Geomorphological Study for Fylde (Starr Hill – St Annes) Sand Dunes

Final Report

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Fylde Dune Steering Group
c/o Blackpool Council
No.1 Bickerstaffe Square
Talbot Road
Blackpool
Lancashire
FY1 3AZ

JBA Project Manager

Philip Bennett-Lloyd
JBA Consulting
Bank Quay House
Sankey Street
WARRINGTON
Cheshire
UNITED KINGDOM
WA1 1NN

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Contract

This report describes work commissioned by Fiona Crayston (Blackpool Council), on behalf of the Fylde Dunes Steering Group, by an email dated 02 June 2015. The Steering Group for this project comprised Fiona Crayston (Blackpool Council), Geoff Willetts (Fylde Council), Charlotte Billingham (Environment Agency) and Kim Wisdom (Lancashire Wildlife Trust). Daniel Rodger, Graham Kenn and Phil Bennett-Lloyd of JBA Consulting carried out this work.

Prepared by .... Daniel Rodger BEnvSci, MEng, GradDipGIS, GCert CoastalEng, CMarEng CEng MIMarEST MICE
Team Leader, Coastal Processes

Reviewed by .... Philip Bennett-Lloyd BSc CMLI MCIEEM MCIWEM C.WEM CEnv
Technical Director

Matthew Williams BSc MSc
Assistant Analyst

Approved by .... Steve Maslen
Director

Purpose

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Executive Summary

Overview

This study has been undertaken by JBA Consulting on behalf of Blackpool Council and the partnership of Fylde Council, the Environment Agency and Lancashire Wildlife Trust. The study's aim is to consider management options of the Starr Hill to St. Annes Sand Dunes system (Fylde Dunes) that improve the resilience of the existing sand dunes and encourage accretion to ensure the system's continued role in coastal erosion and flood risk management for the communities along this frontage, whilst supporting the integrity and development of dune habitats.

The Fylde Dunes are situated on the Fylde Peninsula on the North West Coast of England. The site is bound by the Irish Sea to the west and has the Ribble Estuary to the South. The foreshore is an extensive sandy beach, transitioning into mud and saltmarsh environments in the south at the mouth of the Ribble Estuary. The dunes protect a low-lying hinterland that includes the towns of Lytham and St Annes.

The North West England and North Wales Shoreline Management Plan SMP2 (2011) for Sub-Cell 11 b.2 identifies the long-term plan, "to continue to provide protection through maintenance of formal defences in combination with encouraging the natural dune system to evolve where possible, as a natural form of defence. Dune and beach management should allow the dunes to supply materials to feed Lytham frontage, however, there may be a need to construct localised set back defences behind the current dunes in the future for additional flood protection to low lying areas behind".

The sand dunes cover an area of 80ha between Squires Gate and Lytham Green, which is substantially reduced from its historic extent, prior to the development of St Annes in 1875. Of the remaining sand dune habitat, 24ha is designated as a Site of Special Scientific Interest (SSSI) with 16ha designated as a Local Nature Reserve (LNR). The dunes currently offer a natural protection against coastal flooding, linking hard coastal defences along the Lancashire coastline.

Objectives

The objectives for this study are to evaluate options for future dune management priorities as part of the Environment Agency funded Flood and Coastal Erosion Risk Management project. The ultimate aim of the project is to assist the dunes in advancing seawards to increase their functional width and improve their flood defence value.

A particular focus for this study is on the area around North Beach car park where multiple issues are affecting dune accretion. This area is a known weak point in the dune system where its flood defence value is compromised by a number of factors. This is also the point where the dune system is interrupted by hard infrastructure and begins to be replaced by buildings at its southern extent.

As well as provide a detailed assessment of localised constraints and options, the study also aims to provide a broad scale assessment of future system development including:-

- Identifying constraints on continuing seaward accretion of the dune complex.
- Improving the flood defence value of the system and evaluation of the factors which are positively and negatively affecting the dunes in this regard.
- There are a number of points where urban infrastructure impacts on the system reflecting its fragmented nature and the study examines how urbanisation influences dune processes locally.

Analysis of features and processes

Key ecosystem and physical processes are assessed to develop an understanding of the sediment processes occurring at Fylde Sand Dunes. This has included a site analysis, beach analysis, coastal processes assessment and the consideration of relevant environmental designations. This information has been used to support the development of mitigation strategies for the future management of the sand dunes.

A review of available oblique photography and historic photography has provided an evidence base for the sediment processes assessment.

