, diffraction and refraction and is likely to reduce the incoming wave heights in the area between Great Orme and Prestatyn[13]. The bank provides some shelter to the North Shore frontage from waves from directions East of North (the predominant direction for the west end of the

[11] Haskoning UK Ltd, June 2012. West of Wales Shoreline Management Plan 2.
[12] Hydraulics Research, May 1990. Joint Probability of Waves and Water Levels along the North Wales Coast. Report EX2133
[13] Halcrow, 2010. North West England and North Wales Shoreline Management Plan SMP2 Supporting Studies. Cell Eleven Tidal and Sediment Study (CETASS) Phase 2 (ii) Appendix C - Sandbanks Study;

frontage) but moving easterly across the frontage the degree of protection afforded by the bank decreases as the shoreline becomes exposed to waves from directions west of north.

- Conwy Sands – Wide expanse of inter-tidal sands in the outer part of the Conwy Estuary that acts to attenuate waves as they approach the West Shore frontage.

Closer to the shoreline recorded wave data is available from mid 2007 to the present day at Rhyl Flats, where a wave buoy has been recording data since mid 2007. This buoy is located approximately 16km ENE of Llandudno, at the eastern end of Constable Bank and whilst its records are not directly applicable to either of the sites they do provide the most reliable general information relating to the wave climate applying along the North Wales coast. The approximate location of the wave buoy is also shown on Figure 2.10. A wave rose for the data from this source is provided in

Figure 2.11.

The Aberconwy Coastal Study[14] carried out wave refraction modelling to determine inshore wave conditions at North Shore and West Shore. Wave direction/occurrence distributions are shown schematically in Figure 2.12 and Figure 2.13 for each of these frontages respectively.

Estimates of extreme wave conditions at a single location on the West Shore and North Shore (see Figure 2.14) provided in the Conwy Tidal Flood Risk Assessment[15] from which the data in table 2.1 below has been extracted. Note this data was based on the work undertaken in the early 1990s.

Table 2.1 - Marginal Extreme Wave Conditions (2004)

Return Period (years)	Offshore (Liverpool Bay)		Nearshore Point			
			Point F		Point G	
	Hs(m)	Tm(s)	Hs(m)	Tm(s)	Hs(m)	Tm(s)
1	4.78	10.1	2.40	7.2	3.16	8.2
10	5.56	10.9	2.86	7.8	3.68	8.9
50	6.11	11.4	3.18	8.2	4.04	9.3
100	6.33	11.6	3.32	8.4	4.20	9.5
200	6.57	11.8	3.46	8.6	4.36	9.6
500	6.88	12.1	3.64	8.8	4.56	9.9
1000	7.11	12.3	3.78	9.0	4.72	10.0

[14] British Maritime Technology, 1987. Aberconwy Coastal Study, Part IV;
[15] HR Wallingford, May 2004. Conwy Tidal Flood Risk Assessment, Stage 1 Report. Report EX4667

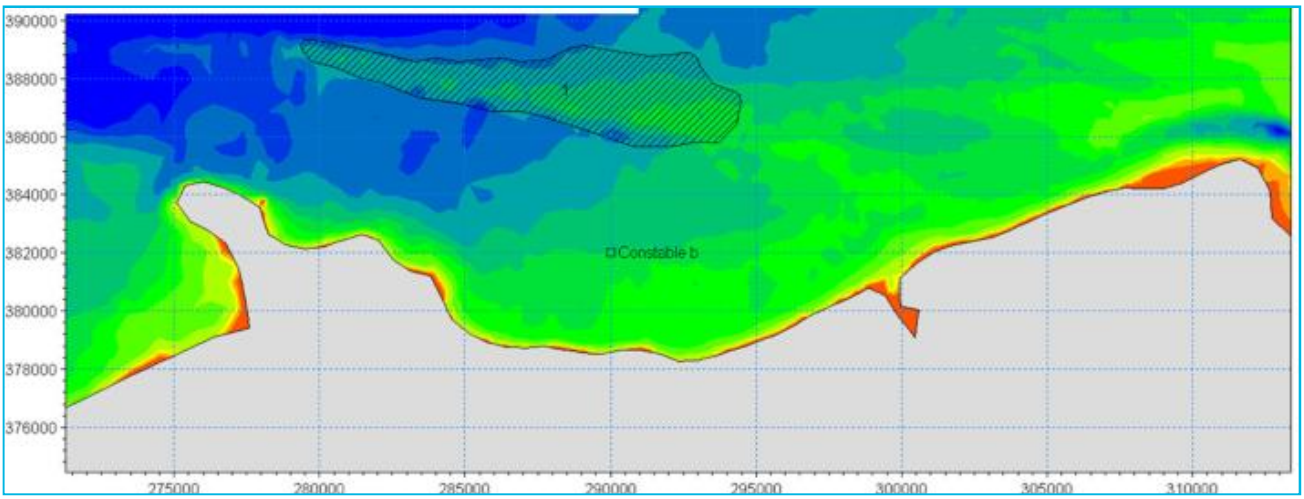


Figure 2.10 – Constable Bank Location Plan

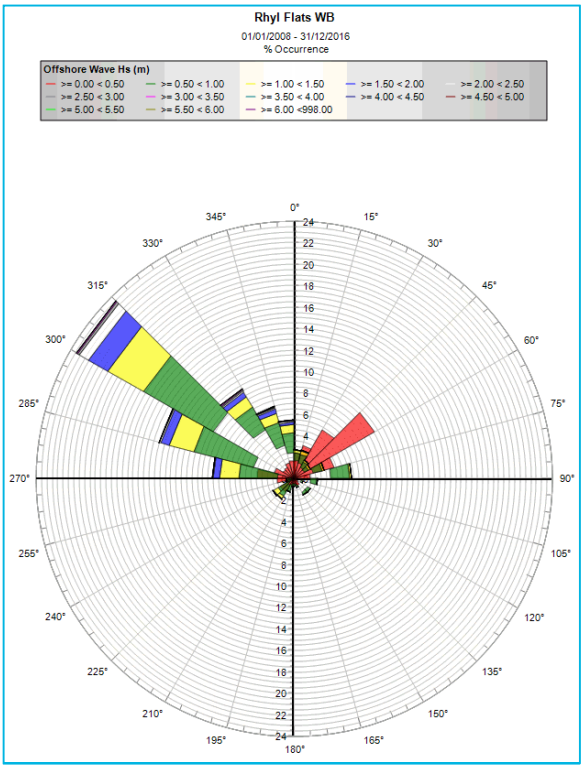


Figure 2.11 – Rhyl Flats Wave Rose: 2008-2016

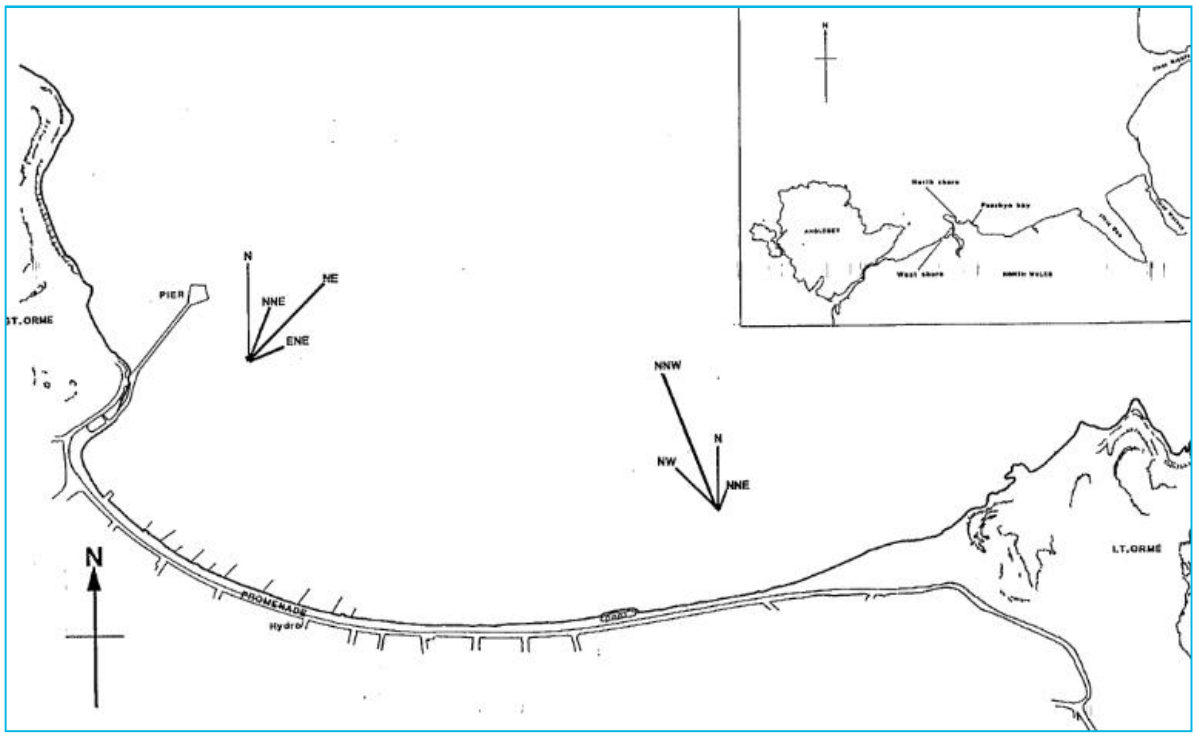


Figure 2.12 - Schematic Wave Exposure Conditions – North Shore

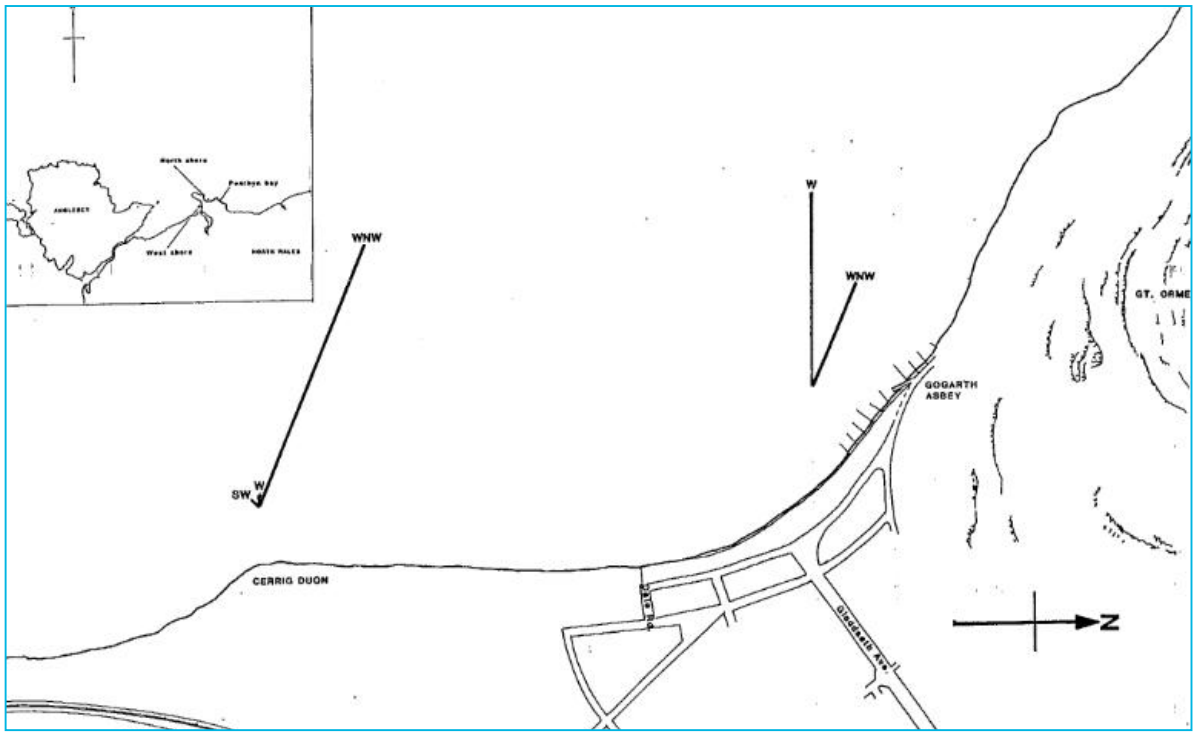


Figure 2.13 - Schematic Wave Exposure Conditions – West Shore

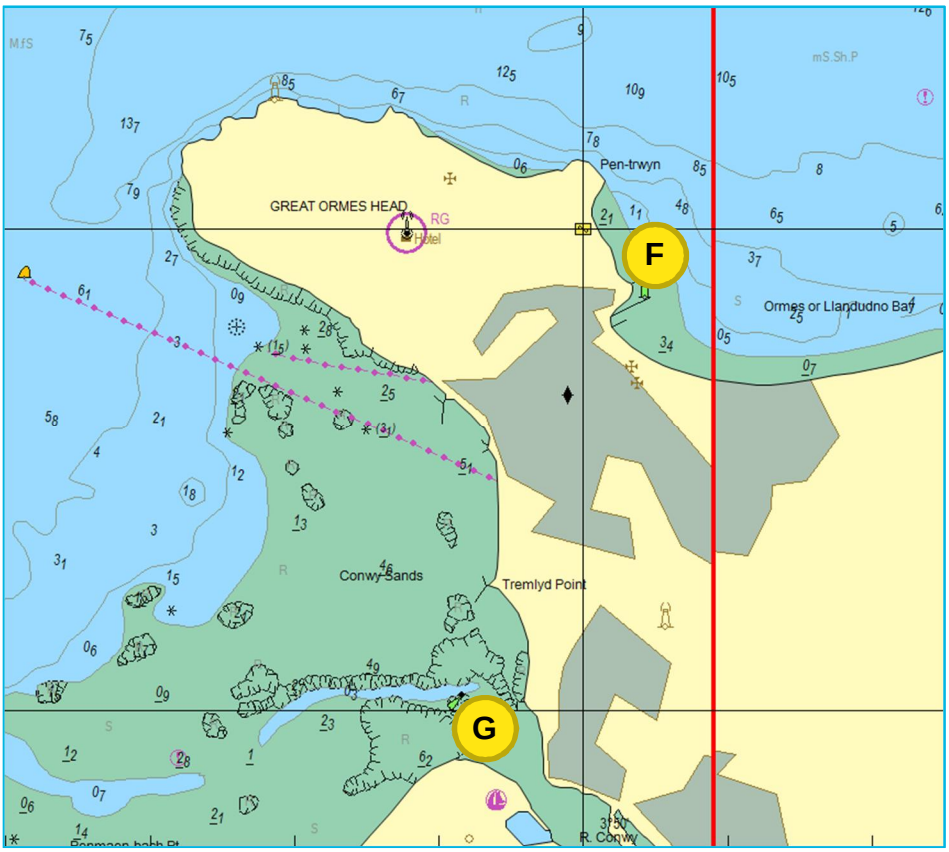


Figure 2.14 – Location of Inshore Wave Climates (ex HR Wallingford, 2004)

More recently the Cell 11 Joint Probability study, carried as part of North West England and North Wales Shoreline Management Plan Supporting Studies[16] provided estimates of marginal extreme wave heights for the Liverpool Bay site and for approximately 50 inshore locations between the east coast of Anglesey and the Solway Firth. For North Shore the relevant location is number 05 (NGR: 279292E, 384149N) approximately 2km from the shoreline. For West Shore the relevant location is number 02 (NGR: 270817E, 382075N) approximately 6km west from the shoreline. These locations are shown in Figure 2.15).

Relevant estimates for these sites are provided in Table 2.2.

Table 2.2 -Estimated Marginal Extreme Wave Heights (ex Cell 11 Joint Probability Study published 2012)

	Estimated Extreme Wave Heights (m) for Various Return Periods in Years and (Equivalent Annual Probabilities of Exceedance)							
Location	0.5 (>99.9%)	1 (>99.9%)	2 (50%)	5 (20%)	10 (10%)	50 (2%)	100 (1%)	200 (0.5%)
Llandudno (05)	3.10	3.44	3.77	4.21	4.53	5.29	5.61	5.94
Conwy Bay (02)	3.15	3.50	3.85	4.32	4.68	5.52	5.88	6.24
Liverpool Bay	3.88	4.21	4.49	4.83	5.09	5.66	5.91	6.15

[16] Halcrow, January 2012. North West England and North Wales Shoreline Management Plan SMP2 Supporting Studies. Joint Probability Study. Extreme wave heights and JOIN-SEA results;

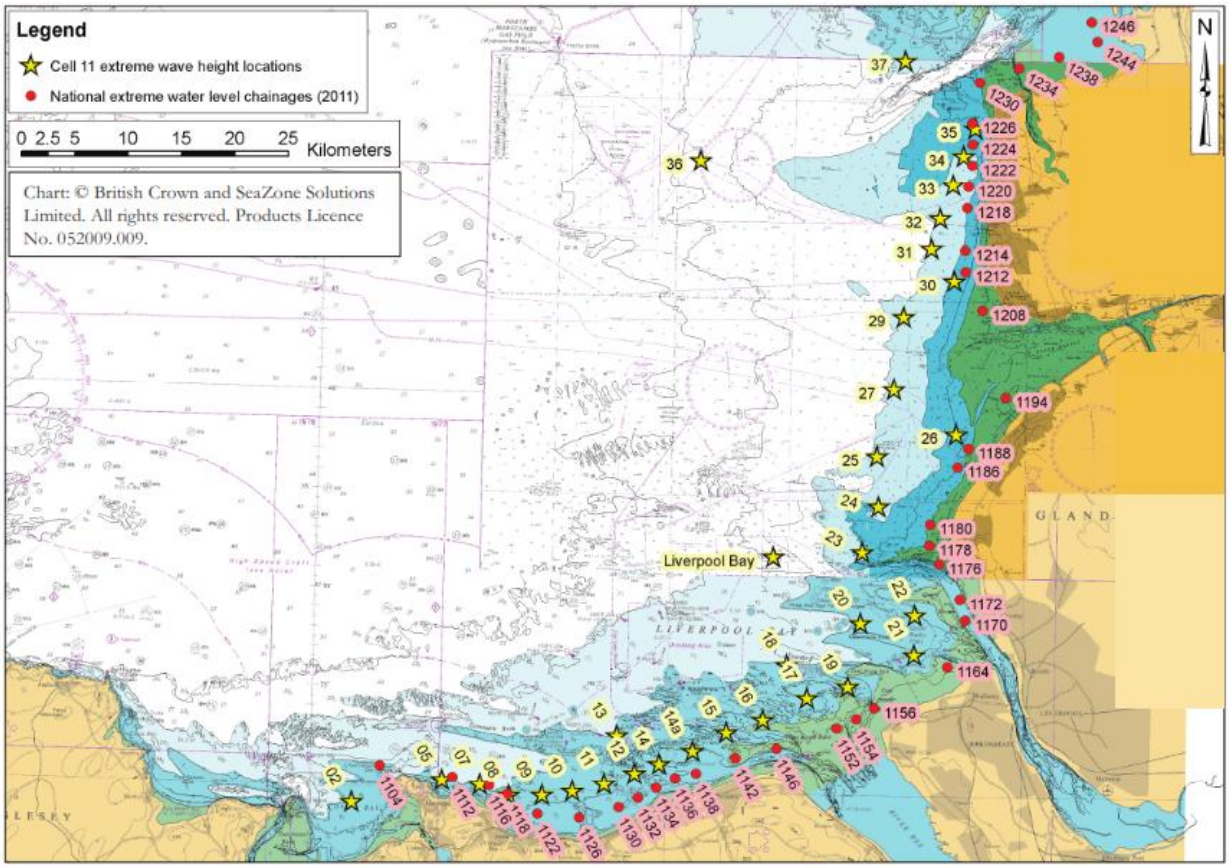


Figure 2.15 – Cell 11 JPS Marginal Extreme and Joint Probability Calculation Locations

Potential Future Changes in Wave Conditions

A study of wave climate change and its impacts on UK coastal management was reported by HR Wallingford in 1991. The literature review for that study found that mean wave heights in the North Atlantic had increased by 1-2% per year since 1960, but there was no corresponding increase in wind speeds. A possible explanation was that swell activity was increasing whilst storm wave generation due to local winds was not. There may also have been a tendency towards increasing proportions of north and easterly winds over the UK.

HR Wallingford (1991) also undertook an assessment of changes in wave conditions, based on hindcasting with long time-series of wind data from several locations. The closest location to the Conwy was off the North Wales coast, where hindcast waves were generated using wind data from Squires Gate from 1970 to 1990. No significant change trend was found, although the significant wave height (Hs) exceeded for 1% of the year was found to increase by 1.1cm/year.