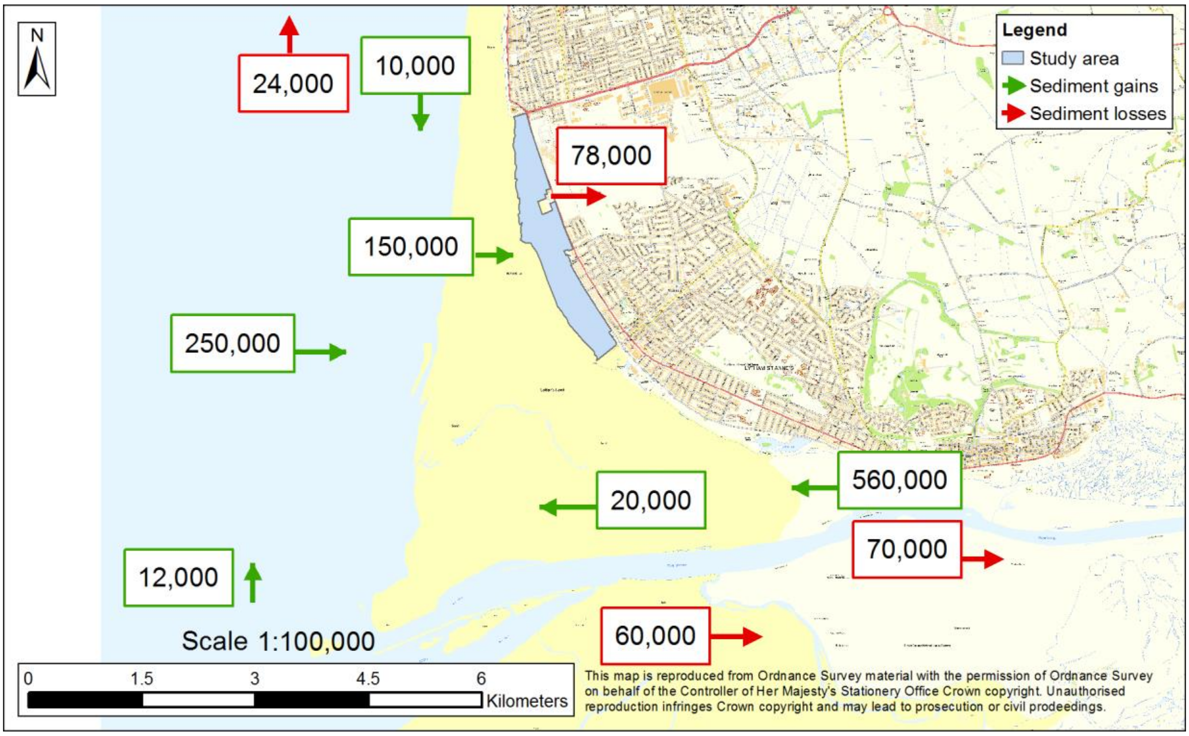
A beach analysis was undertaken using profiles data to understand the change in cross-section along the dunes, and LIDAR to understand the total volumetric change

Beach profile data was collated into spring and autumn profiles for six main cross shore profiles. The changes experienced at these profiles is presented below from north to south, as below:-

Profile name	Description
North extent of the study area/former Pontins (northern most profile)	The dunes are widening, with the toe moving seaward. The dunes are generally increasing in height on their seaward side. The dunes are losing profile height on their landward side. Steepening of the dune's seaward face.
Sand Winning area	The dunes are widening, with the toe moving seaward. The dunes are generally increasing in height on their seaward side. The dunes are losing profile height on their landward side. Steepening of the dune's seaward face.
Kiting centre	A general increase in dune height and seaward migration. Little evidence of beach face steepening.
North Beach Car Park	A general reduction in dune height Some dune widening
North Promenade	Minor increase in dune height and width Note - reduced coverage of survey and profile data.
St Annes North (southernmost profile)	Minor increase in dune height and width Note - reduced coverage of survey and profile data.

Three years of LiDAR data from 2010 to 2013 have been analysed to establish an annual rate of volumetric sediment change throughout the study site. This analysis has been undertaken for the entire Starr Hill to St Annes site, in addition to four smaller sub-sections to identify any localised changes. The analysis shows the system is accreting as a whole, within an overall gain of approximately 70,000m^3 per year. The Sand Winning area experienced the greatest build-up, with an increase of 23,000 m^3 per year. It is noted that this rate would be higher due to the extraction of sand, which is taken off-site, and therefore not included within the volumetric analysis. Both sites adjacent to the Sand Winning area have experienced gains of 17-18,000m^3 per year, whilst the southernmost area along the St Annes North / North Promenade car park frontage experienced the lowest gains at around 13,000m^3 per year.

A conceptual framework for volumetric sediment change of the Fylde Sand Dune system in the context of regional and local processes is provided below:-



Sand dunes provide a vitally important habitat to a wide range of wildlife, including a large number of species that are incapable of surviving in any other habitat, and many of these are of national or international significance.

At Starr Hill, the dunes reach their maximum width and are important as the best example of a calcareous dune system remaining in Lancashire. In spite of past sand extraction, seasonal pressures from holidaymakers and the small size of the dune system, it still shows classic features of dune formation and ecological succession including the widest range of foredune, yellow dune, dune grassland, acid dune grassland, dune scrub and dune slack habitats found anywhere along the Fylde Coast. These support a rich and varied dune flora typical of southern and western Britain with over 230 species of higher plants, some of which are scarce nationally or uncommon locally, occurring on the northern and southern limits of their distribution range. The three management units within the SSSI are all determined as being in an unfavourable recovering condition.

Over 280 different plant species have been recorded on the dunes from the mobile dunes on the coast to the fixed dunes of Lytham St. Annes Local Nature Reserve. This includes internationally rare plants such as the Isle of Man cabbage and the Dune Helleborine, which only grow in Great Britain.

The Ribble and Alt Estuaries Special Protection Area is an EU designated Natura 2000 site and Ramsar Site comprises two estuaries, of which the Ribble Estuary is by far the larger, together with an extensive area of sandy foreshore along the Sefton Coast. It forms part of the chain of western SPAs that fringe the Irish Sea. There is considerable interchange in the movements of wintering birds between this site and Morecambe Bay, the Mersey Estuary, the Dee Estuary and Martin Mere. A large proportion of the SPA is within the Ribble Estuary National Nature Reserve. The site consists of extensive sand- and mud-flats and, particularly in the Ribble Estuary, large areas of saltmarsh. There are also areas of coastal grazing marsh located behind the sea embankments. The intertidal flats are rich in invertebrates, on which waders and some of the wildfowl feed. The highest densities of feeding birds are on the muddier substrates of the Ribble, though sandy shores throughout are also used.

Under Regulation 61 of the Conservation of Habitats and Species Regulations 2010 (as amended) there is a legal requirement to consider the impacts of a plan or project on a European site. In this context the term ‘plan or project’ includes planning strategies, development plans, development proposals or anything else that could impact on the integrity of a European site. A Habitats

Regulations Assessment, if required, would be undertaken of the preferred options as part of the next stage of the process.

Conclusions

Over-stabilised dune systems can be detrimental to nature conservation and biodiversity objectives, since there is a close link between geomorphological dynamics and ecological diversity. Moreover, it has been recognised that a policy of 'hold the line' in the context of frontal dune management is likely to be unsustainable in the face of rising sea levels and global climate change. In this regard, the impacts of coastal squeeze on the dune and foreshore habitats of the Fylde Dunes frontage along with the net sediment budget for the area are critical in determining the optimal management regime to meet biodiversity objectives. A strategy that promotes dune widening, on the basis of creating additional dynamic embryo and foredunes, in the context of a positive sediment budget and generally accretive forces, at least in the short term, is one that can both usefully support both enhanced biodiversity and improved resilience and adaptive capacity in the medium term.

Ongoing survey and monitoring will help to identify how species and habitats respond to interventions, however in principle a deeper and more structurally diverse dune system, with physical connections to existing core habitats should enable valuable dune habitat development.

The analysis of the inherent coastal processes show that, while the underlying trend seems to show the dunes accreting and migrating seaward, a number of locally focussed areas of erosion or 'blow-outs' were noted, that breached the dunes and reduced the width and height. The development of blow-outs clearly needs to be managed to reduce the risk of still water level flooding to the property and infrastructure behind the dunes. Several significant constraints where hard infrastructure (properties, roads) has created very narrow dunes or gaps are also identified.

Additional further dune management issues have arisen due to the underlying accretive trend. Windblown sediments have built-up against property and infrastructure requiring regular interventions to prevent unwanted accretion.

However, it is important to consider the management of the frontage as a whole, where primary objectives point towards ensuring that the net positive sand budget supports procession and the formation of embryo and foredune features. This will benefit future flood and erosion risk, biodiversity, landscape and amenity whilst enabling the dune to evolve as a natural form of defence, in line with SMP policy. Whilst detailed and location-specific issues are addressed in the report, a Multi-Criteria Analysis examines options on a whole-frontage basis.

For the most part, it is believed that a significant number of the issues identified can be addressed over the medium term (10-15 years) by promoting dune growth in both height and width - especially the latter and enabling embryo and foredune formation through sediment trapping measures. While the dunes are currently accreting, the cyclical nature of dune development may result in a switch to an erosive trend in the future. Consequently, it is important to compound the growth of the dunes while the sediment feed is plentiful. Dune growth can be increased by promoting accretion and dune procession within the dunes and trapping sediments within the mid-dune, particularly where vulnerabilities associated with blow-outs are showing signs of increasing. In addition, this will aid in preventing the loss of sediment on to the grounds of property and infrastructure and enable constructive dune formation.

The options appraisal and MCA analysis highlight three viable options: dune planting, thatching and fencing. However, the success of any one of these options can be increased when used in combination with another option. Due to the issues with land use and dune trampling, it is recommended that dune fencing is used in combination with planting. Thatching remains a viable option, but it is believed that the combined effects of fencing and planting will exceed the performance of thatch alone over a longer period. In addition, fencing and planting can show increased efficiency when placed in multiple layers to increase the likelihood of trapped sediment. However, thatching can usefully complement fencing and planting as an economic alternative to installing multiple lines of fencing. The efficiency of this system is critically dependent on maintaining a continuous line or multiple lines of fencing.

At a number of locations throughout the frontage (e.g. to the south of North beach car park) dune planting and fencing have been implemented. However, the success of these options has been limited due to the intermittent placement of the fencing. This highlights the need for a frontage wide approach to dune management to ensure a linear build up and dune procession.

Recommendations

At the Starr Hill to St Annes frontage, the following approach to physical dune management is recommended:

- A frontage wide approach to dune management involving a scheme of multiple layers of dune fencing, thatching and planting of marram and lyme grass (and potentially sand sedge at appropriate locations) to enable procession seawards and the establishment of new transverse ridges of embryo and foredune.
- Localised options to address localised problems, including realignment of access routes
- A formalised sand clearance programme, centred on public safety- at public property and infrastructure on a biannual basis or needs basis.
- Reorientation and inclusion of dog legs in access routes to avoid sand accumulation and wind-blow onto property car parks and roads.
- A five yearly fence maintenance programme to ensure fences are adequately maintained to maximise sediment trapping.

In terms of habitat management, it is important to take an approach that supports ecosystem resilience. Wherever possible, coastal dune and beach systems should be allowed to respond naturally to changes in forcing factors and sediment supply conditions. Where accommodation space exists and conditions are favourable, frontal dune sediments should be allowed to roll back to establish a new equilibrium. However, every locality is different and a number of significant constraints are present at the Starr Hill to St Annes frontage, including the presence of infrastructure such as roads, car parks, residences and other developments creating coastal squeeze and effectively truncating any prospect of landward migration and naturalisation. Consequently, a strategy that enables dune procession to extend embryo and foredune habitat seawards, whilst there is a positive sediment budget in the system, is likely to offer an effective approach towards improving the ecological condition of the protected sites and associated mosaic of habitats and species.

Removal of invasive species such as sea buckthorn will also continue to play a useful part in supporting the natural development of dune habitats.

In such a dynamic environment, subject to such a broad range of pressures, sustained and consistent monitoring will be essential to gauge the effectiveness of interventions and learn from them; to monitor habitat and species dynamics and their responses to change; to monitor vulnerable areas and blow-outs and the risks from erosion, overtopping or flood risk; to review the community's perceptions of the importance of the dunes as part of their lifestyle, well-being or business interest; to ensure an adequate and sustainable budget to enable sound maintenance practices to continue and avoid pressures for high-cost and potentially inappropriate large-scale hard engineered interventions.