The Conwy Tidal Flood Risk Assessment (HR Wallingford, 2004) examined trends in wave climates in Liverpool Bay over two periods (Jan 1970 to Jan 1993) and (Jan 1987 to Dec 2001) at two different two locations. This study identified upward trends in the first data set and downward in the second data set.

The conclusions were:

- The period of the data used is a reasonably representative sample
- Any overall trend for 1970-2000 is small

- The natural variability amongst 5 year blocks of data was of the order of ± 10%.
- A + 10% change in wave height (5% in period) represents a realistic sensitivity allowance for future wave climate change

The most recent scientific reports on climate change, UK Climate Impacts Programme 09 (UKCP09), considered changes in wave climate which identified large uncertainties especially with the projected extreme values.

Current Welsh Government guidance[17] advocates a sensitivity analysis be used in relation to assessing the impacts of changes of wave climate on flood risk and coastal change, and examination of scheme/ management options.

2.3.3 Tidal Regime

Tidal Levels

Coastlines bordering the Irish Sea are subject to the Atlantic tidal wave that propagates into the area via the St. Georges channel to the south and the narrower North Channel (between Ulster and the Mull of Galloway) to the north. Propagation into the Irish Sea by the Northern Channel and St. George's Channel is virtually simultaneous (Myres, 1993). As the tidal wave passes, interactions with the sea bed and landforms produce variations in both elevation and flow patterns.

In the western part of the Irish Sea the north and southward flowing tidal streams meet west of the Isle of Man. To the east of the Isle of Man, flows are deflected eastwards so that there are strong flows into the eastern part of the Irish Sea. The tidal range increases from west to east, being 6.7 metres west of the Great Orme and 8.5 metres at Heysham, during mean spring tides.

Tides within Liverpool Bay are semi-diurnal, i.e. the water level rises and falls twice a day, with a time difference between successive high or low waters of between 12 and 13 hours.

Predicted astronomical tide levels[18] applying at Llandudno are based on corrections from Liverpool, which is the Standard Port for the North West of England and the North Wales coast east of the Great Orme. To the west of the Great Orme levels are corrected from the port of Holyhead. The nearest site where predictions are available relevant to West Shore is Conwy, although as this is located approximately 2km upstream its values are not directly applicable at West Shore. The relative values of astronomical tide levels at the two sites are provided in Table 2.3 -

Table 2.3 - Astronomical Tide Levels

Tidal Level	Level (m AOD)	
	Llandudno	Conwy
Highest Astronomical Tide (HAT)	4.75	4.90
Mean High Water Spring Tide (MHWST)	3.85	3.90
Mean High Water Neap Tide (MHWNT)	2.05	2.20
Mean Tide Level (MTL)	0.21	0.43
Mean Low Water Neap Tide (MLWNT)	-1.55	-1.40

[17] Welsh Government, December 2011. Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales
[18] UKH0, 2016 (published annually). Admiralty Tables – United Kingdom and Ireland including European Channel Ports

Table 2.3 - Astronomical Tide Levels		
Tidal Level	**Level (m AOD)**	
	Llandudno	Conwy
Mean Low Water Spring Tide (MLWST)	-3.35	-2.90
Chart datum to Ordnance datum factor	-3.85	-4.00

The above predicted tidal levels do not however account for changes in atmospheric conditions e.g. air pressure which can lower or increase the level of the tide (surges), or persistent wind conditions that can generate wind-driven currents and set-up water levels.

Storm surges in the Irish Sea are dominated by external forcing from outside the region. The largest surges are generated by depressions travelling from the south and south west at speeds of around 75km/hour (Halcrow, 2008).

Estimates of extreme water levels that apply less frequently can be made based on available records and numerical modelling.

The EA/DEFRA funded R&D project (SC060064) entitled “Coastal Flood Boundaries” (formerly “Development & Dissemination of Information on Coastal and Estuary Extremes”), was completed in 2011[19] (Environment Agency, Feb 2011) and provides the most up to date and consistent set of extreme sea levels for the coastline of England and Wales. Estimates in the vicinity of the Llandudno are provided in Table 2.4 below.

Table 2.4 - Estimated Extreme Tidal Levels for Study frontage (ex Coastal Flood Boundaries Study published 2011)[1]									
	Return Period (Annual Probability of Exceedance)								
Location	1 (>99.9%)	5 (20%)	10 (10%)	20 (5%)	50 (2%)	100 (1%)	200 (0.5%)	500 (0.2%)	1000 (0.1%)
CFB Point 1100 (West Shore)	4.68	4.87	4.95	5.03	5.14	5.22	5.31	5.43	5.52
CFB Point 1110 (North Shore)	4.74	4.93	5.01	5.09	5.20	5.29	5.38	5.49	5.58
Confidence Limits (m)	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4
[1] Values provided by this study (base year 2008) can be considered accurate to one decimal place									

Records of actual measured tide levels are available from the National Tide Gauge Network Class A gauge on Llandudno Pier (NRG 339584 459942). Quality checked tide gauge data from this gauge are freely available (https://www.bodc.ac.uk/data/online_delivery/ntslf/).

Tidal Flows

Tidal flows or streams are pressure generated forces which act through the depth of water between the sea surface and the sea bed. They are produced by the movement of the tide and are driven locally by gradients in sea surface.

[19] Environment Agency, February 2011. Coastal flood boundary conditions for UK mainland and islands. Project: SC060064/TR2: Design sea levels.

In the western part of the Irish Sea the north and southward flowing tidal streams meet west of the Isle of Man. To the east of the Isle of Man flows are deflected eastwards so that there are strong flows into the eastern part of the Irish Sea.

Tidal asymmetry arises from the interactions between tides, ocean currents and bed topography and results in either the ebb or the flood tide being more dominant. In turn, the tidal current associated with the more dominant tide is stronger and results, when the hydrodynamic forces are of sufficient magnitude, to move sediment, with nett transport in the dominant current direction. Within the eastern Irish Sea the flood flow is dominant such that the strongest flows are towards the shoreline and hence sediment is moved in that direction.

Across the outer part of Liverpool Bay flows are generally east/west, from the west on the flood tide and from the east on the ebb tide, with a residual tidal current towards Liverpool and the Dee and Mersey estuaries. The maximum flood currents are greater than the maximum ebb currents because the tidal rise time on the flood is shorter than the time of fall on the ebb. Offshore the mean speed on both flood and ebb is of the order of 1.0m/s.

Closer inshore the currents turn in direction to south of east on the flood tide and north of west on the ebb.

The inshore tidal streams are roughly parallel to the North Wales coast swinging round to closer to south easterly on the flood and north westerly on the ebb across the Llandudno area. Magnitudes also decrease to typically 40-75% of the values offshore. In addition the effect of the Great and Little Ormes is to induce an “eddy” or clockwise circulation in the current on the eastern sides of the headlands, creating local flow reversals.

In Conwy Bay flows are less than 1.0m/s maximum and typically less than the 0.5m/s throughout most of the tidal cycle. The effects of tidal currents within Conwy Bay are poorly understood but generally are from an east to south direction on the flood and west to north direction on the ebb.

Measurements of tidal currents were made across the North Shore and West Shore frontages, prior to the introduction of the present breakwaters[20] (British Maritime Technology, 1987), which identified the eddy behaviour and generally low magnitude flows across the North Shore frontage (ref Figure 2.16) and south easterly flows on the flood and north westerly on the ebb at West Shore (ref Figure 2.17).

Note that with the introduction of the shore connected groynes at West Shore in 1991, these patterns were modified across the upper parts of the beach.

[20] British Maritime Technology, 1987. Aberconwy Coastal Study, Part IV.

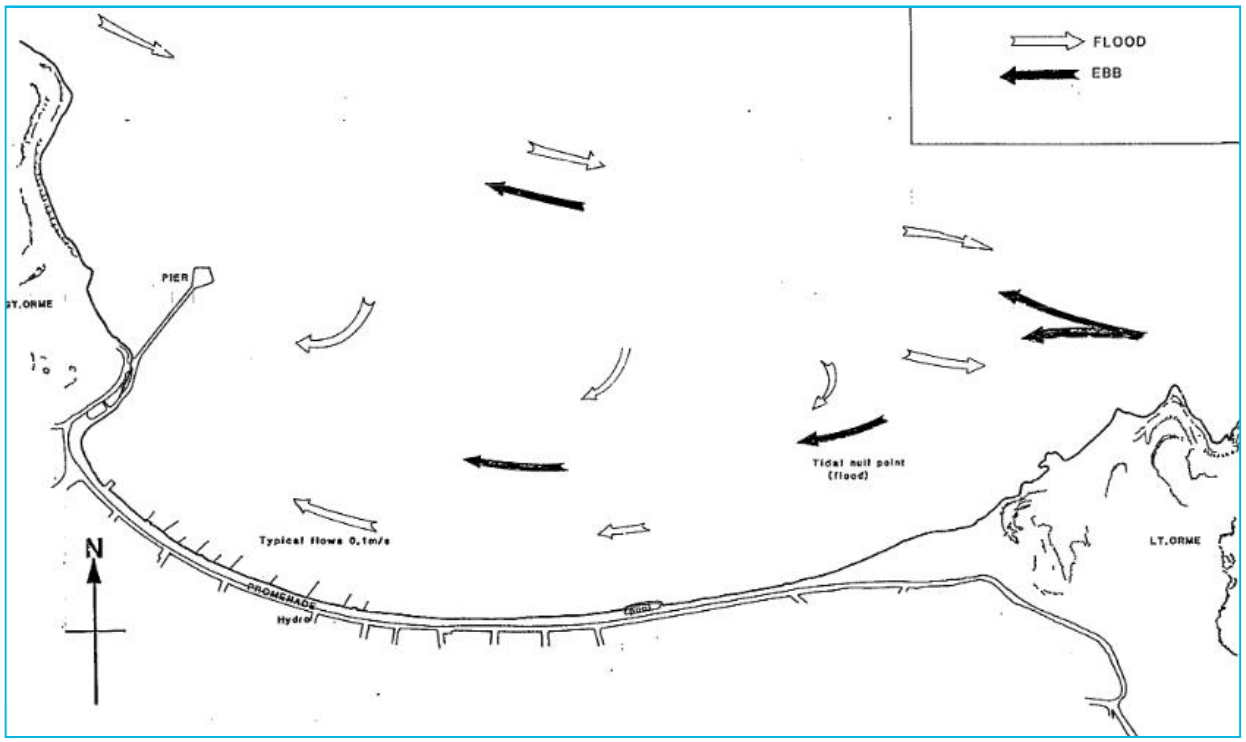


Figure 2.16 – North Shore Schematic Tidal Flows (ex BMT, 1987)

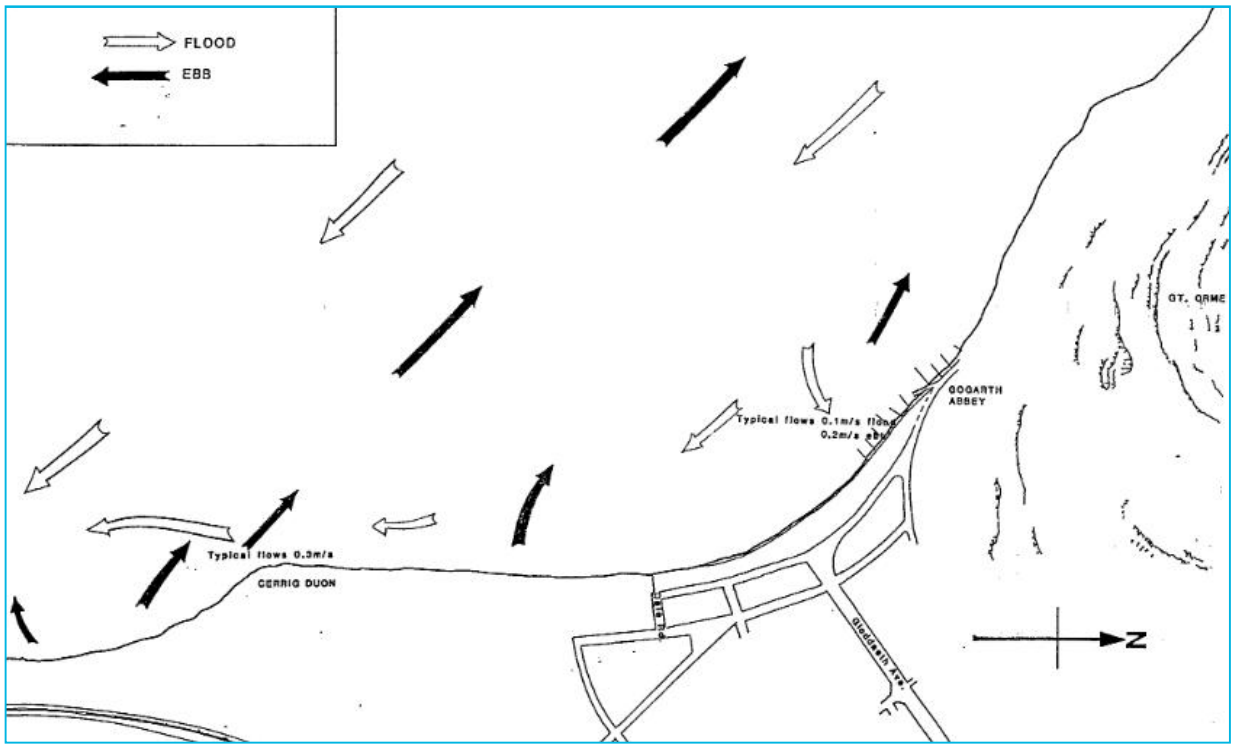


Figure 2.17– West Shore Schematic Tidal Flows (ex BMT, 1987)

Sea Level Rise

The historical trend in rise in mean sea level (MSL) across the North Wales coast is approximately 3mm (±0.5mm) per annum[21] (POL, 1997).

The latest available climate change guidance (UKCIP, 2009) provides revised predictions for the rises in relative sea level (sea level + land changes) for the whole of the UK coastline up to 2100 for different CO2 emission scenarios. Current Environment Agency guidance recommends the use of the 95%ile values in relation to examination of flood and coastal erosion risk management guidance. The figures applicable for the Llandudno frontage in this respect are provided in Table 2.5 below for up to 100 years in the future.

Table 2.5 - Estimated Relative Sea Level Rise during the 21st Century (mm) [ex UKCIP, 2009]

	Year		
CO2 Emission Scenario	**2037**	**2067**	**2117**
Medium 95th Percentile	147	337	734

2.3.4 Joint Probability of Waves and Water Levels

Severe coastal flooding or damage to coastal structures is rarely caused by either large waves or high water levels alone, but by a combination of the two occurring simultaneously. To examine future coastal evolution and to provide design criteria for coastal works, it is necessary to consider the joint probability of any given wave climate occurring at the same time as a given water level. Joint probabilities are derived from the individual variable probabilities and the level of interdependence of the variables. If the conditions producing high waves are totally independent of the conditions producing high water levels then the joint probability of a combined event is the product of the separate probabilities. However, if the conditions producing the waves and high water level are totally dependent then the joint probability is equal to either individual probability. In most cases the situation is one of partial dependence and a factor must be applied based on recorded data, understanding of the forcing conditions and experience.

Following the Towyn disaster in 1990 a joint probability analysis was carried out for conditions off the North Wales Coast, using long term series of recorded wave conditions and water levels[5]. This report provided combinations of wave and water levels for offshore conditions for return periods of between 1 and 1000 years.

This data was used as the basis of definition of inshore joint probability conditions as part of the Conwy Tidal Flood Risk Assessment (HR Wallingford, 2004), from which the data in table 2.5 below has been taken. The locations of the points in the table are as shown for the inshore wave predictions (ref Figure 2.14**Error! Reference source not found.**).

[21] Dixon M.J. & Tawn J.A., 1997. Spatial Analyses for the UK Coast. Proudman Oceanographic Laboratory Internal Document No.112.

The Cell 11 Joint Probability study provides updated estimates of the combinations of wave heights and water levels that would occur for return periods of between 1 in 1 year and 1 in 200 years at the 50 locations for which extreme wave heights were estimated.

Tabulated combinations of waves and water levels for North Shore and West Shore respectively are provided in Table 2.6.

Table 2.6 - Joint probability Conditions (2004) for nearshore prediction points D and E

Return Period (years)	Nearshore point					
	Point F			*Point G*		
	WL (mOD)	Hs (m)	Tm (s)	WL (mOD)	Hs (m)	Tm (s)
1	2.79	1.71	6.35	2.73	2.38	6.35
	3.22	1.49	6.01	3.16	2.13	6.01
	3.65	1.23	5.58	3.59	1.84	5.58
	4.08	0.87	4.95	4.02	1.43	4.95
	4.51	0.02	2.89	4.45	0.46	2.89
10	2.79	2.72	7.70	2.73	3.52	7.70
	3.22	2.72	7.70	3.16	3.52	7.70
	3.65	2.65	7.61	3.59	3.44	7.61
	4.08	2.47	7.38	4.02	3.24	7.38
	4.51	2.20	7.02	4.45	2.93	7.02
	4.93	1.33	5.63	4.87	1.96	5.63
50	3.22	3.15	8.21	3.16	4.01	8.21
	3.65	3.12	8.17	3.59	3.98	8.17
	4.08	3.00	8.03	4.02	3.84	8.03
	4.51	2.83	7.82	4.45	3.64	7.82
	4.93	2.44	7.35	4.87	3.21	7.35
	5.36	1.23	5.58	5.30	1.84	5.58
100	3.22	3.33	8.42	3.16	4.22	8.42
	3.65	3.27	8.34	3.59	4.14	8.34
	4.08	3.19	8.25	4.02	4.06	8.25
	4.51	3.00	8.03	4.45	3.83	8.03
	4.93	2.72	7.70	4.87	3.52	7.70
	5.36	2.20	7.04	5.30	2.94	7.04
200	3.22	3.57	8.68	3.16	4.48	8.68
	3.65	3.56	8.67	3.59	4.47	8.67
	4.08	3.50	8.60	4.02	4.40	8.60
	4.51	3.33	8.41	4.45	4.21	8.41
	4.93	3.00	8.04	4.87	3.84	8.04
	5.36	2.62	7.57	5.30	3.41	7.57
500	3.65	3.83	8.95	3.59	4.78	8.95
	4.08	3.80	8.92	4.02	4.74	8.92
	4.51	3.65	8.77	4.45	4.58	8.77
	4.93	3.42	8.51	4.87	4.31	8.51
	5.36	3.12	8.17	5.30	3.98	8.17
	5.79	2.35	7.24	5.73	3.11	7.24
1000	4.08	4.07	9.20	4.02	5.04	9.20
	4.51	3.96	9.09	4.45	4.92	9.09
	4.93	3.71	8.83	4.87	4.64	8.83
	5.36	3.36	8.45	5.30	4.24	8.45
	5.79	2.80	7.79	5.73	3.61	7.79

Table 2.7 - Joint probability Conditions (2012) for nearshore prediction points North Shore 05 (left) and West Shore 02 (right)

1-year Joint RP		2-year Joint RP		5-year Joint RP	
W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)
0.00	3.44	0.00	3.78	0.00	4.21
2.00	3.40	2.00	3.73	2.00	4.19
2.60	3.26	2.21	3.70	2.60	4.03
2.75	3.20	2.60	3.58	3.00	3.85
3.00	3.10	3.00	3.42	3.27	3.70
3.30	2.99	3.30	3.23	3.30	3.67
3.70	2.75	3.34	3.20	3.70	3.28
3.75	2.70	3.70	2.98	3.84	3.20
4.10	2.32	4.02	2.70	4.10	2.93
4.11	2.30	4.10	2.61	4.32	2.70
4.33	1.90	4.32	2.30	4.40	2.57
4.40	1.73	4.40	2.12	4.53	2.30
4.52	1.40	4.49	1.90	4.67	1.90
4.65	1.00	4.65	1.40	4.79	1.40
4.76	0.00	4.75	1.00	4.87	1.00
10-year Joint RP		20-year Joint RP		50-year Joint RP	
W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)
0.00	4.55	0.00	4.86	0.00	5.29
2.00	4.52	2.00	4.86	2.00	5.29
2.60	4.37	2.60	4.77	2.60	5.25
3.00	4.19	3.00	4.58	3.00	5.11
3.30	3.98	3.30	4.34	3.30	4.81
3.65	3.70	3.70	4.01	3.66	4.45
3.70	3.65	3.93	3.70	4.10	3.77
4.05	3.24	4.16	3.39	4.13	3.70
4.16	3.10	4.25	3.20	4.40	3.26
4.38	2.85	4.40	3.01	4.45	3.20
4.49	2.70	4.64	2.70	4.80	2.70
4.67	2.30	4.80	2.30	4.92	2.30
4.77	1.90	4.87	1.90	4.98	1.90
4.88	1.40	4.96	1.40	5.08	1.40
4.96	1.00	5.06	1.00	5.21	1.00
5.04	0.00	5.16	0.00	5.23	0.00
100-year Joint RP		200-year Joint RP			
W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)		
0.00	5.63	0.00	5.91		
2.00	5.63	2.00	5.91		
2.60	5.59	2.60	5.85		
3.00	5.45	3.00	5.75		
3.33	5.15	3.30	5.55		
3.70	4.75	3.70	5.13		
4.10	4.06	4.14	4.39		
4.32	3.70	4.34	4.01		
4.42	3.55	4.50	3.70		
4.62	3.20	4.76	3.20		
4.92	2.70	5.03	2.70		
5.04	2.30	5.15	2.30		
5.15	1.80	5.24	1.90		
5.24	1.40	5.35	1.40		
5.31	1.00	5.38	1.00		
5.32	0.00	5.41	0.00		