Many of the recommended activities can be (and are) supported by volunteers. This has the added advantage of increasing people's understanding and appreciation of the habitats, the dynamic nature of the environment and the history behind the establishment of a community that is inextricably linked to the landscape of moving sands that constitute the Starr Hill - St Annes dune system.

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1 Introduction

1.1 Background

This study has been undertaken by JBA Consulting on behalf of Blackpool Council and the partnership of Fylde Council, the Environment Agency and Lancashire Wildlife Trust. The study's aim is to consider management options of the Starr Hill to St. Annes Sand Dunes system (Fylde Dunes) to improve the resilience of the existing sand dunes and encourage accretion to ensure its continued role in coastal erosion and flood risk management for the communities along this frontage, whilst supporting the integrity and development of dune habitats.

The Fylde Dunes are situated on the Fylde Peninsula on the North West Coast of England, as shown in Figure 1-1. The site is bound by the Irish Sea to the west and has the Ribble Estuary to the South. The foreshore is an extensive sandy beach, transitioning into mud and saltmarsh environments in the south at the mouth of the Ribble Estuary. The dunes protect a low-lying hinterland, which include the towns of Lytham and St Annes.

The North West England and North Wales Shoreline Management Plan SMP2 (2011) for Sub-Cell 11 b.2 identifies the long-term plan, "to continue to provide protection through maintenance of formal defences in combination with encouraging the natural dune system to evolve where possible, as a natural form of defence. Dune and beach management should allow the dunes to supply materials to feed Lytham frontage, however, there may be a need to construct localised set back defences behind the current dunes in the future for additional flood protection to low lying areas behind."

The sand dunes cover an area of 80ha between Squires Gate and Lytham Green, which is substantially reduced from its historic extent, prior to the development of St Annes in 1875. Of the remaining sand dune habitat, 24ha is designated as a Site of Special Scientific Interest (SSSI) with 16ha designated as a Local Nature Reserve (LNR). The dunes currently offer a natural protection against coastal flooding, linking hard coastal defences along the Lancashire coastline. The dunes were identified in the "Lancashire Tidal Areas Benefitting from Defence" study for their role in coastal flood risk management, assumed to offer complete protection against wave overtopping due to their height and extent. Some sections of the dunes have significant human intervention, integrated with seawalls and promenades being constructed and the main coastal road cuts through the dunes in many locations.

To support the ongoing management of the dunes, the Fylde Sand Dunes Management Plan (FSDMP) was prepared in 2008 (Skeltcher, 2008). Several environmental works have since been undertaken, aimed at improving the sand dune local ecosystem and encouraging accretion.

The following approaches have been used in the project so far to support delivery of the Management Plan:-

- Installation of posts to prevent mechanical cleaning of beach and removal of tidal debris.
- Use of Christmas trees (thatch) dug into a trench to trap windblown sand and form embryo dunes. (In focused stretches)
- Chestnut paling wind trap fences. (In focused stretches)
- Invasive scrub species removal. (In focused areas throughout the dune complex).

The Fylde Coastal Strategy 2015-2032 encompasses the objectives of the Management Plan whilst incorporating wider economic, regeneration and social objectives. It establishes a vision, "to create a unique, high quality visitor destination for residents and visitors, which is based on the conservation and enhancement of the natural landscape and heritage assets of the coastal area of the Borough of Fylde." The purpose of the Fylde Coastal Strategy initiative is to develop a 16 year vision for the collation and coordination of all current strategies and policy objectives for green infrastructure and landscape, coastal protection, water quality, nature conservation, habitat improvement, conservation of the built and natural heritage, culture, the visitor economy, access and transportation, and also develop high level actions to address the major issues affecting the Fylde coast. Necessarily, a deeper understanding of the coastal processes affecting this coastline and its morphology will help to inform the delivery of key elements of this Strategy.

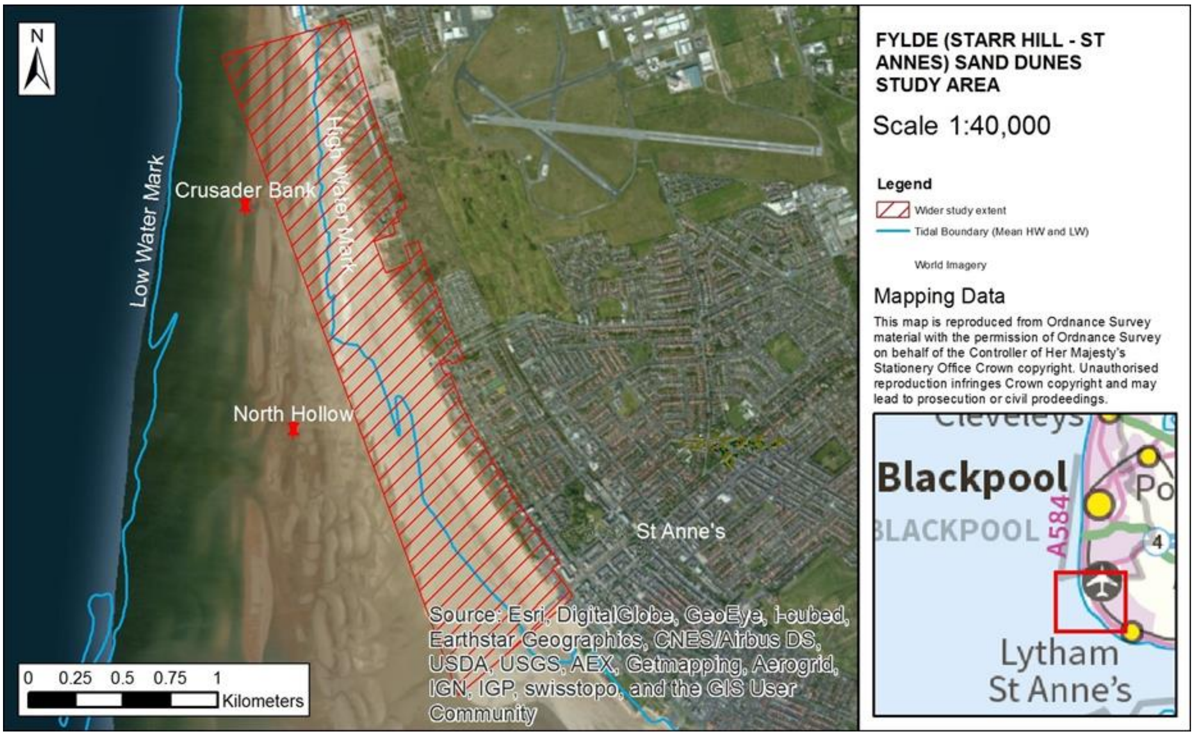


Figure 1-1: Location of the Fylde (Starr Hill – St Annes) Sand Dunes

1.2 Project objectives

The objectives for this study are to evaluate options for future dune management priorities as part of the Environment Agency funded Flood and Coastal Erosion Risk Management project. The ultimate aim of the project is to assist the dunes in pro-grading seawards to increase their functional width and improve their flood defence value.

A particular focus for this study is on the area around North Beach car park where multiple issues are affecting dune accretion. This area is a known weak point in the dune system where its flood defence value is compromised by a number of factors (outlined below). This is also the point where the dune system is interrupted by hard infrastructure and begins to be replaced by buildings at its southern extent.

There are a number of known possible constraints or conflicts of interest in developing the dunes as a flood defence in this area, which are:

- Low point at the coastguard station required for safety purposes and access by the kiting centre;
- North Beach Car Park represents a hard point within the dunes themselves;
- Sand blow from beach and dunes begins to have an impact on residences which lie within the dune system;
- Some dunes on North Promenade are in private ownership and subject to independent management;
- Unknown impact of sand winning operation on dune system sand budget. A separate review will look at these impacts as part of a sustainability review of this operation. This is a limitation on the requirements for this study.

The study will also provide a broad scale assessment of future system development with a focus on geomorphological processes and how they affect dune development, including:-

- Identifying constraints on continuing seaward accretion of the dune complex.
- Improving the flood defence value of the system and evaluation of the factors, which are positively and negatively affecting the dunes in this regard.

There are a number of points where urban infrastructure impacts on the system reflecting its fragmented nature and the study examines how urbanisation influences dune processes locally.

2 Background data and coastal processes

2.1 Introduction

The ecological and coastal processes affecting the Fylde Sand Dunes are of key importance in developing new management options. Sand dunes are naturally dynamic environments that are constantly changing in extent and form due to fluctuations in natural environmental forcing factors (wind, waves, tides, sediment supply, rainfall etc.) and human activities (land-use, recreational pressure etc.). In most circumstances, the nature and extent of dune habitats is dependent on the balance of these factors, only some of which can be controlled by management intervention.

Regional processes bring an influx of sediment to the Fylde Coast, with an overall trend of accumulation within the local sediment cell. This is explained in more detail in Section 3.4. This provides a very positive aspect to the potential of the Fylde sand dune and beach system in achieving gains for biodiversity, social and especially sea defence services. On the other hand, there are also, a number of human activities altering the balance of sediment transport within the beach cell and sand dunes. These can affect the natural habitats and species of the sand dunes. In recognising the need for a sustainable approach to managing the sand dunes at Fylde, it is important to allow it to provide protection locally from flooding and erosion whilst maintaining its recreational and landscape values for public enjoyment. Compared with many other forms of sea defence, dunes are less visually intrusive, have greater value for wildlife and recreation, and are able to respond more readily to changes in environmental forcing factors (e.g. climate and sea level change, sediment supply conditions). Sand dunes cannot be viewed in isolation, but must be considered together with adjoining beaches, tidal flats, saltmarshes and other related environments.

2.2 Key ecosystem processes

Coastal Sand Dunes are formed from sand (0.2–2 mm grain size) that is blown inland from the beach, and are usually stabilised by vegetation (Packham & Willis, 1997). Typically, phases of mobility and natural coastal dynamics lead to a sequence of dune ridges, which increase in stability the further away from the sea they are (Fig 2-1 Overleaf). Embryonic and mobile dunes occur mainly on the seaward side of a dune system where sand deposition is occurring and occasionally further inland in blow-outs. They support plant species tolerant of moving sand and salt spray, the most characteristic being marram grass. As environmental stresses such as wind speed, sand mobility and salt-spray decrease further inland, pioneer plant species are replaced by more diverse vegetation communities and soil development advances. In the wake of migrating dunes, or on accreting coasts, wind can scour bare sand down to the water table; the exposed damp sand is colonised by a different set of plant species, creating low-lying dune slacks: a (usually) seasonal wetland, flooded in winter and often with high botanical diversity. The main vegetation types are dry dune grassland (fixed dunes) and dune slacks, with dune heath on some acidic sites; all have the potential for succession to woodland over time (Provoost, et al., 2010). Therefore, sand dunes provide a highly diverse mix of habitats and services (often on the same site) due to differences in successional age, soil pH, local disturbance, management history, the steepness and aspect of slopes, groundwater chemistry and the hydrological regime in dune slacks (Everard, et al., 2010).