1-year Joint RP		2-year Joint RP		5-year Joint RP	
W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)
0.00	3.50	0.00	3.84	0.00	4.31
2.50	3.35	2.50	3.73	2.40	4.20
3.00	3.15	3.00	3.52	2.79	4.06
3.38	3.00	3.03	3.50	3.04	3.96
3.50	2.90	3.50	3.17	3.50	3.54
3.85	2.50	3.72	3.00	3.52	3.50
4.00	2.31	4.00	2.62	3.97	3.00
4.20	2.00	4.08	2.50	4.00	2.97
4.50	1.47	4.40	2.00	4.31	2.50
4.64	1.00	4.50	1.84	4.50	2.26
4.69	0.00	4.74	1.00	4.63	2.00
		4.77	0.00	4.84	1.00
				4.89	0.00
10-year Joint RP		20-year Joint RP		50-year Joint RP	
W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)
0.00	4.72	0.00	5.07	0.00	5.52
2.40	4.59	2.50	4.90	2.50	5.40
2.69	4.47	3.00	4.73	3.00	5.22
3.00	4.33	3.30	4.50	3.50	4.65
3.33	4.00	3.50	4.27	3.56	4.50
3.50	3.86	3.69	4.00	3.92	4.00
3.77	3.50	3.98	3.50	4.00	3.84
4.02	3.20	4.03	3.45	4.17	3.50
4.17	3.00	4.32	3.00	4.50	3.08
4.50	2.55	4.50	2.82	4.58	3.00
4.53	2.50	4.69	2.50	4.88	2.50
4.77	2.00	4.90	2.00	5.00	2.13
4.95	1.00	5.00	1.40	5.04	2.00
4.97	0.00	5.04	1.00	5.18	1.00
		5.05	0.00	5.18	0.00
100-year Joint RP		200-year Joint RP			
W. Level (mODN)	H_{m0} (m)	W. Level (mODN)	H_{m0} (m)		
0.00	5.88	0.00	6.24		
2.50	5.70	2.50	6.10		
3.00	5.52	3.00	5.85		
3.50	5.07	3.50	5.28		
3.86	4.50	4.05	4.57		
4.00	4.23	4.12	4.48		
4.15	4.00	4.35	4.00		
4.42	3.55	4.55	3.63		
4.57	3.27	4.63	3.47		
4.76	3.00	4.90	3.00		
4.98	2.50	5.00	2.78		
5.00	2.41	5.08	2.50		
5.12	2.00	5.24	2.00		
5.23	1.00	5.32	1.00		
5.23	0.00	5.36	0.00		

Table 2.8 – AECOM Suggested Joint probability data for extreme wave and water levels for North Shore (top) and West Shore (bottom).

		Joint exceedance return period (years)							
		1	**2**	**5**	**10**	**20**	**50**	**100**	**200**
		Wave Height [m]							
Water Level North Shore **[mOD]**	**4.62**	2.14	2.33	2.57	2.76	2.94	3.19	3.37	3.56
	4.72	1.99	2.17	2.42	2.60	2.79	3.04	3.22	3.41
	4.81	1.79	1.97	2.22	2.40	2.59	2.83	3.02	3.21
	4.90	1.63	1.82	2.07	2.25	2.44	2.68	2.87	3.05
	4.99		1.67	1.91	2.10	2.28	2.53	2.72	2.90
	5.09			1.71	1.90	2.08	2.33	2.51	2.70
	5.18				1.75	1.93	2.18	2.36	2.55
	5.26					1.78	2.02	2.21	2.40
	5.37						1.82	2.01	2.19
	5.56							1.86	2.04
	5.65								1.89
Water Level West Shore **[mOD]**	**4.55**	2.91	3.12	3.40	3.61	3.82	4.10	4.31	4.52
	4.63	2.74	2.95	3.23	3.44	3.65	3.92	4.13	4.34
	4.74	2.51	2.72	3.00	3.21	3.42	3.70	3.91	4.12
	4.82	2.34	2.55	2.83	3.04	3.25	3.52	3.73	3.94
	4.90		2.38	2.65	2.86	3.07	3.35	3.56	3.77
	5.01			2.43	2.64	2.85	3.12	3.33	3.54
	5.09				2.46	2.67	2.95	3.16	3.37
	5.17					2.50	2.78	2.99	3.20
	5.28						2.55	2.76	2.97
	5.46							2.59	2.80
	5.55								2.63

2.3.5 Sediment Data

The original Shoreline Management Plan provides the following description of general sediment composition within Liverpool Bay.

"Liverpool Bay is a comparatively shallow basin characterised by numerous nearshore banks situated within the 10 metres depth contour. Off the North Wales coast the banks such as the Constable Bank, Rhyl Flats and Chester Flats are submerged.

The seabed surface consists predominantly of fine to medium sized sand overlying a partly eroded surface of boulder clay from which much of the mobile sediment has been derived. Gravel tends to occur locally, often filling in depressions in the Boulder Clay surface. There is a large area between Colwyn Bay and Prestatyn where the sand has a high gravel content. This patch of superficial sandy gravel is as close as the 10m CD depth contour off Prestatyn and extends out to the 20m CD depth contour off Colwyn Bay. Larger patches also occur well offshore, in water depths of about 40m CD where it is believed that the fines have been winnowed out by waves and currents. In such areas the gravels tend to be left as a thin residual layer over sand or boulder clay.

The seabed within Liverpool Bay is relatively free of fines as waves and strong tidal currents generally prevent deposition. The major concentrations of mud occur in

deep holes, for example, in the approaches to the River Mersey. Some muddy areas also occur off the North Wales coast in small areas where waves and tidal currents are significantly reduced in strength by the sheltering affect of offshore banks. Past research of sediment distribution has shown that the median size of the predominant sands of the Bay decreases in a landward direction, this being indicative of a nett shoreward transport of the finer fractions with the coarser fractions remaining offshore".

The general sediment types applying across the inter-tidal zone within the North Shore and West Shore Llandudno area are described in section 2.1.2 above.

Sediment sampling was carried out as part of a regional study in 2014/15[22]. Details of the sediment types recorded are provided in Figure 2.18 and Figure 2.19 for North Shore and West Shore respectively.

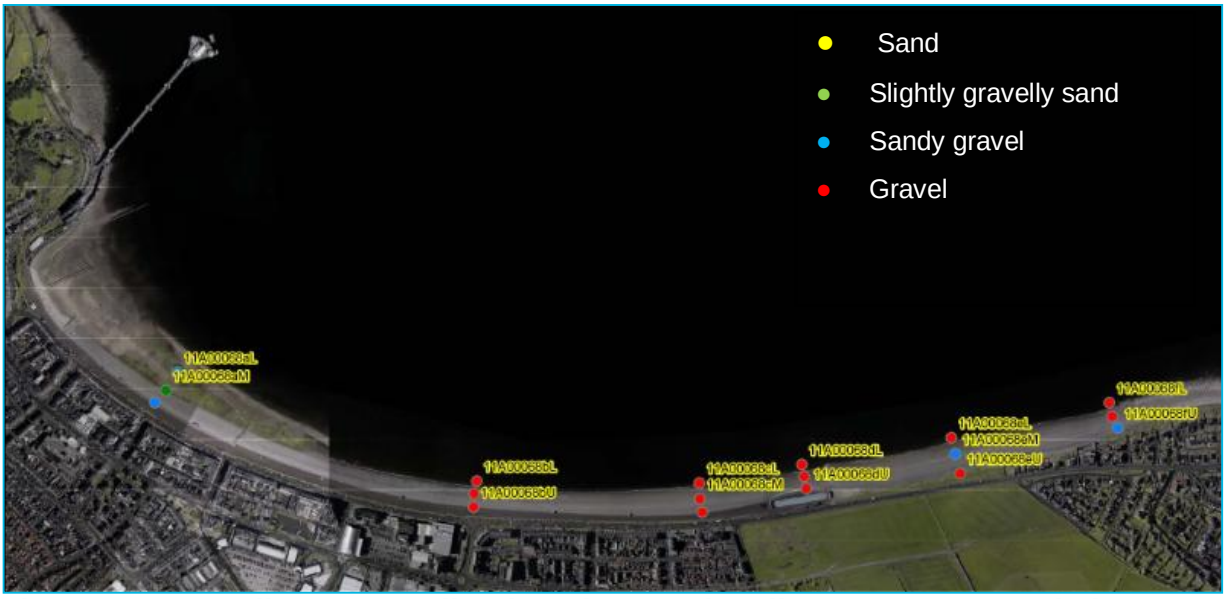


Figure 2.18 – Sediment sampling locations and sediment types recorded – North Shore

The upper beaches at West Shore comprise a mixture of natural sand and shingle mixed with artificial quarried shingle and cobbles. Sediments on the flatter lower beach are sand near the toe of the recharged beach but generally slightly gravelly sand further offshore. At North Shore the upper beach is a mixture of indigenous shingle with imported glacial gravel. The lower beach sediments are a mixture of sand, sandy gravel and gravelly sand. The lower beach is wider at the western end becoming narrower moving westwards.

[22] Coastal Engineering UK Ltd/Kenneth Pye Associates Ltd, November 2015. North West Strategic Monitoring - Regional Sediment Analysis and Reporting 2015. Inter-tidal Report

Figure 2.19 – Sediment sampling locations and sediment types recorded – West Shore

2.3.6 Sediment Movement

General Behaviour

Liverpool Bay is subject to a large tidal range, significant surges, relatively strong nearshore currents and fetch limited storm waves from the west through to the north. In addition some areas of intertidal sands are subject to transport by dry winds from the northwest through to the northeast.

The overall trend of littoral drift is from west to east along the North Wales and Wirral coasts. The magnitude of drift varies with wave exposure and the pattern is segmented into sub-units by estuaries and bays where tidal currents and local wave patterns dominate sediment transport.

The main transport pathways offshore in Liverpool Bay are from east to west towards the Dee and Mersey estuaries. Whilst this would mean material offshore bypassing Llandudno, historical data on bottom currents (Figure 2.20 below) suggests that there may be a feed from offshore towards the shoreline.

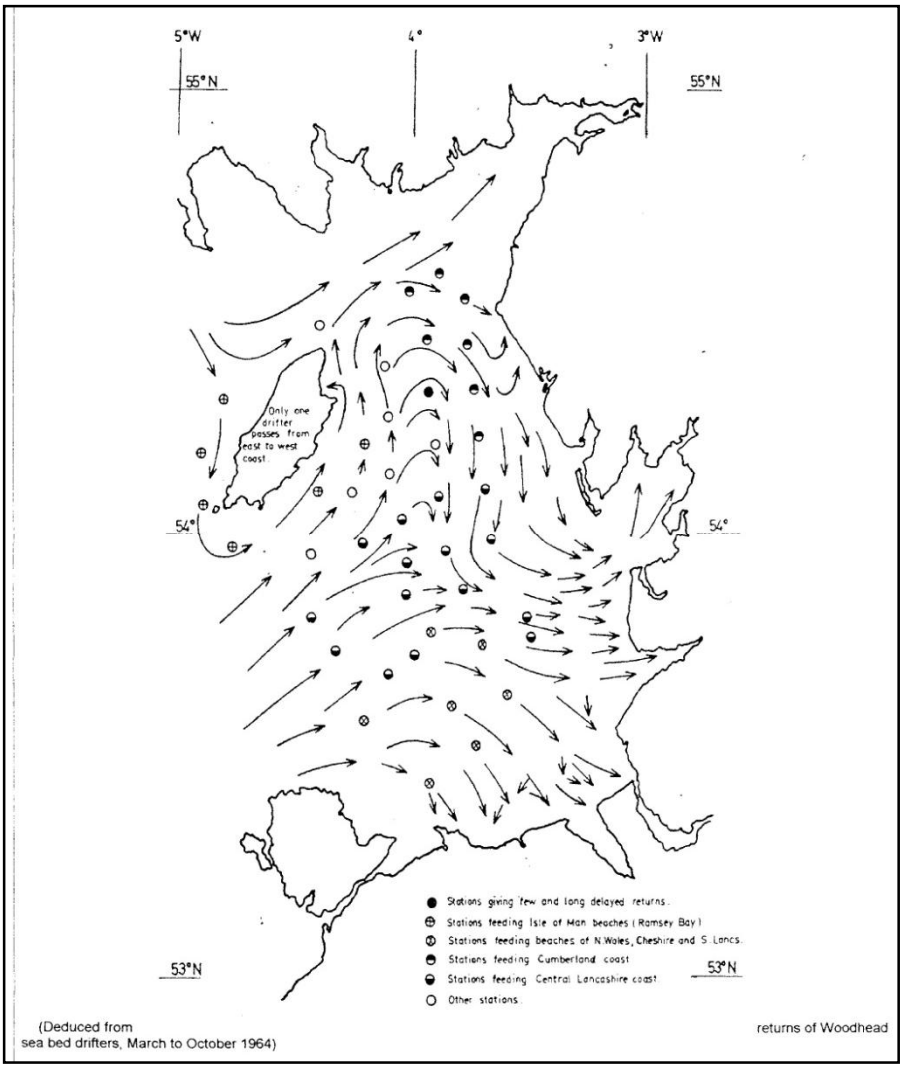


Figure 2.20 - Net direction of bottom currents in the eastern Irish Sea

(ex Liverpool University Hydraulics Research Unit, 1968)

The cutting off of the supply of sand and gravel to the coastal zone east of Little Orme, as a result of the change in the course of the River Conwy, undoubtedly would have deprived the Llandudno area of its main source of beach feed.

With the shoreline being artificially reinforced over the past 100 years, in order to provide coastal defence to the developed hinterland, present day supplies of material are now limited to local erosion of the headlands of Great and Little Orme, a small quantity of eroded material from the remaining natural cliffs, redistribution of sands from nearshore bars and losses from beach recharge schemes.

North Shore Behaviour

General Behaviour

Sediment movement within Ormes Bay (North Shore) has been the subject of much research and assessment during the 20th century.

In 1937, Sir Cyril Kirkpatrick, when asked to investigate the causes of erosion and propose remedial works to the original defences that had been damaged by the Feb 1937 storm identified *"that observations of tidal flows had clearly shown that any travel of shingle of the beach from the west to the east is not due to tidal currents but must only be caused by wave action"*[23].

In 1977 Scott, Wilson, Kirkpatrick and Partners identified that "*material movement longshore from the east to the west does occur but the mass transport quantity appears to be relatively small. The longshore drift has separated the backshore materials, the fine materials tending to be more readily transported towards the western end of the bay whilst the coarser fractions are transported at a slower rate. The result is that the beach material at the eastern end of the bay is coarser than at the west".*[24]

BMT's Aberconwy Coastal study, identified although the eddy circulation in the lee of the Great Orme affected tidal flows it was wave action and in particular an edge wave effect between the Pier and the eastern end of the groyne field that produced nett easterly drift across the western end of the frontage.

HR Wallingford's second opinion on the 1987 proposed coastal defence scheme[25] estimated theoretical potential longshore drift rates, based at standard longshore drift equations, at three locations, as shown in Table 2.9 below. These rates are based on an annual wave climate

Table 2.9 – Longshore Drift Estimates (1992)

Location	Gross Drift (m^3 p.a.)	Net Drift/Direction (m^3 p.a.)
300m east of Craig-Y-Don Pool	24,250 (± 750)	11,500 east (± 1,250)
500m west of Craig-Y-Don Pool	14,000 (± 600)	10,500 east (± 750)
Opposite Clonmel St	15,000 (± 500)	10,000 west (± 1,000)

[23] Sir C Kirkpatrick, June 1937. Report to Llandudno UDC on Proposed Sea Defence Scheme for North Shore;
[24] Scott, Wilson, Kirkpatrick, December 1977. Preliminary Report on Coast Protection to Aberconwy Borough Council;
[25] HR Wallingford, September 1992. North Shore, Llandudno. Second Opinion on Proposed Coast Protection Scheme.

(adjacent to bandstand promontory)		

Subsequent physical modelling of nourishment of the beach alone and with wave interception/beach control structures at the root of the Pier (see Figure 2.21) identified that any structure would intercept waves but would not significantly alter drift rates across the bay. It would however mean that v rather than material that feeds easterly drift being scoured from the west end of the frontage, shingle would migrate from a long stretch of beach between Children's corner and Vaughan St.

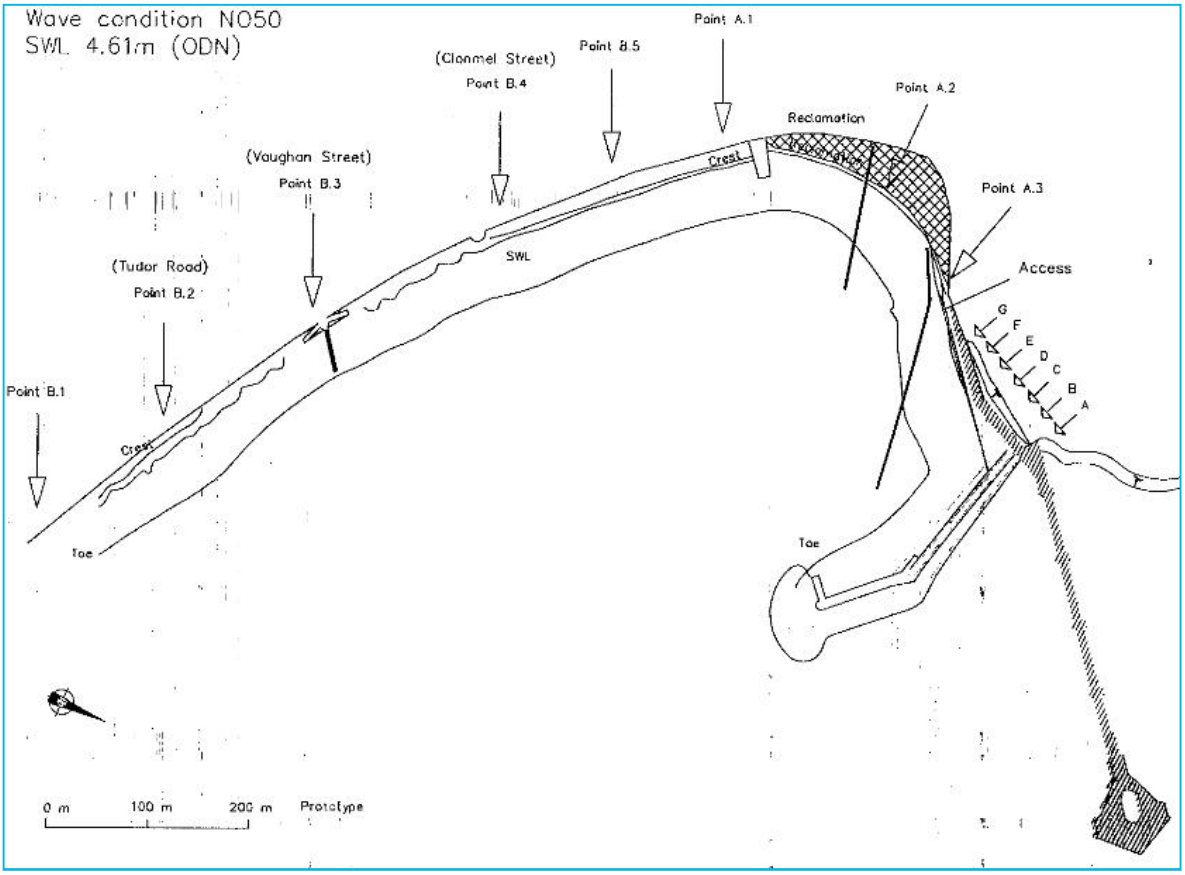


Figure 2.21 – Physical modelling layout (1992)

In 1994, Scott Wilson Kirkpatrick in their report to Llandudno Town Council[26] on the proposed scheme suggested that annual longshore rates of transport of 10,000m^3 per annum were excessive and that perhaps a rate of 2-3, 000m^3 per annum would be more realistic, with a maximum rate of 5,000m^3 per annum due to short term, storm conditions.

More recently the North West England and North Wales SMP2 identified that "*sediment transport is generally from west to east, the projection of Great Ormes Head into the Irish Sea induces a clockwise eddy, which results in a small localised circulatory current cell within the western end of Ormes Bay, this means that sediments do not move from west to east at the western end of the bay in the nearshore. Over the remainder of the frontage material moves longshore and on/offshore with generally movement from west to east although drift reversal does take place. The Great Orme headland is also a barrier to the littoral sediment of*

[26] Scott Wilson Kirkpatrick, 1994. Review of Sea Defence Options for Llandudno Town Council.

transport and the very slow erosion of the Great Orme cliffs means there is little or no sediment inputs from the west into the Bay. Similarly there is only limited linkage with beaches to the east of Little Orme.

This means that the upper shingle beach deposits within the Bay are essentially relict, with little contemporary source apart from artificial recharge. The lower sandy beach may still receive limited sediments from erosion of the till cliffs that flank the headlands of Great Ormes and Little Ormes and also potentially from offshore, Sediment transport within the bay therefore tends to be a reworking of existing sediments. There may be a loss of sand and fines into Penrhyn Bay, although it is thought that this is modest.

This coastline is vulnerable to storm surge conditions; during these events the coarser sediments may become more mobile, with the risk of beach drawdown, thus exposing the backshore defences to increased wave action".

Recorded Beach Movement & Change

Monitoring of the beach at North Shore has been carried out by the succession of Urban District, Borough and County Councils, since the start of the 20th century and is continuing to this day.

In 1907 the borough surveyor estimated, from recording of beach sections, the loss of 12,000 tons of shingle over a period of 6-10 years.

In 1937, Sir Cyril Kirkpatrick estimated that the had been a loss of approximately 21,000m^3 of beach between the Trevor St slipway and the bastion approximately 200 metres east of Vaughan St – a distance of approximately 700 metres – between 1899 and 1937.

HR Wallingford in their 1992 Second Opinion, identified from analysis of OS plans and beach profile surveys, that there had been a drop in level of the upper beach of about 10-20mm per annum from 1900-1990, equivalent to a reduction in level of 0.9-1.8 metres in total. This appears to be borne out by comparison of historical photos (ref Figure 2.2 - Figure 2.4 above). Based on surveys from 1878-1990 only the rate was 3-6x the longer term rate (60mm per annum or 0.7 metres over that period).

Monitoring of the beach since 1997 following scheme implementation has been carried out by the recording of beach plan surveys, across the whole bay. Analysis of this data split the frontage into 9 sections, as shown on Figure 2.22 below. Note Section 1 (Children's Corner, west of Trevor St slipway) and section 9 at the east end of the frontage are also monitored.

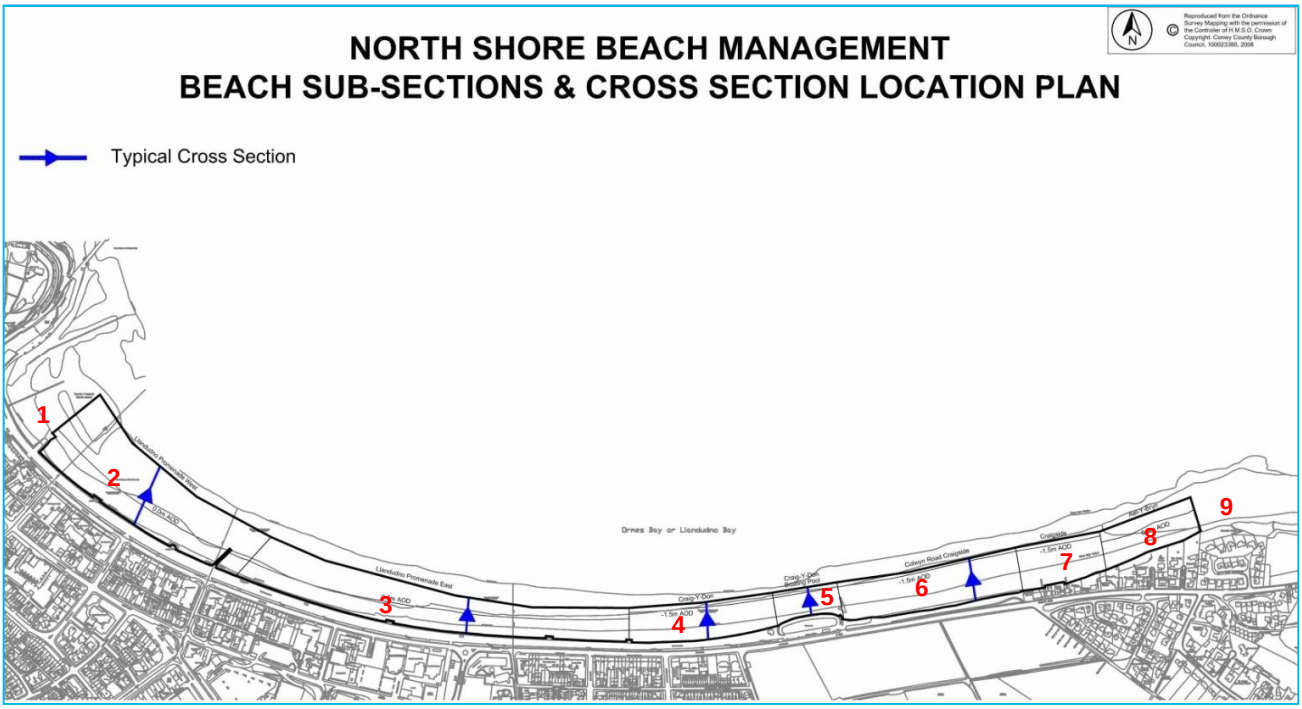


Figure 2.22 – Beach Plan Monitoring Areas 1997 to present day - North Shore

Analysis of the surveys comprises comparison of surveys to produce plots show areas of gains and losses. Since 2008 surveys have sub divided the longshore areas into upper and lower beach to record the changes across the sections of shingle/cobble beach and sand beach separately. The results of the changes are provided in Table 2.10 below.

Table 2.10 – Beach Volume Changes – North Shore 1997-2014

			Fill (+) / Cut (-) Balances										
Drawing No	Base Model	Re-Survey Model	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Total	
LLN01	Oct-97	May-98	-4161	1303	7700	-1132	-901	-8766	-2339	-835		-8439	
LLN02	May-98	Oct-98	-3696	-3505	802	-1398	-427	3856	-2682	-67		-7364	
LLN03	Oct-98	Apr-99	-722	-3079	-24553	-7299	-82	-6936	7470	4946		-29438	
LLN04	Apr-99	Oct-99	1026	2289	9054	4107	580	5653	1182	-529		23612	
LLN05	Oct-99	May-00	-1177	8807	-8329	-1634	-1205	2244	633	-1072		-1915	
LLN06	May-00	Oct-01	7857	17186	32953	9695	2446	4454	-2051	272		73643	
LLN07	**Oct-97**	**Oct-01**	**-1281**	**23211**	**15717**	**1947**	**293**	**1068**	**2769**	**6422**	**7253**	**57725**	
LLN08	Oct-01	Jun-02	-1352	-10538	-27071	-10354	-31	-4061	6909	4451	-1468	-43578	
LLN09	Jun-02	Oct-02	-967	-2509	-2295	5	-565	113	911	-585	-2918	-9240	
LLN10	Oct-02	May-03	1657	-60	-3747	-467	-732	1700	-1726	-1177	3374	-1107	
LLN11	May-03	Sep-03	185	1784	3224	942	654	1070	944	281	-652	8486	
LLN12	Sep-03	May-04	-956	-3841	-2696	-586	353	636	-91	-382	-630	-8209	
LLN13	May-04	Nov-04	428	2397	-1068	-926	400	-2007	819	1855	355	2460	
LLN14	Nov-04	Feb-05	-629	-5408	-4707	-1597	-177	-733	2949	3212	735	-6423	Post Storm
LLN15	Feb-05	Jul-05	-394	-1021	15	2073	-1238	7416	-2851	-4972	-882	-2012	
LLN16	Jul-05	Nov-05	95	1203	3484	666	618	157	-316	326	1791	8128	
LLN17	**Oct-01**	**Nov-05**	**-2658**	**-19271**	**-34899**	**-10194**	**-645**	**4616**	**7479**	**2983**	**-918**	**-53888**	
LLN18	**Oct-97**	**Nov-05**	**-3081**	**4007**	**-17830**	**-8267**	**-359**	**5728**	**9931**	**9594**	**6290**	**6463**	
LLN19	Nov-05	Jul-06	-1433	-5071	-2029	1508	733	-1020	-2369	-2037	-1134	-12960	
LLN20	Jul-06	Oct-06	344	114	-1861	-1477	-126	-2273	627	752	-56	-4022	
LLN21	Oct-06	Apr-07	984	-241	3301	923	-266	298	4226	4809	436	14703	Post Storm
LLN22	Oct-06	May-07	1709	3600	4235	-221	-1463	-1986	3142	3328	-533	11990	
LLN23	May-07	Nov-07	-3132	-10228	-9956	-1535	927	1262	-826	-1358	549	-24468	
LLN24	**Oct-97**	**Nov-07**	**-5771**	**-7671**	**-27741**	**-9275**	**-200**	**2224**	**10532**	**10347**	**3491**	**-23856**	
LLN25	Nov-07	May-08	405	-346	2570	1812	-1119	3228	1617	-225	1285	9299	
LLN26	May-08	Nov-08	981	1897	839	314	97	1213	80	-2784	-189	5995	Lower Beach
				1199	1640	1501	1442	-629	-2925				Upper Beach
LLN27	Nov-08	May-09	-694	-1092	-14	-43	11	-627	-35	1252	-1393	-4756	Lower Beach
				-1001	-377	-334	187	-695	783				Upper Beach
LLN28	May-00	May-09	3784	-5575	419	127	1	211	174	2385		3673	Lower Beach
				-7389	-6850	1036	2382	7414	5319				Upper Beach
LLN29	May-09	Nov-09	-1083	-1908	882	320	176	341	322	927	1080	-8664	Lower Beach
				-303	-3600	-1705	294	-4369	-842				Upper Beach
LLN30	Nov-09	Apr-10	269	1603	-1813	-387	-114	-65	-331	-2110		4807	Lower Beach
				840	4014	2707	-806	3363	-1971				Upper Beach
LLN31	May-09	Apr-10	-795	-263	-960	-22	49	221	-51	-1135		-3848	Lower Beach
				540	274	1022	-501	-973	-2771				Upper Beach
LLN32	**Oct-01**	**Nov-09**	**-5037**	**-13900**	**-5494**	**-40**	**-14**	**48**	**310**	**2960**	**-2300**	**-81970**	Lower Beach
				-17262	**-28483**	**-9980**	**385**	**-677**	**6552**				Upper Beach
LLN33	Nov-09	May-10	295	1179	-3058	-680	-270	-182	-560	-4174	-1758	1801	Lower Beach
				1570	6299	3873	-1207	4240	-2737				Upper Beach
LLN34	May-10	Oct-10	328	578	2918	349	330	255	-13	365	1141	5540	Lower Beach
				24	-1066	-658	422	-278	129				Upper Beach
LLN35	**Oct-01**	**Oct-10**	**-5108**	**-12125**	**-5496**	**-150**	**36**	**-8**	**5**	**-875**	**-2835**	**-74953**	Lower Beach
				-15611	**-23754**	**-6747**	**-415**	**3400**	**3922**				Upper Beach
LLN36	**Oct-01**	**Feb-13**	**-4086**	**-12533**	**-9887**	**-217**	**-130**	**-69**	**79**	**2892**	**-3195**	**-83259**	Lower Beach
				-16583	**-24496**	**-10239**	**-728**	**24**	**7273**				Upper Beach
LLN37	**Oct-01**	**Spr-13**	**-5484**	**-14208**	**-15779**	**-582**	**-244**	**-522**	**-65**	**-1895**	**-2836**	**-84990**	Lower Beach
				-16577	**-23610**	**-7578**	**-1773**	**2692**	**3472**				Upper Beach
LLN38	Oct-10	Spr-13	203	-1072	-5604	14	-450	-548	4	-892	-161	-5806	Lower Beach
				923	4815	-802	-1515	-520	-200				Upper Beach
LLN39	Spr-13	Jan-14	-339	289	-587			2		3568	-492	-4849	Lower Beach
				1935	-3249	-1586	1241	-5561	-72				Upper Beach
LLN40	**Oct-01**	**Jan-14**	**-5117**	**-9475**	**-8335**					**1712**	**-3325**	**-74937**	Lower Beach
				-14642	**-26859**	**-9078**	**-512**	**-2704**	**3395**				Upper Beach
LLN41	Spr-13	Aut-13	467	1274	1	-160	-65	415	-33	-1075	-499	5396	Lower Beach
				705	2272	1587	750	1454	-1698				Upper Beach
LLN42	**Oct-01**	**Aut-13**	**-5145**	**-12934**	**-15778**	**-664**	**-189**	**-129**	**56**	**-2971**	**-3335**	**-79370**	Lower Beach
				-15872	**-21337**	**-5992**	**-1023**	**4146**	**1797**				Upper Beach
LLN43	Jan-14	Spr-14	25	1556	911					2376	577	30223	Lower Beach
				4641	18206	-303	93	-280	2421				Upper Beach
LLN44	**Oct-01**	**Spr-14**	**-5839**	**-13451**	**-12728**	**-282**	**250**	**-311**	**-78**	**4045**	**-2746**	**-57282**	Lower Beach
				-10001	**-8653**	**-9468**	**-412**	**-3258**	**5921**				Upper Beach
LLN45	Spr-14	Aut-14	-41	1045	117	-539	-296	-605	-115	703	-404	4178	Lower Beach
				1218	-1856	1666	202	1865	1201				Upper Beach
LLN46	**Oct-01**	**Aut-14**	**-5880**	**-12406**	**-12611**	**-821**	**-46**	**-916**	**-194**	**4753**	**-3151**	**-53101**	Lower Beach
				-8783	**-10508**	**-7801**	**-211**	**-1393**	**7122**				Upper Beach

The key points arising from the analyses carried out are:

- Behaviour is cyclical within sections and overall across the frontage but generally the majority of the sections are showing losses of material, since the recharge was completed in 2000;
- Comparing the first post full recharge survey (Oct-01) with the pre winter 13-14 storm survey (Aut-13) – LLN37, there had been beach losses of nearly 85,000m^3 of material with all areas of the beach with only the upper beach in sections 7 and 8 showing an increase. This suggests that whilst there is some longshore movement taking place, on-offshore movement contributes more to losses than longshore change;
- By analysing the differences between Spr-13 and Jan-14 and Spr-13 the total losses due to the December 2013 and January 2014 storms was about 10,000m^3 across the entire bay, of which 8,000m^3 was lost from the recharged section; and
- Even allowing for the 30,000m3 import of material following the winter 13-14 storms in spring 2014, LLN43 refers, beach volumes at the end of 2014 were 50,000m^3 less across the both the recharged section (sections 2-5) and the bay as a whole, suggesting that the sections to the east of the paddling pool (ref 6-9) are in reasonable equilibrium over that period.

The North West England and North Wales SMP2 suggested that *"there is some evidence of a drop in beach levels within Ormes Bay over the last century, which is thought to have been exacerbated by the defences. In terms of future evolution, the resilient cliffs of Great Orme and Little Orme are unlikely change significantly, but the future of Ormes Bay will depend, in part, upon how the frontage is managed. Evolution of the frontage may also be affected by the future development of Constable Bank which, due to its 5-10 metre elevation above the surrounding seabed, currently affords some protection to this shoreline. In addition there may also be a sediment transfer between the bank and the shoreline, although the magnitude and predominant direction of this is uncertain".*

West Shore Behaviour

General Behaviour

The west of Wales SMP2 provided a general synopsis of sediment transport behaviour and produced a conceptual map of processes, as shown in Figure 2.23 below.

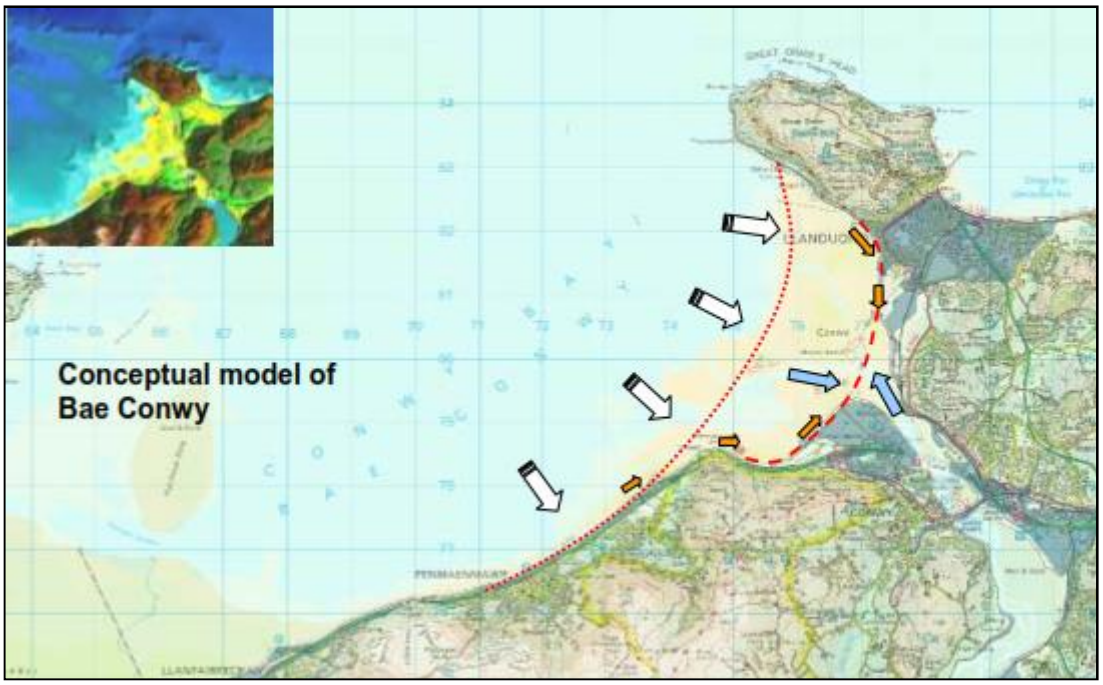


Figure 2.23 – West Shore and Conwy Bay Conceptual Process Behaviour

The SMP2 suggests that *"at the macro scale, the area can be seen as a large bay formed between Penmaenmawr (Pen-y-Clip) and the Great Orme. This effectively forms the low water shape of the area with a sediment slope against which larger waves are working. To the north, one might expect some drift to the south over the low water area and this is reflected in the way in which the southern channel of the Conwy forms a spit in a south westerly direction".*

Locally, along the northern shoreline of the outer estuary the glacial deposit to the base slopes of the Great Orme has been a contributor to sediment into the system. These coastal slopes are at present
relatively stable and much of this supply will have been taken out of the process. Drift along the Gogarth frontage will be towards Llandudno West Shore. Prior to construction of the fishtail breakwaters there was a relatively rapidly dropping foreshore in front of the sea wall. The breakwaters and subsequent recharge have slowed this process. With the breakwaters in place, the shoreline has adapted to a relatively stable orientation. The backshore in the centre of the frontage between the north and central breakwater is still in advance of the fully developed bay shape, but is capable of retaining a good width of shingle beach.

Recorded Beach Movement & Change

There is much less historical data relating to sediment movement across the West Shore frontage. In 1940, Sir Cyril Kirkpatrick in his report to , identified changes in beach level across the frontage over periods ranging from 12 (1927-1939) to 35 years (1904-1939) of between 0 and 2 metres, dependant on location and length of record.

The Aberconwy Coastal Study identified that there were no long term data sets of beach profiles available but that generally beach levels at the toe of the sea were at MHWNT level or lower.