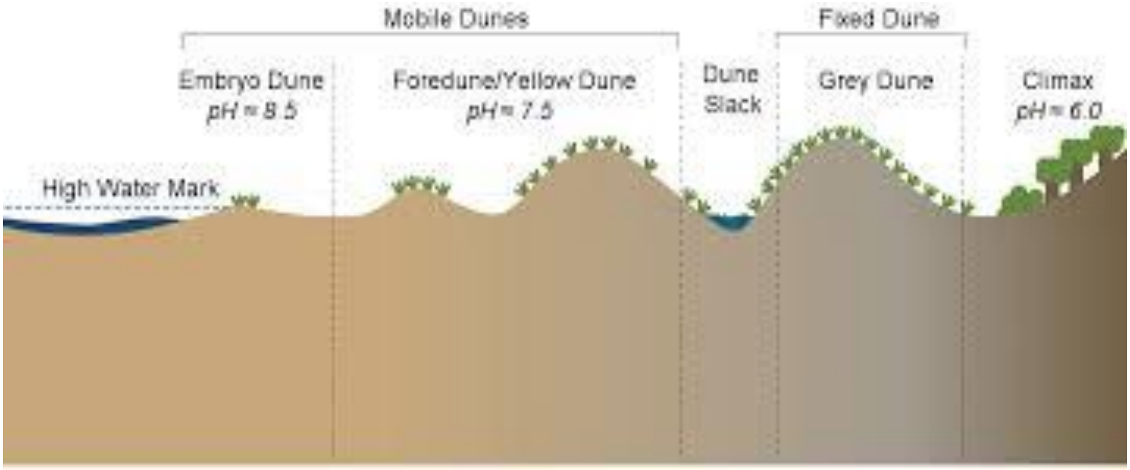


Figure 2-1: Sand dune succession

The dynamic nature of sand dune habitats means that they provide some of the best examples of early successional environments in the UK. They support a wide range of highly specialised and distinctive species that can tolerate difficult and harsh environmental conditions associated with the adjacent seas, such as, salt spray, strong winds and tidal waves. The sand dunes provide a refuge for habitats and species lost from other intensively farmed or developed lands. Their biological diversity provides a wide range of ecosystem services. Indirectly, they modify the ecosystem level processes underlying the regulating services including sea defence, pest control and pollination.

Fixed dunes and dune heath are particularly threatened habitats and are regarded as priorities under the EC Habitats Directive. Sand dunes have been identified as a national priority due to high losses resulting from both human and natural factors. Habitat losses due to sea-level rise have been relatively small so far, estimated at 2% over the past 20 years for sand dunes and 4.5% for saltmarsh. However, habitat losses are projected to reach 8% by 2060.

Steepening of the intertidal coastal profile on soft coasts has been observed across the UK. Future losses will increase throughout the UK as storm erosion events increase in magnitude and sea-level rise further outstrips isostatic readjustment; this issue is of particular concern where coastal squeeze operates, preventing land-ward migration of these habitats in response to sea-level rise.

Climate change may shift species distributions northwards and future decreases in rainfall and altered seasonality of rainfall are predicted to lower dune water tables by up to 1 m by 2080 (Clarke & Sanitwong, 2010). The associated drying out of dune slacks will result in a loss of many rare species, and may cause release of stored soil carbon due to faster decomposition. Furthermore, dune soils develop faster in the wetter regions of the UK, but warmer temperatures due to climate change may speed up soil development in other areas too (Sevinik, 1991), leading to successional change.

Invasive species (including garden escapees) can change the character of dune vegetation and significantly impact on native species. Sea buckthorn (*Hippophae rhamnoides*) is considered non-native around most of the UK, except in some sites in Lincolnshire and Norfolk where it is classed as native. It has been used in the past to stabilise sand dunes and for erosion control, however it is a serious threat to native dune flora and fauna.

2.3 Key physical coastal processes

Dune system morphology and individual dune morphology are extremely complex processes, influenced by a many controlling variables, including:

(a) the nature of forcing processes;

(b) available sand supply;

(c) vegetation characteristics;

(d) water table levels; and

(e) land-use and recreational pressures.

The interactions of these variables are illustrated in Figure 2-2 below

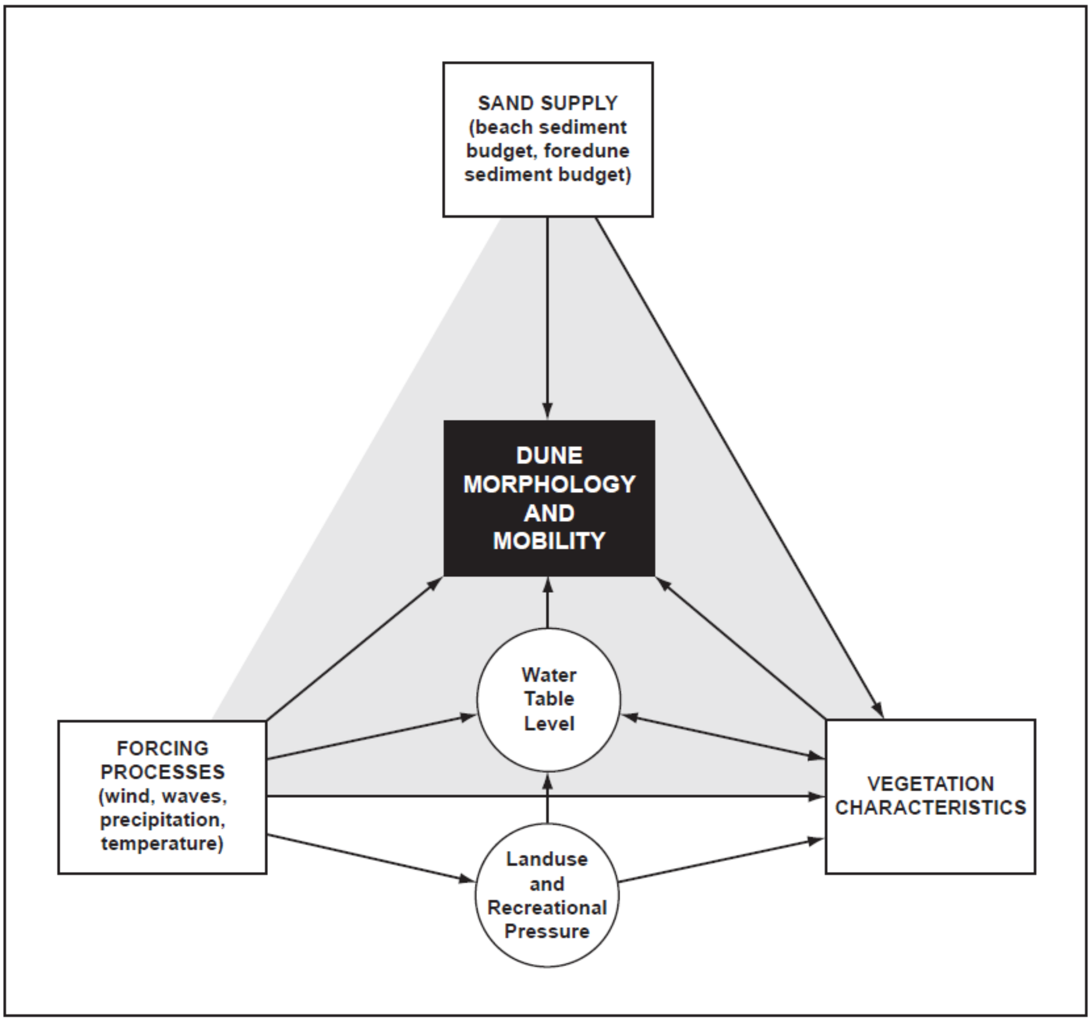
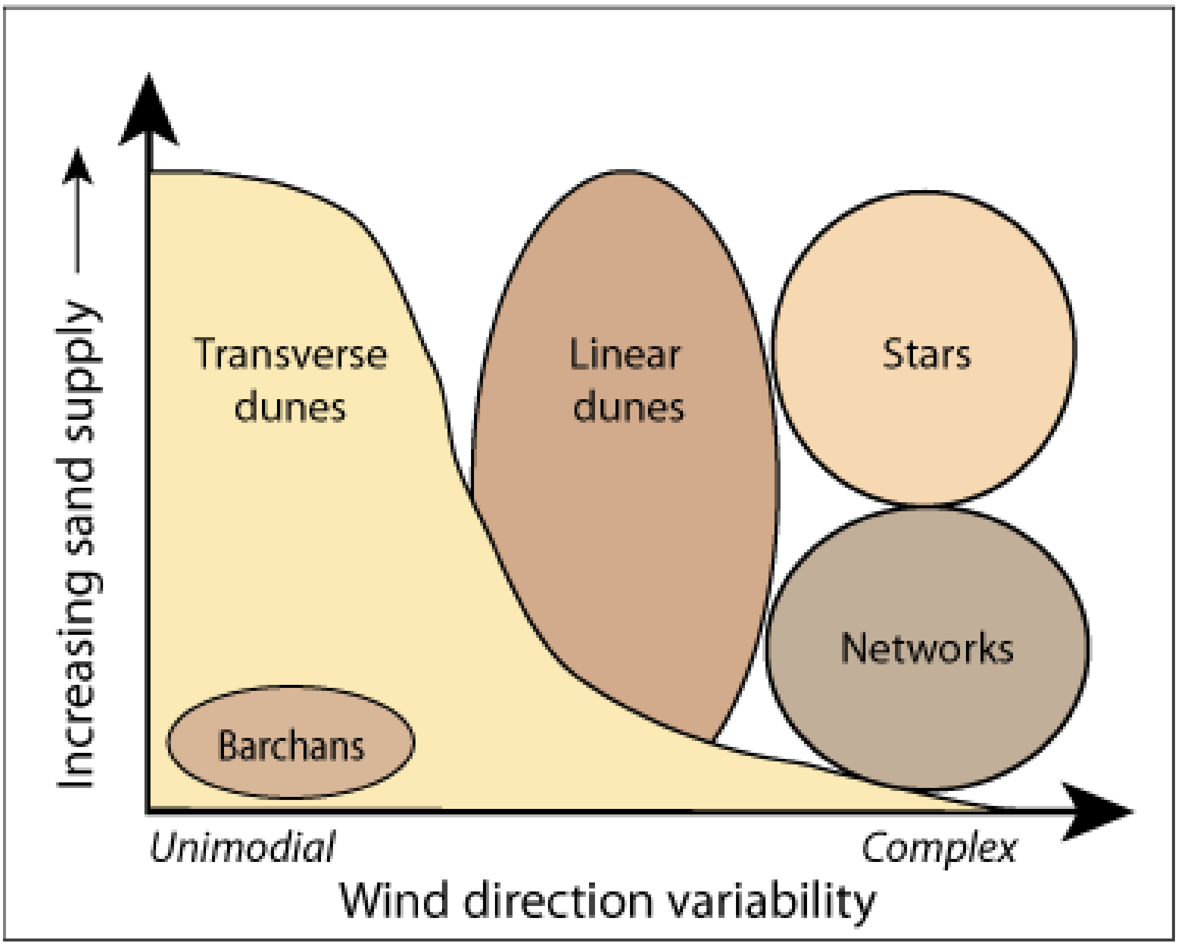