Monitoring of the beach since 1997 following scheme implementation in 1992 has been carried out by the recording of beach plan surveys from the Great Orme to Deganwy. The following sections, as shown on Figure 2.24 below, are of primary interest to the present study:

- Areas 1 to 4 north of the Gogarth Breakwater;
- Area 5 between the Gogarth and Lloyd St Breakwaters;
- Area 6 between the Lloyd St and Cerrig Duon Breakwaters;

Analysis of the surveys comprises comparison of surveys to produce plots show areas of gains and losses. Since 2008 surveys have sub divided the longshore areas into upper and lower beach to record the changes across the sections of shingle/cobble beach and sand beach separately. The results of the changes are provided in Table 2.11 below.

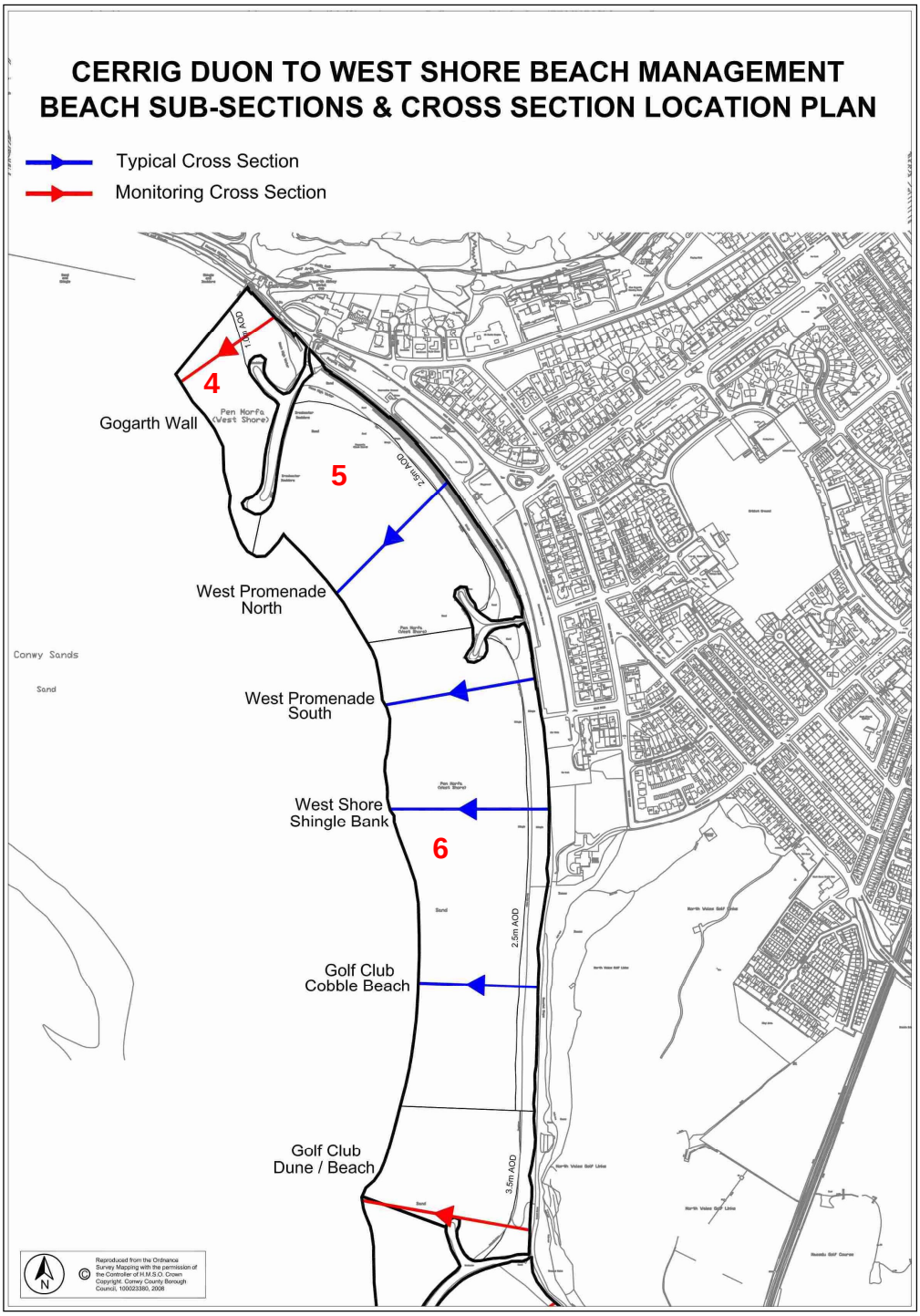


Figure 2.24 – Beach Plan Monitoring Areas 1997 to present day - West Shore

Table 2.11 – Beach Volume Changes – West Shore 1997-2013

			Fill (+) / Cut (-) Balances							
Drawing No	Base Model	Re-Survey Model	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Total Sections 4-6	
LLW-1	Oct-97	May-98			2540	1095	18740	-980	18855	
LLW-2	May-98	Oct-98			-4346	-5533	-36097	-35068	-76698	
LLW-3	Oct-98	Apr-99			3491	7489	8152	23375	39016	
LLW-4	Apr-99	Oct-99			1622	654	4638	4069	9361	
LLW-5	Oct-99	May-00			1502	1057	-4353	-10587	-13883	
LLW-6	May-00	Oct-01			3982	3609	10571	14488	28668	
LLW-13	**Oct-97**	**Oct-01**			**9242**	**8648**	**1870**	**-4829**	**5689**	
LLW-7	Oct-01	Jun-02	573	-45	-1490	1114	-1271	1728	1571	
LLW-8	Jun-02	Oct-02	-382	-1112	1279	2590	2103	895	5588	
LLW-9	Oct-02	May-03	43	-869	741	145	-1560	-5527	-6942	
LLW-10	May-03	Sep-03	-870	1168	-326	646	-311	2529	2864	
LLW-11	Sep-03	May-04	-624	-1726	-295	412	-2122	-15866	-17576	
LLW-16	**Oct-01**	**May-04**	**-1197**	**-2446**	**-76**	**5015**	**-3006**	**-15189**	**-13180**	
LLW-12	May-04	Oct-04	25	-2019	-836	1081	673	1817	3571	
LLW-15	**Oct-01**	**Oct-04**	**-1242**	**-4392**	**-770**	**6130**	**-2280**	**-13431**	**-9581**	
LLW-14	**Oct-97**	**Oct-04**			**8280**	**14953**	**-285**	**-22489**	**-7821**	
LLW-17	Oct-04	Jul-05	135	860	1544	7	-774	-6691	-7458	
LLW-18	Jul-05	Nov-05	419	-40	-4600	-1323	-4653	-10770	-16746	
LLW-19	**Oct-01**	**Nov-05**	**-599**	**-3574**	**-3564**	**4425**	**-7575**	**-32687**	**-35837**	
LLW-20	**Oct-97**	**Nov-05**			**5508**	**13301**	**-5251**	**-47412**	**-39362**	
LLW-21	Nov-05	Jul-06	-522	-549	-885	695	2931	2555	6181	
LLW-22	Jul-06	Oct-06	301	1472	-423	502	1910	4108	6520	
LLW-23	Oct-06	Apr-07	1	580	1092	2779	4023	4672	11474	
LLW-24	Apr-07	Nov-07	-585	-83	-2119	-1942	-5325	-7139	-14406	
LLW-25	**Oct-97**	**Nov-07**			**3927**	**15484**	**-1677**	**-40096**	**-26289**	
LLW-26	Nov-07	May-08	219	-1865	-936	-571	-482	-5790	-6843	
LLW-27	May-08	Oct-08	-225	-327	-238	-466	-1316	-2094	-3876	Lower Beach
				-21	77	-1			-1	Upper Beach
LLW-28	Oct-08	Jun-09	489	-793	-153	750	3516	-7626	-3360	Lower Beach
				270	-141	542			542	Upper Beach
LLW-29	Jun-09	Nov-09	-444	1725	-738	-216	-514	91	-639	Lower Beach
				-207	492	-132			-132	Upper Beach
LLW-30	**May-04**	**Nov-09**	**-211**	**-110**	**-1874**	**945**	**1397**	**-1994**	**348**	Lower Beach
				-564	**1910**	**1910**			**1910**	Upper Beach
LLW-31	Nov-09	Jun-10	86	-307	-152	98	-519	4158	3737	Lower Beach
				140	237	266			266	Upper Beach
LLW-32	Jun-10	Oct-10	15	-288	325	305	2000	4680	6985	Lower Beach
				-175	-580	242			242	Upper Beach
LLW-33	**May-04**	**Oct-10**	**-82**	**-792**	**-7319**	**-297**	**1695**	**-16765**	**-15367**	Lower Beach
				-543	**-763**	**2479**			**2479**	Upper Beach
LLW-34	**Oct-97**	**Oct-10**		**2451**	**8568**	**998**	**-46678**	**-37112**	Lower Beach	
					-1467	**6985**			**6985**	Upper Beach
LLW-35	Oct-10	Spr-13	-91	-1001	-3058	-269	-1164	-17971	-19404	Lower Beach
				-198	1567	1230			1230	Upper Beach
LLW-36	**May-04**	**Spr-13**	**-176**	**-1795**	**-10280**	**-461**	**320**	**-32856**	**-32997**	Lower Beach
				-776	**808**	**3789**			**3789**	Upper Beach
LLW-37	Spr-13	Dec-13PS	164	15	-100	702	763	1207	2672	Lower Beach
				-279	-678	-384			-384	Upper Beach
LLW-38	**May-04**	**Dec-13PS**	**-44**	**-1782**	**-10381**	**241**	**1083**	**-30947**	**-29623**	Lower Beach
				-1054	**130**	**3405**			**3405**	Upper Beach

The key points arising from the analyses carried out are:

- Behaviour is cyclical within sections and overall across the frontage but generally the upper sections of beach are showing are stable/ modestly accreting trend, whilst the lower sections of beach are showing losses. Some of these losses will be associated with aeolian transport of sand from the lower beach into the upper sections, which has been a direct contributor of the dune development at the root of the Gogarth and Lloyd St groynes and along the North Wales Golf Club frontage;
- The lower beach sections don't include the whole area of the inter-tidal zone with surveys generally not recording lower than the -1.0m ODN contour. The total area of lower beach monitored in sections 4-6 is approximately 350,000m^2. With total lower beach losses since 1997 of about 50,000m^3, this equates to an average reduction of approximately 150mm per m^2 or 10mm/m^2/annum.
- The effects of the December 5th 2013 storm at West Shore appear to be a reverse of normal behaviour with overall an increase in lower beach volume coupled with a slight decrease in upper beach volume, with waves potentially mobilising out inter-tidal sediments further offshore and moving them shoreward whilst at the same time causing scour at the upper beach and draw down of sediment into the upper parts of the lower beach.

Generally, as identified in the SMP2, the construction of the breakwaters and associated fishtail groynes has acted to stabilise upper beach conditions across the frontage intercepting waves from the predominant direction that previously would have been incident on the sea wall and blocking wave induced southerly longshore sediment transport across the frontage. Predominant NW incident waves that by-pass the northerly groyne are still able to drive material southerly across the lower beach some of which is trapped by the Cerrig Duon breakwater at the southern end of the frontage. Conversely, the Gogarth breakwater may be contributing to the losses associated with the lower beach in sections 5 and 6 by trapping material that might otherwise have been moved southerly across the lower parts of the beach.

3. Coastal Defence Assessment

3.1.1 Coastal Defence Inspections

Details of all coastal defence structures applying in Wales were brought together in the Coastal Survey of Wales (Welsh Office, 1995) based on information largely provided by the Coast Protection Authorities and the then Flood defence body, the National Rivers Authority.

Since 1996, Conwy County Borough Council has carried out regular inspections of their defences, to identify defects and to support their on-going capital and maintenance programme.

Repeat annual inspections were carried out on behalf of Conwy CBC by Coastal Engineering from 2002 to 2012[27]. The proforma used for recording information relating to these asset inspections provides summary information relating to code, location and structure type for each defence length, together with an assessment of the condition and rate of deterioration since the previous inspection and photos of key aspects of each defence length. A quantitative risk based assessment of the integrity of each defence length, in accordance with an agreed risk methodology adopted by the Cell 11 Coastal Groups is also provided. A summary of this for the defence lengths within the Llandudno BMP area is provided in below.

In addition it also includes an assessment of the residual life of each defence length under two scenarios – No Active Intervention (Do-Nothing) and Continued Current Management.

Relevant details from the 2012 survey, relevant to the Llandudno area are provided in Appendix I.

Table 3.1 – CCBC Asset Condition & Risk Assessment 2012

WOS (1995) Ref. No.	Structure		Nature	Status - Condition	Status - Deterioration	Significance	Risk Score	Risk level
	Name	Length (km)						
W.41.6488	Cerrig Duon Breakwater	0.25	Armour stone breakwater	2	2	4	16	Low
W.41.6485	North Wales Golf Club (1)	0.60	Recharge, Dunes	2	1	3	6	Low
	West Shore Shingle Bank	0.31	Shingle Bank	3	2	4	24	Medium
W.41.6480	Lloyd St.Breakwater	0.07	Armour stone breakwater	3	2	5	30	Medium
W.41.6725	Llandudno West Promenade	0.76	Recharge, Sea Wall	3	2	5	30	Medium
W.41.6478	Gogarth Breakwater	0.26	Armour stone breakwater	2	2	5	20	Low
W.41.6475	Gogarth Wall	0.10	Sea Wall, Revetment	4	2	4	32	Medium
W.41.6450	Grand Hotel and Pier	0.36	Sea Wall	3	2	4	24	Medium
W.41.6720	Llandudno Promenade	1.43	Recharge,Revetment, Sea Wall	2	2	5	20	Low
W.41.6445	Craig-y-Don	0.32	Sea Wall, Recharge	2	2	5	20	Low
W.41.6440	Craig-y-Don, Boating Pool	0.16	Sea Wall, Groyne	3	2	3	18	Low

[27] Coastal Engineering, December 2012. Annual Coastal Defence Monitoring Inspection 2012. Report for Conwy County Borough Council

In 2015 JBA undertook a nationwide survey of the profile and condition of tidal defences in Wales[28], on behalf of Natural Resources Wales.

At West Shore, three assets were recorded:

The North West Golf Club Dunes;

The main stepped sea wall structure – Asset Ref: 31949;

The concrete promenade and recurved wave wall – Asset Ref 10155551

No condition was identified for the dunes. All other assets were given condition grade 3 – Fair.

At North Shore, the following assets were recorded:

1. The vertical wall to the Grand Hotel and Children's corner – Asset Ref: 131292B;
2. The main concrete stepped revetment – Asset Ref: 131293A;
3. The sloping masonry around the pool at Craig-Y-Don – Asset Ref: 131293; and
4. The promenade and secondary flood wall along the whole frontage – Asset Ref 10155551

No condition survey was provided for element 131292B. All other assets were given condition grade 3 – Fair.

The attached pdf files provide details of the asset condition. Note the record for length ref 131293 has the wrong asset ID (131297).

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4. Appendices

Appendix A. Coastal Defence Inspection Details 2012

WEST SHORE, LLANDUDNO – CERRIG DUON to GOGARTH

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Cerrig Duon Breakwater

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**12th October 2012**
Easting	**277283**	**277080**		
Northing	**380676**	**380535**	**Inspector:**	**AJW/AO**
			Low water time:	**15.20 (BST)**
Length:	**250 metres**		**Low water height:**	**-2.05m AOD (Llandudno)**
			Weather conditions:	**Generally dry and bright, occasional showers later**
			Wind Conditions:	**W-NW Force 4-5**
Coastal Survey Length Ref:		**W.41.6488**	**NFCDD Length Ref:**	**101JC90730401C01**
SMP2 Policy Unit Ref:		**10 20.11/12**	**Responsibility:**	**Conwy CBC**

HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**Varies ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**Varies ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:		**Relative Foreshore Level:**	

Beach Type:	**Sand**
Defence Type:	**Breakwater**
Revetment Type:	**Rock Armour 3-6 t**
Defence Description:	**Armour Stone breakwater**
Design Standard:	

Residual Life Expectancy			
No Active Intervention:	>40 years	**Current Management:**	>50 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 16	**Assessment: Low**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	**ST**	**Con**	**Photo Ref.**	**Position**	**Report/Description**	**Action Required**	**Action Implemented**

14.17	7	2	12_109	CC114	View from root of structure looking seaward along shore connected arm	On-going monitoring of defence condition and foreshore	Monitoring on-going
14.22			12_113		View from junction of arms looking along south west arm		
14.22	7	2	12_112	CC115	View from junction of arms looking along north west arm		
14.22			12_111		View from junction of arms looking landward along shore connected arm		Monitoring on-going
14.25	1,7	2	12_114	CC115b	Main arm roundhead and apron		
14.29	7		12_115		Navigation Marker	Re-painting	
14.34	1,7	2	12_116	CC115c	'Crotch' of breakwater arms from beach	On-going monitoring of defence condition and foreshore	Monitoring on-going
					Outside face of upstream arm		Monitoring on-going
14.37	1,7	2	12_117	CC115d	Roundhead and upper beach at downstream arm		

Photographs

Frame CCBC_ 121012_109

Frame CCBC_ 121012_115

INSPECTION OBSERVATIONS	
July 2004	No noticeable change in condition of defences observed from previous inspection
July 2005	No noticeable change in condition of foreshore or defences observed from previous inspection
August 2006	Increased beach levels on north side otherwise no noticeable change in condition of foreshore or defences observed from previous inspection
August 2007	No noticeable change in condition of foreshore or defences observed from previous inspection
July 2008	No noticeable change in condition of foreshore or defences observed from previous inspection
October 2009	Outer perimeter of breakwater inspected with good sand build up along southern flank and offshore between arms.

	No change in structure condition.
October 2010	No change in structure condition. Some sand build up around roundheads.
September 2011	No overall change in structure condition and generally beach conditions around structure as previously observed, apart from a scour pond on the landward side of the downstream arm roundhead [LH side of frame 137-38].
October 2012	Further accretion on northern side of structure but no change in structure condition. Bedstone apron to main arm partially exposed. Navigation marker pole and can mark [12_115] in need of re-painting.
ON-GOING MONITORING/MANAGEMENT ACTIONS	
Frontage incorporated within Conwy Council's on-going bi-annual coastal defence monitoring programme, as recommended in final report of Conwy Estuary Monitoring (2004-08) programme. Frontage included within (draft) Authority wide beach management plan. Maintenance works to navigation markers. Continue with regular visual inspections (minimum annually).	

Chronological Photograph Log **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**October 2012**
View from root of structure looking seaward along shore connected arm	8070118	7280115	2009_3_129 2009_3_130	18_137_38	07_123-24	12_109
View from junction of arms looking along south west arm	8070122	7280118	2009_3_133	18_140_41 18_141_42	07_127 07_128	12_113 12_112
View from junction of arms looking seaward between SW and NW arms			2009_3_134	2009_3_134		
View from junction of arms looking along north west arm	8070123	7280119	2009_3_135	2009_3_135		
View from junction of arms looking landward along shore connected arm	8070125	7280121	2009_3_137	18_143_44	07_126	12_111
Lower beach upstream from upstream roundhead			2009_3_139	18_146	07_129-30	12_114
Lower beach downstream from upstream roundhead			2009_3_141	18_147	07_131-32	
Navigation Marker on upstream roundhead			2009_3_140	18_145		12_115
Outer 'Crotch' of breakwater arms			2009_3_142	18_148_49	07_133-36	12_116
Outside of upstream arm			2009_3_143	18_150		
Roundhead and upper beach at downstream arm			2009_3_144	18_151_52	07_137-38	12_117

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: North Wales Golf Club (1)

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**12th October 2012**
Easting	**277283**	**277314**	**Inspector:**	**AJW/AO**
Northing	**380676**	**381273**	**Low water time:**	**15.20 (BST)**
			Low water height:	**-2.05m AOD (Llandudno)**
Length:	**600 metres**		**Weather conditions:**	**Generally dry and bright, occasional showers later**
			Wind Conditions:	**W-NW Force 4-5**
Coastal Survey Length Ref:		**W.41.6485**	**NFCDD Length Ref:**	**101JC90730401C01**
SMP2 Policy Unit Ref:		**10 20.11/12**	**Responsibility:**	**Conwy CBC**

HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**6.0m ODN**	**Beach Stability:**	**Eroding**
Foreshore Level:	**5.5-6.0m ODN**	**Foreshore Dependency:**	
Action Beach Level:	**5.0m ODN**	**Relative Foreshore Level:**	**High**

Beach Type:	**Cobbles (upper); Sand (lower)**
Defence Type:	**Shore**
Revetment Type:	**Cobbles**
Defence Description:	**Recharged beach and dunes**
Design Standard:	

Residual Life Expectancy

No Active Intervention:	NA	**Current Management:**	NA

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 6	**Assessment: Low**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
14.19	3,26	2	12_110	CC114	View from root of Cerrig Duon breakwater looking north	On-going monitoring of defence condition and foreshore. Wind blown	Monitoring and wind blown sand removal on-going
14.22	1,3	2	12_111	CC115	View from crotch of Cerrig Duon breakwater looking landward		
14.40	3,23	2	12_118	CC115a	View south towards breakwater		
14.42	3,23	2	12_119	CC115a	View north towards breakwater		

14.45	1	2	12_120	CC116	View south from interface of sand/shingle beach with cobble reinforced beach	sand removal	
14.45	3	2	12_121	CC116	View north from interface of sand/shingle beach with cobble reinforced beach		
14.48	3,23	2	12_122	CC116a	View south along cobble beach		
14.48	3,23	2	12_123		View north along cobble beach		
14.49	1,3	3	12_124	CC116a	Beach Panorama		
14.52	3	2	12_125	CC117	View from northern end of dunes looking south	On-going monitoring of defence condition and foreshore. Wind blown sand removal	Monitoring and wind blown sand removal on-going

Photographs

Frame CCBC_ 121012_110

Frame CCBC_ 121012_119

Frame CCBC_ 121012_124

INSPECTION OBSERVATIONS	
July 2004	No noticeable change in condition of defences observed from previous inspection
July 2005	Further accretion at upper beach/dune interface, otherwise no noticeable change in condition of foreshore observed from previous inspection
August 2006	Beach recharge carried out to first 200 metres north of breakwater with new unbound access constructed along crest of beach along entire frontage. Some movement of toe of cobble beach observed along entire length
August 2007	Significant wind blown sand on access track between CC115 and CC115a. No significant movement of newly recharged beach cobble or shingle observed.
July 2008	Wind blown sand continuing to cover access track immediately north of Cerrig Duon breakwater and further to the north. No change in defence condition.
October 2009	Wind blown sand being removed from access track. New sand fences erected towards crest of

	breakwater [132]. Otherwise no change in defence or beach condition.
October 2010	No change in the condition of the cobble beach but significant quantities of wind blown sand deposited on to the upper beach and access. Some additional sand fencing erected at southern end.
September 2011	Despite erection of sand fencing wind blown sand has continued to be deposited on the cycle path access, notably at the southern end between the breakwater and the cobble beach (between Waypoints 115 and 116a) [139-40; 142; 144].
October 2012	Dune growth at the southern end of the frontage is continuing [12_110]. Clearance of the path through the dunes has been carried out but the present sand fences are being overwhelmed [12_119], requiring a more robust construction and more regular clearance. Lower foreshore channel closest to the shoreline appears more prominent with underlying deposits beneath sand exposed [12_124]. These observations need correlating with beach monitoring surveys.
ON-GOING MONITORING/MANAGEMENT ACTIONS	
On-going monitoring and management of beach and access track required as necessary. Suggestions for improved wind blown sand management contained within report (Coastal Engineering, Sept 2012). Frontage included within (draft) Authority wide beach management plan. Wind blown sand to be disposed of on lower sections of beach, in accordance with MCU licence T&C. Frontage incorporated within Conwy Council's on-going bi-annual coastal defence monitoring programme, as recommended in final report of Conwy Estuary Monitoring (2004-08) programme. Continue with regular visual inspections. Although risk assessments suggest annual frequency, susceptibility of beach to movement indicates a more proactive monitoring regime (minimum bi-annually).	

Chronological Photograph Log **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**October 2012**
View from root of Cerrig Duon breakwater looking north along frontage	8070120	7280117	2009_3_132	18_139	07_125	12_110
View from Cerrig Duon Breakwater (CC115)	8070126	7280122	2009_3_138	18_143_44	07_126	12_111
View south from mid-way down new recharged beach (CC115a)	8070127	7280123	2009_3_146	18_153	07_139-40	12_118
View north from mid-way down new recharged beach (CC115a)	8070128	7280124	2009_3_147	18_154	07_141	12_119
View from interface of sand/shingle beach with cobble reinforced beach looking south (CC116)	8070130	7280125	2009_3_148	18_155	07_142	12_120
View from interface of sand/shingle beach with cobble reinforced beach looking north (CC116)	8070129	7280126	2009_3_149	18_156	07_143	12_121
Wind blown sand clearance			2009_3_150			
View south from part way along cobble beach		7280127	2009_3_151	18_157	07_144	12_122
View north from part way along cobble beach		7280128	2009_3_152	18_158	07_145	12_123
Beach Panorama from middle of frontage			2009_3_153	18_159_60	07_146-47	12_124
			2009_3_154	2009_3_154		
			2009_3_155	2009_3_155		
View from northern end of dunes looking south	8070131	7280129	2009_3_156	18_161	07_148	12_125

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: West Shore Shingle Bank

Position Details

	Start	Finish
Easting	277314	277315
Northing	381273	381579

Length: 310 metres

Survey Details

Date: 12th October 2012
Inspector: AJW/AO
Low water time: 15.20 (BST)
Low water height: -2.05m AOD (Llandudno)
Weather conditions: Generally dry and bright, occasional showers later
Wind Conditions: W-NW Force 4-5

Coastal Survey Length Ref:		**NFCDD Length Ref:**	**101JC90730401C01**
SMP2 Policy Unit Ref:	**10 20.11/12**	**Responsibility:**	**Conwy CBC**
HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**6.0m ODN**	**Beach Stability:**	**Eroding**
Foreshore Level:	**5.0-6.0m ODN**	**Foreshore Dependency:**	
Action Beach Level:	**4.5m ODN**	**Relative Foreshore Level:**	**Medium**

Beach Type:	**Shingle (upper); Sand (lower)**
Defence Type:	**Shore**
Revetment Type:	**Shingle**
Defence Description:	**Natural Shingle Bank**
Design Standard:	

Residual Life Expectancy

No Active Intervention: NA	**Current Management:** NA

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 24	**Assessment: Medium**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
14.53	2, 23	2	12_126	CC117	View north across frontage from southern end	On-going monitoring of defence condition and foreshore. Wind blown sand removal	Monitoring on-going
14.58	2	2	12_127	CC118	View south across frontage from northern end		

Photographs

Frame CCBC_ 121012_126

Frame CCBC_ 121012_127

INSPECTION OBSERVATIONS	
July 2004	No noticeable change in condition of foreshore observed from previous inspection Temporary access ramp with sand covering formed across upper shingle beach
July 2005	No noticeable change in condition of foreshore observed from previous inspection No temporary access ramp
August 2006	New unbound access built behind crest of shingle bank and localised re-profiling of shingle beach carried out. No significant change in beach condition.
August 2007	No noticeable change in condition of foreshore or defences observed.
July 2008	Some movement of upper beach deposits but no change in shoreline condition
October 2009	Little change in beach condition and no evidence of significant disruption
October 2010	Some movement and apparent depletion of shingle bank with seaward edge of crest steepened at south end. No evidence of disruption to access or hinterland
September 2011	Less surficial sand observed mixed in with upper beach shingle but otherwise no change in conditions observed.
October 2012	Little change in beach condition and no evidence of significant disruption

ON-GOING MONITORING/MANAGEMENT ACTIONS

On-going monitoring and management of beach and access track required as necessary. Suggestions for improved wind blown sand management contained within report (Coastal Engineering, Sept 2012). Frontage included within (draft) Authority wide beach management plan.
Wind blown sand to be disposed of on lower sections of beach, in accordance with MCU licence T&C.
Frontage incorporated within Conwy Council's on-going bi-annual coastal defence monitoring programme, as recommended in final report of Conwy Estuary Monitoring (2004-08) programme.
Continue with regular visual inspections. Although risk assessments suggest annual frequency, susceptibility of beach to movement indicates a more proactive monitoring regime (minimum bi-annually).

Chronological Photograph Log Description of View	August 2007	July 2008	October 2009	October 2010	September 2011	October 2012
View north across frontage from southern end (CC117)	8070132	7280130	2009_3_157	18_162	07_149	12_126
View south from start of armour rocks (CC117a)	8070133	7280131	2009_3_158			
View north from start of armour rocks (CC117a)	8070134	7280132	2009_3_159	18_163		
View south across frontage from northern end (CC118)	8070135	7280133	2009_3_160	18_164	07_150	12_127

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Lloyd St. Breakwater

Position Details			**Survey Details**	
			Date:	**12th October 2012**
			Inspector:	**AJW/AO**
			Low water time:	**15.20 (BST)**
			Low water height:	**-2.05m AOD (Llandudno)**
			Weather conditions:	**Generally dry and bright, occasional showers later**
			Wind Conditions:	**W-NW Force 4-5**
	Start	**Finish**		
Easting	**277293**	**277228**		
Northing	**381728**	**381722**		
Length:	**70 metres**			
Coastal Survey Length Ref:	**W.41.6480**		**NFCDD Length Ref:**	**101JC90730501C01**
SMP2 Policy Unit Ref:	**10 20.11/12**		**Responsibility:**	**Conwy CBC**

HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**Varies ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**Varies ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:		**Relative Foreshore Level:**	

Beach Type:	**Sand**
Defence Type:	**Breakwater**
Revetment Type:	**Rock Armour 3-6 t**
Defence Description:	**Armour Stone breakwater**
Design Standard:	

Residual Life Expectancy

No Active Intervention:	>40 years	**Current Management:**	>50 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 20	**Assessment: Medium**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
15.06	1	2	12_131	CC119	View seaward from sea wall at root of groyne showing embryo dune growth	On-going monitoring of defence condition and foreshore. Beach to be cleared from in front of outfall	Monitoring on-going
15.08	7	2	12_132	CC120	View from junction of arms looking along south west arm		
15.09	7		12_133		View from junction of arms looking along north west arm		
15.09	20		12_134		View of discharge of storm water outfall		
15.13	7	4	12_137	CC120aa	Lloyd St Breakwater (Beach - North Arm)	Replace and re-fit armour blocks to breakwater toe	
15.12	7	4	12_136	CC120ab	Lloyd St Breakwater (Beach - South Arm)		

Photographs

Frame CCBC_ 121012_131

Frame CCBC_ 121012_136

Frame CCBC_ 121012_137

INSPECTION OBSERVATIONS	
July 2004	No noticeable change in condition of structure observed from previous inspection
July 2005	No noticeable change in condition of structure observed from previous inspection
August 2006	No noticeable change in condition of structure observed from previous inspection
August 2007	No noticeable change in condition of structure observed from previous inspection
July 2008	No change in structure condition
October 2009	More channels in evidence on lower beach seaward of breakwater but no change in defence condition.
October 2010	Toe blocks to both armour arms have moved with some local undermining on north west arm [18_176]. Also the beach needs has built up in front of the outfall flap valves. Otherwise no change identified.
September 2011	Reinstatement of armour blocks along seaward edge of breakwater arms has been carried out, although one block on upstream flank remains out of position [161]. Sediment build up in front of flaps has also been moved allowing valves to open. Otherwise no change in conditions observed.
October 2012	Reinstatement of toe rock armour and navigation marker beacons to both seaward flanks of breakwater arms has been undertaken and maker piles and can markers have been re-painted [12_136, 12_137]. Apron in front of outfall flap valves clear. Dune growth at landward end of structure on-going [12_131].
ON-GOING MONITORING/MANAGEMENT ACTIONS	
Frontage incorporated within Conwy Council's on-going bi-annual coastal defence monitoring programme. No changes to existing monitoring regime proposed. Frontage included within (draft) Authority wide beach management plan. Wind blown sand to be disposed of on lower sections of beach, in accordance with MCU licence T&C. Suggestions for improved wind blown sand management contained within report (Coastal Engineering, Sept 2012). Continue with regular visual inspections (minimum annually).	

Chronological Photograph Log **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**October 2012**
View seaward from sea wall at root of groyne showing embryo dune growth	8070138	7280137	2009_3_163	18_168_69	07_153-54	12_131
View from junction of arms looking along south west arm	8070140	7280138	2009_3_165	18_170	07_156	12_132
View from junction of arms looking along north west arm	8070141	7280139	2009_3_166	18_171	07_158	12_133
View of discharge of storm water outfall	8070143	7280140	2009_3_167	18_174 18_178	07_157	12_134
Lloyd St Breakwater (Beach - North Arm)				18_175 18_176	07_162 07_163	12_137
Lloyd St Breakwater (Beach - South Arm)				18_177	07_161	12_136

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Llandudno West Promenade

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**12th October 2012**
Easting	**277315**	**276900**	**Inspector:**	**AJW/AO**
Northing	**381579**	**382213**	**Low water time:**	**15.20 (BST)**
			Low water height:	**-2.05m AOD (Llandudno)**
Length:	**760 metres**		**Weather conditions:**	**Generally dry and bright, occasional showers later**
			Wind Conditions:	**W-NW Force 4-5**
Coastal Survey Length Ref:		**W.41.6725**	**NFCDD Length Ref:**	**101JC90730501C01**
SMP2 Policy Unit Ref:		**10 20.11/12**	**Responsibility:**	**Conwy CBC**

HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**6.7m ODN**	**Beach Stability:**	**Accreting**
Foreshore Level:	**6.0m ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:	**4.0m ODN**	**Relative Foreshore Level:**	**High**

Beach Type:	**Shingle and Cobbles (upper); Sand (lower)**
Defence Type:	**Sea Wall**
Revetment Type:	**Concrete (in situ)**
Defence Description:	**Stepped concrete sea wall with recharged beach**
Design Standard:	

Residual Life Expectancy

No Active Intervention:	>10 years	**Current Management:**	>20 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 30	**Assessment: Medium**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
15.00	2,22	3	12_128	CC118	View from southern end looking north	On-going monitoring of defence condition and foreshore.	Monitoring and wind blown sand removal on-going
15.05	22, 24	3	12_129	CC119	View from landward end of Lloyd St groyne looking south and north		
15.05	1,22	2	12_130				

					respectively with embryo dune growth and wind blown sand on promenade	Wind blown sand removal	
15.10	1,2	2	12_135	CC120	Upper beach to either side of breakwater		
15.18	3	2	12_138	CC121	View from centre of cobble reinforced upper beach looking south		
15.19 15.21	3	2	12_139 12_141	CC121	View from centre of cobble reinforced upper beach looking north		
15.21	3,22	2	12_140	CC121a	South from end of cobble upper beach	On-going monitoring of defence condition and foreshore. Wind blown sand removal	Monitoring and wind blown sand removal on-going
15.21	2,11	3	12_142		North showing exposed steps		
15.26	1		12_143		View of compacted area of upper beach in front of wall on north side of Gogarth groyne		
15.45	11	3	12_152	CC124	View from north end of wall section looking south		
	1,2	2			View across upper beach		

Photographs

Frame CCBC_ 121012_129

Frame CCBC_ 121012_142

INSPECTION OBSERVATIONS	
July 2004	No noticeable change in condition of defences observed from previous inspection
July 2005	Increased accretion and vegetation growth around roots of Lloyd St. and Gogarth breakwaters, otherwise no noticeable change in condition of foreshore or defences observed from previous inspection.
August 2006	Observations as 2005
August 2007	Some localised movement of shingle on north side of Lloyd St. Breakwater but otherwise no significant changes observed.
July 2008	Localised movement of upper beach deposits. No change in defence condition apart from loss of small section of concrete overlay to revetment counterfort [149].
October 2009	Artificial cobble mounds on crest flattened. Otherwise no change in defence or foreshore condition.
October 2010	Apart from some localised movement of cobble, no significant change observed. Concrete overlay defect not repaired.
September 2011	Conditions remain as previously identified, with concrete wall defects still outstanding.
October 2012	No change in conditions applying across frontage. Existing defects are still outstanding.
ON-GOING MONITORING/MANAGEMENT ACTIONS	
Frontage incorporated within Conwy Council's on-going bi-annual coastal defence monitoring programme. No changes to	

existing monitoring regime proposed.
Frontage included within (draft) Authority wide beach management plan. Wind blown sand removed from promenade to be disposed of on lower sections of beach, in accordance with MCU licence T&C. Suggestions for improved wind blown sand management contained within report (Coastal Engineering, Sept 2012).
Continue with regular visual inspections (minimum bi-annually).
Localised repairs to exposed steps required.

Chronological Photograph Log **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2009**	**October 2010**	**October 2012**
View from southern end looking north	8070136	7280134	2009_3_161	18_165	07_151	12_128
View from south side of Lloyd St groyne looking south with wind blown sand on promenade	8070137	7280135	2009_3_162	18_166	07_152	12_129
View from north side of Lloyd St groyne looking north with embryo dune growth and wind blown sand on promenade inn foreground	8070139	7280136	2009_3_164	18_167	07_155	12_130
View(s) of upper beach to south from end of Lloyd St breakwater		7280141	2009_3_168	18_172_73	07_159-60	12_135
View(s) of upper beach to north from end of Lloyd St breakwater	8070142	7280142	2009_3_169	2009_3_169		
Crest of beach	8070144	7280143	2009_3_170	18_179_80		
View from centre of cobble reinforced upper beach (CC121) looking south	8070145	7280144	2009_3_171	18_181	07_164	12_138
View from centre of cobble reinforced upper beach (CC121) looking north	8070147	7280145	2009_3_172 2009_3_173	18_182 18_183	07_165 07_166	12_139 12_141
View south from start of exposed stepped revetment (2008)		7280147	2009_3_174	18_184	07_167	12_140
View north from start of exposed stepped revetment (2008)		7280148	2009_3_175	18_185_86	07_168-69	12_142
View across beach from start of exposed stepped revetment (2008)		7280149	2009_3_176	18_187	07_170	
View of root of Gogarth groyne looking south with embryo dune growth in foreground	8070148	7280150	2009_3_177	18_188	07_171	12_143
View of compacted area of upper beach in front of wall on north side of Gogarth groyne	8070149	7280151	2009_3_178	18_189	07_172	
View from north end of wall section (CC124) looking south	8070155	7280157	2009_3_195	18_204_5	07_186-87	12_152
View from north end of West Shore promenade wall section (CC124) looking across upper beach towards Gogarth Breakwater	8070156	7280158	2009_3_196			

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Gogarth Breakwater

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**12th October 2012**
Easting	**276931**	**276850**	**Inspector:**	**AJW/AO**
Northing	**382156**	**381905**	**Low water time:**	**15.20 (BST)**
			Low water height:	**-2.05m AOD (Llandudno)**
Length: 260 metres			**Weather conditions:**	**Generally dry and bright, occasional showers later**
			Wind Conditions:	**W-NW Force 4-5**
Coastal Survey Length Ref:		**W.41.6478**	**NFCDD Length Ref:**	**101JC90730501C01**
SMP2 Policy Unit Ref:		**10 20.11/12**	**Responsibility:**	**Conwy CBC**

HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**Varies ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**Varies ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:		**Relative Foreshore Level:**	

Beach Type:	**Sand**
Defence Type:	**Breakwater**
Revetment Type:	**Rock Armour 3-6 t**
Defence Description:	**Armour Stone breakwater**
Design Standard:	

Residual Life Expectancy

No Active Intervention:	>40 years	**Current Management:**	>50 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	8 Vertical Sea Wall
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	12 Timber Retaining Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	16 Gabion Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	20 Outfalls
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	24 Wave Return Wall
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	28 Clay Cliff
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 20	**Assessment: Low**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	**ST**	**Con**	12_143	**Position**	**Report/Description**	**Action Required**	**Action Implemented**
15.26	7	2	12_144	CC122	View from root of structure looking seaward along shore connected and SW	On-going monitoring of defence condition and foreshore	Monitoring on-going

					heading arm		
15.31	1,7	2	12_145	CC123	View from junction of arms along secondary arm		
15.31	7	2	12_146		View from junction of arms along main wave arm		
15.33	7, 26	2	12_147		View landward from junction of arms		
15.35	1	2	12_148	CC123a	Offshore from main arm roundhead		
15.37	1,7	2	12_149		Panorama of main arm roundhead.		
15.37	7	2	12_150	CC123a	Main arm navigation marker beacon	Re-painting	
15.40	1,7	2	12_151	CC123b	Outer 'Crotch' of breakwater arms	On-going monitoring of defence condition and foreshore	Monitoring on-going
15.43	1,7	2	12_151	CC123c	Roundhead and upper beach at secondary arm roundhead		

Photographs

Frame CCBC_ 121012_149

Frame CCBC_ 121012_151

INSPECTION OBSERVATIONS	
July 2004	No noticeable change in condition of defences observed from previous inspection
July 2005	Increased vegetation at root of breakwater, otherwise no noticeable change in condition of foreshore or defences observed from previous inspection
August 2006	Observations as 2005
August 2007	No noticeable change in condition of structure observed from previous inspections.
July 2008	Continued sand build up in "Y" embayment of breakwater. No change in structure condition.
October 2009	Outer perimeter of breakwater inspected with good sand build up along southern flank and offshore between arms. No change in structure condition.
October 2010	No change in structure condition or foreshore observed
September 2011	Observations as previously, with no change in structure condition or foreshore observed.
October 2012	Further accretion on northern side of structure but no change in structure condition. Bedstone apron to main arm partially exposed. Navigation marker pole and can mark [12_149] in need of re-painting.
ON-GOING MONITORING/MANAGEMENT ACTIONS	

Chronological Photograph Log **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**October 2012**
View from root of structure looking seaward along shore connected and SW heading arm	8070150	7280152	2009_3_179	18_190_91	07_173-74	12_143
View from junction of arms looking along south west arm	8070151	7280153	2009_3_180	18_192	07_175	12_145
						12_146
						12_147
View from junction of arms looking along north west arm	8070152	7280154	2009_3_182	18_193_94	07_176	12_144
View from junction of arms looking seaward between SW and NW arms	8070154	7280155	2009_3_181	2009_3_181		
View from junction of arms looking landward along shore connected arm	8070153	7280156	2009_3_183	18_195		
Panorama of lower beach and apron upstream side of roundhead			2009_3_184	18_196_97	07_177-78	12_148
			2009_3_185	2009_3_185		
			2009_3_186	2009_3_186		
Panorama of lower beach and apron downstream side of roundhead			2009_3_187	18_198_99	07_179-80	
			2009_3_188	2009_3_188		
			2009_3_189	2009_3_189		
Main arm Navigation Marker						12_149
Outer 'Crotch' of breakwater arms			2009_3_190	18_200-02	07_181-83	12_150
			2009_3_191	2009_3_191		
			2009_3_192	2009_3_192		
Roundhead and upper beach at downstream arm			2009_3_193	18_203	07_184-85	12_151
			2009_3_194			

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Gogarth Wall

Position Details

	Start	Finish
Easting	276900	276829
Northing	382213	381286

Length: 100 metres

Survey Details

Date: 12th October 2012
Inspector: AJW/AO
Low water time: 15.20 (BST)
Low water height: -2.05m AOD (Llandudno)
Weather conditions: Generally dry and bright, occasional showers later
Wind Conditions: W-NW Force 4-5

Coastal Survey Length Ref:	**W.41.6475**	**NFCDD Length Ref:**	**101JC90730601C01**
SMP2 Policy Unit Ref:	**10 20.11/12**	**Responsibility:**	**Conwy CBC**
HAT Level:	**4.6m ODN**	**Exposure:**	**High**
Defence Crest Level:	**8.0-9.0m ODN**	**Beach Stability:**	**Eroding**
Foreshore Level:	**2.5-3.5m ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:	**1.0m ODN**	**Relative Foreshore Level:**	**Medium**
Beach Type:	**Sand & Shingle (upper); Sand (lower)**		
Defence Type:	**Sea Wall**		
Revetment Type:	**Concrete (in situ)**		
Defence Description:	**Stepped concrete sea wall with rear vertical wall**		
Design Standard:			

Residual Life Expectancy

No Active Intervention:	<10 years	**Current Management:**	10-20 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 32	**Assessment: Medium**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implement

							ed
15.45	11	4	12_153	CC124	View along frontage	On-going monitoring of defence condition and foreshore Remedial works to wall and steps (as necessary)	Monitoring on-going
15.47	11	4	12_155	CC124a	View of steps		
15.46			12_154				
15.47	11	4	12_156		Damaged steps		
15.48	11	4	12_157	CC125	Exposed reinforcement to steps		
15.48	11	4	12_158	CC125	View from north end looking south		

Photographs

Frame CCBC_ 121012_153

Frame CCBC_ 121012_158

INSPECTION OBSERVATIONS	
July 2004	Further spalls and damage to steps observed Beach lower than last year at same time – two more steps exposed
July 2005	Blocks missing from rear wall, otherwise no further deterioration in condition of defences observed from previous inspection
August 2006	Beach levels fairly constant across this section. No significant worsening of defects – action still required
August 2007	Observations as for 2006
July 2008	Beach levels at toe higher than at time of previous inspection. Previous defects remain as identified – a number of additional defects recorded [0162, 0163] but no significant change in overall structure condition or risk.
October 2009	Beach levels along toe are higher than at time of previous inspection. Some patch repairs to steps have been carried out but others are still outstanding. Hole in rear wall sealed. No change in overall structure risk rating.
October 2010	Higher beach levels at southern end of frontage so some of previously identified defects covered up. No further repairs carried out to revetment. Defects identified remain.
September 2011	Wind blown sand ramped up over steps so some of defects remain covered. No change observed in condition of "uncovered" defects and generally no change in overall condition of defences or foreshore.
October 2012	Less wind blown sand but shingle beach levels improved along toe of defences. Previously identified defects still outstanding.

ON-GOING MONITORING/MANAGEMENT ACTIONS

Further repairs to stepped revetment or local beach nourishment to cover revetment (the latter is most appropriately subject to a review of whole life project costs for West Shore Coastal Works Scheme).
No changes to existing monitoring regime proposed.
Frontage included within (draft) Authority wide beach management plan.
Continue with regular visual inspections (minimum bi-annually).

Chronological Photograph Log **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**October 2012**
View from south end (CC124) looking north	8070157	7280159	2009_3_197	18_206	07_188	12_153
Step damage	8070158	7280160	2009_3_201			
	8070159	7280161	2009_3_198			
		7280163	2009_3_202	18_209	07_191	12_155
		7280162	2009_3_199	18_208 18_207	07_190 07_189	12_154
Missing blocks to rear wall	8070160	7280164	2009_3_200			
Damaged steps in northerly bay						12_156
Exposed reinforcement top step at northern end requiring overlay			2009_3_205	18_210	07_192	12_157
View from north end (CC125) looking south	8070161	7280165	2009_3_204	18_211	07_193	12_158

NORTH SHORE, LLANDUDNO – PIER to CRAIG-Y-DON BOATING POOL

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Grand Hotel and Pier

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**6th September 2012**
Easting	**278335**	**278220**		
Northing	**382934**	**382598**	**Inspector:**	**AJW/NC/MB**
			Low water time:	**09.04 (BST)**
Length:	**360 metres**		**Low water height:**	**-2.35m AOD (Llandudno)**
			Weather conditions:	**Generally dry and bright**
			Wind Conditions:	**W-SW force 2-4**
Coastal Survey Length Ref:	**W.41.6450**		**NFCDD Length Ref:**	**101KA90740201C01**
SMP2 Policy Unit Ref:	**11a 1.2**		**Responsibility:**	**Private**

HAT Level:	**4.7m ODN**	**Exposure:**	**High**
Defence Crest Level:	**7.0-7.5m ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**1.0-4.5m ODN**	**Foreshore Dependency:**	**Medium**
Action Beach Level:	**1.0m ODN**	**Relative Foreshore Level:**	**Medium**

Beach Type:	**Sand, Shingle and Cobbles**
Defence Type:	**Sea Wall**
Revetment Type:	**Stone (worked)**
Defence Description:	**Vertical stone wall**
Design Standard:	

Residual Life Expectancy

No Active Intervention:	<20 years	**Current Management:**	>20 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 24	**Assessment: Medium**
Change from previous inspection:	**No change**

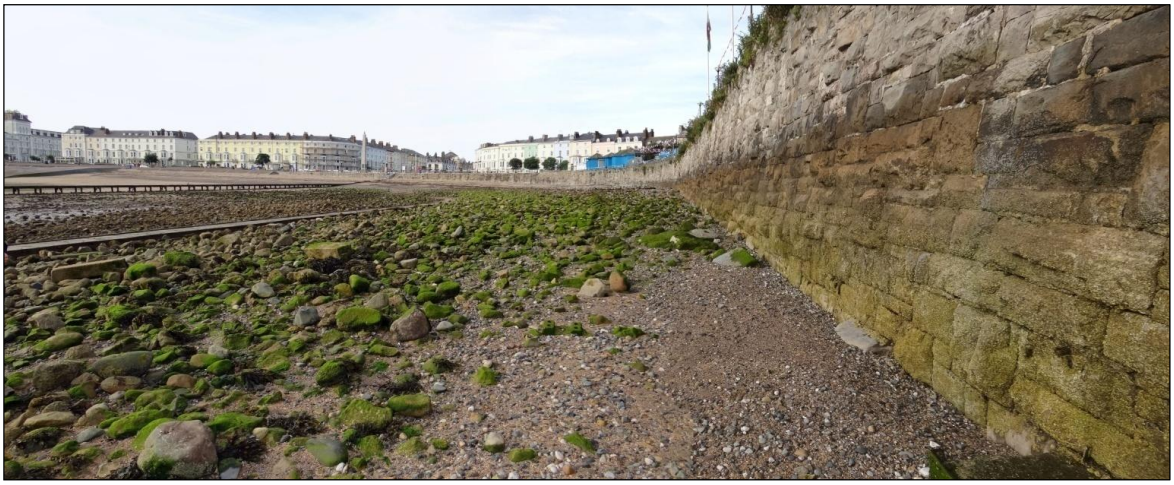
INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
09.17 09.19	8,27	3	06_013 06_014	CC136a	View from beach at root of Pier	On-going monitoring of defence condition	Monitoring on-going
09.22	8	3	06_015	CC137	Close up of wall under		

					Pier	and foreshore	
			06_016		View of section moving away from pier	Remedial works as necessary	
09.24	8,15	3	06_017	CC138	View showing exposed toe piles		
09.26	8,3	3	06_018_19		View to east		
09.26	8	3	06_020		Open joints		
09.28	8		06_021	CC139	View east from start of concrete apron		
09.29	2,8	3	06_022	CC139	View west from start of concrete apron		
09.29	3,8	3	06_023_24	CC139	Damage to Coping	On-going monitoring of defence condition and foreshore Remedial works as necessary	Monitoring on-going
09.32	1,17		06_025		Timber Jetty		
	1,8				East from timber jetty		
09.35	2,7	3	06_026	CC139a	View from east end of wall with high sand beach in foreground		

Photographs

Frame CCBC_ 120906_014



Frames CCBC_ 120906_018_19

Frame CCBC_ 120906_025

INSPECTION OBSERVATIONS	
July 2004	Some damage to coping observed, odd blocks missing Higher beach levels applying towards Trevor Street slipway
July 2005	The beach across this section was altered by high tides over the weekend 12th/13th February 2005. Beach material was moved both longshore and offshore with comparison of the post storm survey and the previous routine monitoring survey (Autumn 2004) identifying a loss of material from the beaches across the whole of the bay of approximately 6500 m^3. Losses across this section were estimated at approximately 600m^3. At the time of this inspection, no noticeable change in the condition of foreshore or defences was observed compared to the previous inspection
September 2006	Remedial works to pier decking being carried out at time of inspection Lower beach levels and fewer fines along toe of wall towards Pier end of frontage but similar further round towards Trevor St. No change in structure condition observed
August 2007	Section beneath Pier not inspected due to tidal conditions. Some change in beach surface conditions and elevation in front of defences. Generally more fines in surface towards Trevor St. No noticeable change in condition of defences observed from previous inspection.
July 2008	Tidal conditions allowed complete inspection beneath Pier. Wall in good to fair condition. More surface fines on upper beach. No change in conditions. Previously identified defects remain.
October 2009	Less sand & shingle observed within boulders on upper beach. No change in defence condition. Defects remain as advised previously.
October 2010	No noticeable change in condition of defences/foreshore observed from previous inspection. Previously identified defects remain.
September 2011	Tide conditions did not allow for access under the Pier, however remainder of views indicate no change in conditions applying across frontage, apart from general movement of sand and shingle sized sediment.
September 2012	Tide conditions allowed for access under Pier during inspection. No change in condition of structures generally. Some pointing to blockwork required in wall behind Pier [014]. Previous defects as previously reported. More surficial fines in beach boulders between jetty and pier.
ON-GOING MONITORING/MANAGEMENT ACTIONS	
No changes to existing monitoring regime proposed. Frontage included within (draft) Authority wide beach management plan. Continue with regular visual inspections (minimum bi-annually). Remedial works to coping and block replacement/pointing still required Remnants of groynes to be removed	

Chronological Photograph Log / **Description of View**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**September 2012**
View from road at root of Pier (CC136)	8080010	7240099	2009_4_107	04_128	08_100	06_011

Chronological Photograph Log Description of View	August 2007	July 2008	October 2009	October 2010	September 2011	September 2012
View from beach at CC136		7240010	2009_4_93	04_109		
View at Grand Hotel (CC136b)		7240012 7240013 7240014	2009_4_92 2009_4_90 2009_4_91	04_106 04_107_08	08_098 08_099	06_013 06_014
Views of section beneath pier founded on rock (CC137)		7240015 7240016	2009_4_88 2009_4_89	04_104 04_105	08_095-96	06_015
View of section moving away from pier (CC137)		7240017	2009_4_87	04_103	08_097	06_016
View to east of CC138	8080011	7240019	2009_4_85	04_102	08_094	06_018_19
Open joints in blockwork between CC138 and CC139.						06_020
View showing exposed toe piles at CC138	8080012	7240018	2009_4_86	04_101	08_093	06_017
Damaged to coping above CC139	8080013	7240020	2009_4_84	04_100	08_088	06_021
View east from start of concrete apron (CC139)	8080015	7240022	2009_4_83	04_096_97	08_089-90	06_022
View west from start of concrete apron (CC139)	8080014	7240021	2009_4_82	04_098_99	08_091-92	06_023_24
Views at timber jetty	8080016	7240023	2009_4_81	04_095 04_093_94	08_087	06_025
View from east end of wall with high sand beach in foreground	8080017	7240024	2009_4_80	04_092	08_085	06_026

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Llandudno Promenade

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**6th September 2012**
Easting	**278220**	**279563**		
Northing	**382598**	**382121**	**Inspector:**	**AJW/NC/MB**
			Low water time:	**09.04 (BST)**
Length:	**1430 metres**		**Low water height:**	**-2.35m AOD (Llandudno)**
			Weather conditions:	**Generally dry and bright**
			Wind Conditions:	**W-SW force 2-4**
Coastal Survey Length Ref:	**W.41.6720**		**NFCDD Length Ref:**	**101KA90740202C01**
SMP2 Policy Unit Ref:	**11a 1.2**		**Responsibility:**	**Conwy CBC**

HAT Level:	**4.7m ODN**	**Exposure:**	**High**
Defence Crest Level:	**7.0m ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**5.0-5.8m ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:	**4.5m ODN**	**Relative Foreshore Level:**	**Medium**

Beach Type:	**Shingle and Cobbles (upper); Sand (lower)**
Defence Type:	**Sea Wall**
Revetment Type:	**Concrete (insitu)**
Defence Description:	**Stepped concrete wall, rear promenade and crest wall with beach recharge**
Design Standard:	

Residual Life Expectancy

No Active Intervention:	<30 years	**Current Management:**	20-50 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Rock Groynes	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 20	**Assessment: Low**
Change from previous inspection:	**Deterioration mitigated to a degree by beach management – No change**

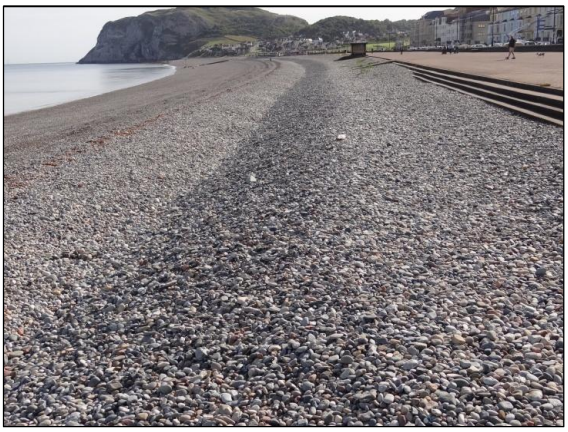
INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
09.35	1,11	2	06_027	CC140	View east from west end	On-going	Monitoring,

					of frontage	monitoring and management of defence condition and foreshore Minor repairs to stepped revetment and beach management as necessary	beach management and repairs on-going
09.36	1,11, 22	2	06_028	CC141	View along short section west of Trevor St slipway		
09.37	18	2	06_31		View down east flank of slipway		
09.37	2,11, 22	2	06_029_30		View across lower shore (west)		
09.40	2,11	2	06_032	CC141a	View west		
09.41	2,11	2	06_033		View east		
09.48 09.45	2	2	06_035 06_034	CC143	View west from Vaughan St slipway		
09.51	2		06_039		View east from Vaughan St slipway		
09.51 09.52	22		06_040 06_041		Cracked promenade surfacing		
09.50	18	2	06_038	CC143	East side of slipway	On-going monitoring and management of defence condition and foreshore. Minor repairs to stepped revetment and beach management as necessary	Monitoring, beach management and repairs on-going
09.50	22, 25		06_036		View along promenade west from Vaughan St.		
09.50	22, 25		06_037		View along promenade east from Vaughan St.		
09.59	2,11	2	06_042	CC144	View west from shelter at change in wall section		
10.00			06_043		View east from shelter at change in wall section		
10.08	2,11	2	06_047	CC145	View west from change in rear wall section		
10.07	2,11	2	06_046		View east from change in rear wall section		
10.03	22	3	06_044	CC144a	Damaged rear wall opposite Venue Cymru		
10.07	2	2	06_045	CC145	View across beach down slipway		
10.11	2	2	06_048	CC145a	View west along beach		
10.13			06_049		View east along beach		
10.14	2	3	06_050		Beach loss around shelter		
10.18	2	2	06_051	CC146	View west along beach		

Photographs

Frame CCBC_ 120906_040



Frame CCBC_ 120906_049

Frame CCBC_ 120906_050

INSPECTION OBSERVATIONS	
July 2004	Artificial beach management carried out between Trevor St and Washington
July 2005	The shingle/cobble beach across this section was moved significantly by high tides over the weekend 12th/13th February 2005. Beach material was moved both longshore and offshore with comparison of the post storm survey and the previous routine monitoring survey (Autumn 2004) identifying a loss of material from the beaches across the whole of the bay of approximately 6500 m^3. Losses across this section were estimated to be approximately 10,000m^3. Post storm beach management was carried out to reinstate profiles with levels and profiles reinstated to at or just below design levels but with a reduced crest width, thereby providing a reduced level of service. Additional post storm photographs of views taken on the 15th February are provided for comparison purposes. Apart from more parts of the defences being exposed, generally no change was observed in the condition of the hard defences
September 2006	Beach crest level maintained but crest appears narrower than in previous years'. No change to structure condition apart from small section of steps at east end [041], where surface repair has come away. This could spread in time and needs to be monitored.
August 2007	A number of additional surface defects to the stepped revetment where observed during the inspection, with specifics recorded by CCBC staff. East of the Vaughan St slipway there was little change in the upper beach with a crest width of typically 5metres and a uniform slope to seaward. To the west generally more of the stepped revetment was exposed than in previous years'. Beach monitoring will confirm changes and inform on-going beach management but some reprofiling would be recommended to reinstate crest levels.
July 2008	Generally comparison of photos shows that there has been a reduction in beach volume across the frontage with crest levels and widths reduced in many places. This is supported by the monitoring data which identifies both longshore and on/offshore movement. There has been no change in the condition of the backshore defences but more parts of the stepped/sloping revetment are exposed. A number of minor defects have been repaired [052]. Previous recommendations to evaluate beach management actions bay wide, including re-nourishment, should be carried out at the earliest opportunity.
October 2009	Upper beach shingle on west side of Trevor St slipway covered (artificial recycling of wind blown sand). Upper crest on east side of slipway also managed with material retrieved from lower beach. Visually beach volumes appear to be continuing to fall at western end with material generally moving eastwards. Generally levels east of Vaughan St appear to be improved compared to last year's inspection. Topping up of beach levels between Trevor St and Vaughan St required as a matter of urgency. Section of concrete step overlay missing [50]
October 2010	Significant shingle and cobble was thrown up onto the promenade as a result of the storm at the end of March 2010, following which material was re-deposited on the beach and beach management/reprofiling carried out. An additional 3500 tonnes of additional beach cobble was

	imported between the two slipways in March 2010. The key points arising from the inspection in relation to the frontage are: · Higher and sandier beach to west side of Trevor St slipway. · Beach conditions between Trevor St and Vaughan St similar to last year · East of Vaughan St beach crest higher and wider, presumably resulting from the management undertaken · No overall change in structure or condition. Section of concrete step overlay not repaired.
September 2011	No change in the condition of hard structures, apart from: · some localised spalling around bandstand [77]; · loss of step repair facing in the vicinity of the "Washington" [62]; · Promenade surfacing showing signs of wear with surface cracks visible, which will in time require sealing. Beach conditions were generally as recorded last year. No beach management has been carried out this year.
September 2012	Good sand upper beach to west side of Trevor St slipway. No change in the condition of structures apart from some localised damage to rear wall beneath seating [044]. Cobble beach in similar shape as previously between Trevor St. and Vaughan St. slipways and at west end of section east of Vaughan St. Further west beach begins to develop trough and secondary ridge below crest [049]. Most significant change noted at eastern end between last two shelters with much of sloped protection around second to last shelter visible [050].
ON-GOING MONITORING/MANAGEMENT ACTIONS	
No changes to existing monitoring regime proposed. Continue with regular visual inspections (minimum bi-annually). Frontage included within (draft) Authority wide beach management plan. Future beach management as necessary, including additional re-charge, if appropriate. Need for this to be reviewed against original scheme proposals and whole life cost assessment. Damage to step facing to be repaired.	

Chronological Photograph Log **Description of View**	**September 2006**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**September 2012**
View east from west end of frontage (CC140)	9040020	8080018	7240025	2009_4_79	04_091	08_086	06_027
View along short section west of Trevor St slipway	9040021	8080019	7240026	2009_4_77	04_089	08_083-84	06_028
Views across lower beach from Trevor St slipway	9040023	8080021	7240027 7240029	2009_4_78 2009_4_76	04_090		
View east from Trevor St slipway	9040022	8080020	7240028	2009_4_75	04_087_88	08_080-81 08_082	06_029_30 06_31
View west from shelter (CC141a)	9040024	8080022	7240030	2009_4_74	04_085_86	08_079	06_032
View east from shelter (CC141a)	9040025	8080023	7240031	2009_4_73	04_084	08_078	06_033
View west from bandstand (CC142)		8080024	7240032	2009_4_72	04_082_83		
View east from bandstand (CC142)		8080025	7240033	2009_4_71	04_081		
Damaged coping to bandstand (CC142)			7240034	2009_4_70	04_080	08_076 08_077	06_035 06_034
View west from Vaughan St slipway (CC143)	9040028	8080026	7240035 7240038	2009_4_67 2009_4_68	04_076_77	08_074	06_039
View east from Vaughan St slipway (CC143)	9040029	8080027	7240036 7240039	2009_4_64 2009_4_65	04_074_75	08_073 08_072	06_040 06_041

Chronological Photograph Log Description of View	September 2006	August 2007	July 2008	October 2009	October 2010	September 2011	September 2012
East side of slipway				2009_4_66	04_078	08_075	06_038
View down slipway				2009_4_69	04_079		
View along promenade west from Vaughan St.	9040030	8080028	7240040	2009_4_62	04_073	08_071	06_036
View along promenade east from Vaughan St.	9040031	8080029	7240041	2009_4_63	04_072	08_070	06_037
View west from Shelter at CC143a	9040032	8080030	7240042	2009_4_61	04_070		
View east from Shelter at CC143a	9040033	8080031	7240043	2009_4_60	04_071		
View west from shelter at change in wall section (CC144)	9040034	8080032	7240044	2009_4_59	04_069	08_069	06_042
View east from shelter at change in wall section	9040035	8080033	7240045	2009_4_57	04_067	08_067	06_043
Pitted concrete surround below steps around shelter (CC144)			7240046	2009_4_58	04_068	08_068	
View west from change in rear wall section (CC145)	9040036	8080034	7240047	2009_4_54	04_064	08_063	06_047
View east from change in rear wall section (CC145)	9040037	8080035	7240048	2009_4_53	04_063	08_062	06_046
View west along rear wall from change in rear wall section (CC145)	9040038	8080037	7240050	2009_4_56	04_065	08_066	
View east along rear wall from change in rear wall section (CC145)	9040039	8080038	7240051	2009_4_55	04_066	08_065	
Damaged rear wall opposite Venue Cymru							06_044
View across beach down slipway (CC145)	9040040	8080036	7240049	2009_4_52	04_062	08_064	06_045
Loss of surface repair 15m east of CC145	9040041	8080039	7240052	2009_4_51	04_061		
View west from Shelter at CC145a		8080040	7240053	2009_4_50	04_060	08_061	06_048
View east from Shelter at CC145a		8080041	7240054	2009_4_49	04_059	08_060	06_049
View of beach loss around shelter at CC145a							06_050
View west from shelter at east end of frontage (CC146)	9040042	8080042	7240055	2009_4_48	04_058	08_059	06_051

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Craig-y-Don

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**6th September 2012**
Easting	**279563**	**279877**		
Northing	**382121**	**382160**	**Inspector:**	**AJW/NC/MB**
Length:	**320 metres**		**Low water time:**	**09.04 (BST)**
			Low water height:	**-2.35m AOD (Llandudno)**
			Weather conditions:	**Generally dry and bright**
			Wind Conditions:	**W-SW force 2-4**
Coastal Survey Length Ref:	**W.41.6445**		**NFCDD Length Ref:**	**101KA90740202C01**
SMP2 Policy Unit Ref:	**11a 1.2**		**Responsibility:**	**Conwy CBC**

HAT Level:	**4.7m ODN**	**Exposure:**	**High**
Defence Crest Level:	**7.8m ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**6.0-6.5m ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:	**6.0m ODN**	**Relative Foreshore Level:**	**Medium**

Beach Type:	**Shingle and Cobbles (upper); Sand (lower)**
Defence Type:	**Sea Wall**
Revetment Type:	**Concrete (insitu)**
Defence Description:	**Concrete wall, rear promenade and crest wall with beach recharge**
Design Standard:	

Residual Life Expectancy			
No Active Intervention:	<30 years	**Current Management:**	20-50 years

Structure Type(s) (ST)			
1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Concrete Groyne	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)				
1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

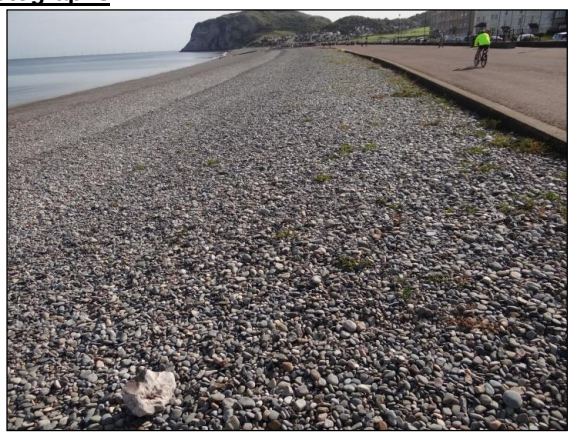
RISK ASSESSMENT	
Score: 20	**Assessment: Low**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	**ST**	**Con**	**Photo Ref.**	**Position**	**Report/Description**	**Action Required**	**Action Implemented**
10.18	2,8	2	06_052	CC146	View from west end of frontage looking east	On-going monitoring and management of	Monitoring on-going

10.23	2,8	2	06_053	CC147	View west from change in front wall section	defence condition and foreshore	
			06_054		View east from change in front wall section		
10.28	8	2	06_055	CC147a	Spalling to edge of beam at joint		
10.30	2,8	2,3	06_057	CC148	View west from east end of frontage		

Photographs



Frame CCBC_ 120906_052

Frame CCBC_ 120906_057

INSPECTION OBSERVATIONS	
July 2004	Localised lowering of beach at east end of frontage adjacent to boating pool defences
July 2005	The shingle/cobble beach across this section was moved significantly by high tides over the weekend 12th/13th February 2005. Beach material was moved both longshore and offshore with comparison of the post storm survey and the previous routine monitoring survey (Autumn 2004) identifying a loss of material from the beaches across the whole of the bay of approximately 6500 m^3. Losses across this section were estimated to be approximately 1,500m^3. Post storm beach management was carried out to reinstate profiles with levels and profiles reinstated to at or just below design levels but with a reduced crest width, thereby providing a reduced level of service. Additional post storm photographs of views taken on the 15th February are provided for comparison purposes. The underside of the promenade edge beam at the east end of this section was exposed by the storm [54,55] but generally no change was observed in the condition of the hard defences
September 2006	Some stains on top face and spalling to edges of beam at joints observed, otherwise no change in structure condition observed. Beach levels still low against beam face towards western end with crest of beach located 8-10 metres from the beam face, with dip between beach crest and beam.
August 2007	Beach levels satisfactory along frontage at time of inspection. Spalling to edges of joints noted at four locations – deterioration to be monitored.
July 2008	No change in structure condition and beach volume, although having reduced in the ten years since nourishment, appears to be relatively stable at the present time. Notwithstanding this, previous recommendations to evaluate beach management actions bay wide, including re-nourishment, should be carried out at the earliest opportunity. No change in condition of crest beam.
October 2009	Generally conditions appear to be stable across this section with no change in crest beam and beach conditions similar to last year.
October 2010	No change in observations across this section of frontage from last year.
September 2011	Monitoring results confirm generally stable beach conditions across this frontage. No change in crest beam conditions. Promenade surfacing showing signs of wear, as across main Llandudno promenade section to the west, with surface cracks visible, which will in time require sealing.
September 2012	No change in observations across this section of frontage from last year.

ON-GOING MONITORING/MANAGEMENT ACTIONS
No changes to existing monitoring regime proposed. Continue with regular visual inspections (minimum bi-annually). Frontage included within (draft) Authority wide beach management plan. Future beach management as necessary, including additional re-charge, if appropriate. Need for this to be reviewed against original scheme proposals and whole life cost assessment. Monitor condition of crest beam

Chronological Photograph Log Description of View	September 2006	August 2007	July 2008	October 2009	October 2010	September 2011	September 2012
View from west end of frontage looking east	9040043	8080043	7240056	2009_4_47	04_057	08_058	06_052
View west from change in front wall section (CC147)	9040045	8080045	7240058	2009_4_45	04_056	08_057	06_053
View east from change in front wall section (CC147)	9040044	8080044	7240057	2009_4_46	04_055	08_056	06_054
Stains on surface of edge beam (CC147a)	9040046	8080046	7240059	2009_4_44	04_054	08_055	
Spalled edge to joint in edge beam (CC147a)	9040047	8080047	7240060	2009_4_43	04_053	08_054	06_055
View from east end of frontage looking west	9040048	8080048	7240061	2009_4_42	04_051	08_052	06_057

CONWY COUNTY BOROUGH COUNCIL – COASTAL DEFENCE INSPECTION SHEET

Location: Craig-y-Don, Boating Pool

Position Details			**Survey Details**	
	Start	**Finish**	**Date:**	**6th September 2012**
Easting	**279877**	**280033**	**Inspector:**	**AJW/NC/MB**
Northing	**382160**	**382174**	**Low water time:**	**09.04 (BST)**
			Low water height:	**-2.35m AOD (Llandudno)**
Length:	**160 metres**		**Weather conditions:**	**Generally dry and bright**
			Wind Conditions:	**W-SW force 2-4**
Coastal Survey Length Ref:	**W.41.6440**		**NFCDD Length Ref:**	**101KA90740202C01**
SMP2 Policy Unit Ref:	**11a 1.2**		**Responsibility:**	**Conwy CBC**

HAT Level:	**4.7m ODN**	**Exposure:**	**High**
Defence Crest Level:	**6.7m ODN**	**Beach Stability:**	**Variable**
Foreshore Level:	**4.0-5.0m ODN**	**Foreshore Dependency:**	**High**
Action Beach Level:	**3.5m ODN**	**Relative Foreshore Level:**	**Medium**

Beach Type:	**Shingle and Cobbles (upper); Sand (lower)**
Defence Type:	**Sea Wall**
Revetment Type:	**Stone (worked)**
Defence Description:	**Sloping stone wall, dwarf crest wall and rear promenade with beach recharge**
Design Standard:	

Residual Life Expectancy			
No Active Intervention:	<20 years	**Current Management:**	20-50 years

Structure Type(s) (ST)

1 Sand Beach	2 Shingle Beach	3 Cobble/Boulder Beach	4 Salt Marsh
5 Timber Groynes	6 Concrete Groyne	7 Rock Breakwater	8 Vertical Sea Wall
9 Sloping Revetment	10 Linear Rock Revetment	11 Stepped Revetment	12 Timber Retaining Wall
13 Timber Breastwork	14 Quay Wall	15 Sheet Piling	16 Gabion Wall
17 Jetty	18 Slipway – Bound Surface	19 Slipway – Unbound Surface	20 Outfalls
21 Amenity Pool	22 Bound Access/Promenade	23 Unbound Access/ Promenade	24 Wave Return Wall
25 Dwarf Wall	26 Sand Dune	27 Rock Cliff	28 Clay Cliff

Overall Structure Condition (Con)

1 Very Good	2 Good	3 Fair	4 Poor	5 V Poor/Failed

RISK ASSESSMENT

Score: 18	**Assessment: Low**
Change from previous inspection:	**No change**

INSPECTION RECORD

Time	ST	Con	Photo Ref.	Position	Report/Description	Action Required	Action Implemented
10.30	2,9	3	06_056	CC148	View east from west end of frontage	On-going monitoring and management of defence condition and foreshore	Monitoring on-going
10.33	9	3	06_058	CC149	View west from centre of frontage		
10.33	9	3	06_059	CC149	View east from centre of frontage		
10.36	25	3	06_060	CC149	Cracked concrete at base of		

					railings		
10.39	6	2	06_063	CC150	View along crib groyne		
10.38	6	2	06_061_62	CC151	Craig-y-Don Paddling Pool East End		

Photographs

Frame CCBC_ 120906_059

Frame CCBC_ 120906_060

INSPECTION OBSERVATIONS	
July 2004	Slightly lower beach levels applying, adjacent to crib groyne; otherwise no significant difference in condition of defences
July 2005	The shingle/cobble beach across this section was moved significantly by high tides over the weekend 12th/13th February 2005. Beach material was moved both longshore and offshore with comparison of the post storm survey and the previous routine monitoring survey (Autumn 2004) identifying a loss of material from the beaches across the whole of the bay of approximately 6500 m^3. Losses across this section were estimated to be only 200m^3. Beach levels across this section did not appear to be as significantly affected as those to the west possibly as a result of easterly longshore drift being held up by the groyne structure. Post storm beach management was carried out to reinstate profiles. Additional post storm photographs of views taken on the 15th February are provided for comparison purposes. Generally no change was observed in the condition of the hard defences
September 2006	Movement of beach across this section with upper beach pushed up against pool wall with levels higher along the toe of the defences. No change in condition of structures
August 2007	Beach in satisfactory condition, although slightly lower than during last year's inspection. No noticeable change in condition of defences observed from previous inspection. Navigation marker beacon at end of groyne missing.
July 2008	No change in structure condition. Beach volumes across this section, although fluctuating, are overall equivalent to the amount recorded post recharge (1997). Notwithstanding this, previous recommendations to evaluate beach management actions bay wide, including re-nourishment, should be carried out at the earliest opportunity. Surface abrasion of concrete groyne units on-going. Navigation marker beacon at end of groyne still missing.
October 2009	Beach and defence conditions across frontage stable with no change in defence condition. Navigation marker to end of groyne still missing.
October 2010	This section of frontage is stable/modestly accreting in relation to beach volumes. Movement of the shingle beach has occurred, as elsewhere across the frontage but no change in the condition of defence structures observed. Navigation marker has been re-instated to end of the crib groyne.
September 2011	Monitoring identifies variable but overall generally stable beach conditions applying across this section. Beach material pushed up against the terminal crib groyne with a significant step in beach level across the frontage [45]. No change in condition of structures apart from some

	cracking of concrete foundation to railings along crest of wall.
September 2012	Cracks to bases of railing posts observed in crest beam [60], otherwise no change in structure conditions
ON-GOING MONITORING/MANAGEMENT ACTIONS	
No changes to existing monitoring regime proposed. Continue with regular visual inspections (minimum bi-annually). Future beach management as necessary, including additional re-charge, if appropriate. Need for this to be reviewed against original scheme proposals and whole life cost assessment Frontage included within (draft) Authority wide beach management plan.	

Chronological Photograph Log **Description of View**	**September 2006**	**August 2007**	**July 2008**	**October 2009**	**October 2010**	**September 2011**	**September 2012**
View east from west end of frontage	9040049	8080049	7240062	2009_4_41	04_052	08_053	06_056
View from centre of frontage (CC149) looking west	9040050	8080050	7240063	2009_4_40	04_050	08_051	06_058
View from centre of frontage (CC149) looking east	9040051	8080051	7240064	2009_4_39	04_049	08_050	06_059
Cracked concrete beam at base of railings							06_060
View of frontage from terminal crib groyne	9040053	8080053	7240066	2009_4_36	04_044_45	08_046	
View along crib groyne	9040055	8080055	7240068	2009_4_35	04_043	08_045	06_063
Craig-y-Don Paddling Pool East End	9040052	8080052	7240065	2009_4_38	04_047_48	08_048-49	06_061_62

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Appendix C. Condition assessments for coastal defences

Asset ID	10155550

Surveyor	Richard Flew

Overall Asset Grade	3

Date of Survey	04/06/2015

Element Sequence	Element Type	Material	ENI	Weighting	Condition Grade	W x CG
1	Channel side	Concrete promenade	1	6	3	18
3	Exposed face	Concrete Wall	1	7	3	21
4	Crest	Concrete	1	7	3	21
5	Landward face	Tarmac	1	7	3	21
6	Landward toe	Tarmac	1	7	3	21
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
			Sum	34		102

Elements with a 9 weighting will override the overall calculated condition of the asset, if that element has a worst condition grade.

Element Sequence	Element Type		Weighting	Condition Grade
			9	
			9	

Asset ID	10155551

Surveyor	Richard Flew

Overall Asset Grade	3

Date of Survey	04/06/2015

Element Sequence	Element Type	Material	ENI	Weighting	Condition Grade	W x CG
1	Channel side	Tarmac	1	6	3	18
3	Exposed face	Concrete Wall	1	7	3	21
4	Crest	Concrete	1	7	3	21
5	Landward face	Tarmac	1	7	3	21
6	Landward toe	Tarmac	1	7	3	21
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
			Sum	34		102

Elements with a 9 weighting will override the overall calculated condition of the asset, if that element has a worst condition grade.

Element Sequence	Element Type		Weighting	Condition Grade
			9	
			9	

Asset ID	10155551A

Surveyor	Richard Flew

Overall Asset Grade	3

Date of Survey	04/06/2015

Element Sequence	Element Type	Material	ENI	Weighting	Condition Grade	W x CG
1	Channel side	Tarmac	1	6	3	18
3	Exposed face	Concrete Wall	1	7	3	21
4	Crest	Concrete	1	7	3	21
5	Landward face	Tarmac	1	7	3	21
6	Landward toe	Tarmac	1	7	3	21
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
			Sum	34		102

Elements with a 9 weighting will override the overall calculated condition of the asset, if that element has a worst condition grade.

Element Sequence	Element Type		Weighting	Condition Grade
			9	
			9	

Asset ID	131293A

Surveyor	Richard Flew

Overall Asset Grade	3

Date of Survey	04/06/2015

Element Sequence	Element Type	Material	ENI	Weighting	Condition Grade	W x CG
1	Promenade	Concrete Stepped Revetmer	1	4	3	12
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
			Sum	4		12

Elements with a 9 weighting will override the overall calculated condition of the asset, if that element has a worst condition grade.

Element Sequence	Element Type		Weighting	Condition Grade
			9	
			9	

Asset ID	31949

Surveyor	Richard Flew

Overall Asset Grade	3

Date of Survey	04/06/2015

Element Sequence	Element Type	Material	ENI	Weighting	Condition Grade	W x CG
1	Promenade	Concrete	1	4	3	12
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
			Sum	4		12

Elements with a 9 weighting will override the overall calculated condition of the asset, if that element has a worst condition grade.

Element Sequence	Element Type		Weighting	Condition Grade
			9	
			9	

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