Figure 2-2 Factors which influence the morphology and mobility of coastal dunes ((Sand dune processes and management for flood and coastal defence, R&D Technical Report FD1302/TR, Defra, 2007)

Whilst there have been many studies of sediment transport associated with dunes and beaches, the range of variables is such that predictive vs. measured rates of erosion or deposition offer very little scope to anticipate longer term changes in dune morphology to support shoreline management planning or habitat management. With yet more variables at play, predicting sand movement within dune systems is even harder. Variables include wind fetch and direction, tidal range, beach width and profile, sediment grain size, moisture content (influenced by rainfall, tidal range, drying rates etc.), compaction, crusting, surface debris, vegetation, wind shear stresses and so on. However, broadly speaking, deposition of blown (Aeolian) sand is determined by a reduction in wind-speed or an increase in the roughness of the surface and this, along with an understanding of sand budget and overall topography, can be used to make better-informed decisions about dune management and possible interventions in terms of their flood and erosion risk management value. Systematic and consistent monitoring is essential to determine the effectiveness of interventions or the risks associated with vulnerable areas and how they might respond to storm or surge events or human erosive pressures including development, access, sand redistribution and sand removal.

The type of dune that may be established, its stability, and value for biodiversity, amenity and flood risk is determined by a combination of all the factors above. There are a number of dune classification approaches, whether they are stable, eroding or accreting (Pye & Tsoar, 1990) and dune development and characteristics can encompass one or multiple formations as shown in Figure 2-3 (Livingstone & Warren, 1996) and Figure 2-4.



Adapted from Livingstone and Warren (1996, 80)

Figure 2-3 Dune variability and classification

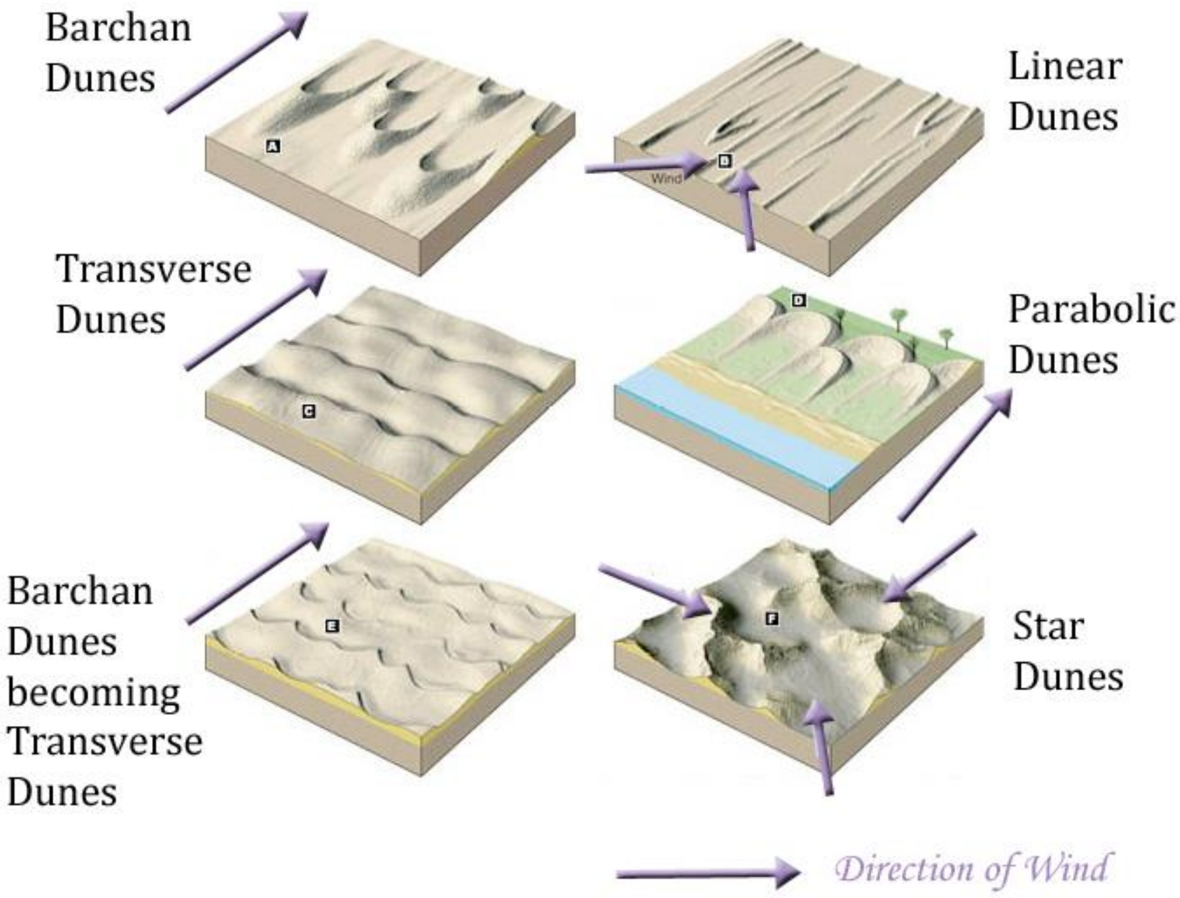


Figure 2-4 Dune Classification (Geocaching, 2014)

The coastal defence value of a dune is a factor of its height above mean and surge sea levels, its shape and its width. Dune systems offering the most protection are both wide and high. High flood defence values may be anticipated from dunes over 30-40m wide and above 10m high whilst narrower systems (over 16m) may provide a medium level of defence where they are over 5m high. Very low, narrow ridges (less than 5m wide x 2m high) can be considered to have no flood defence value and can easily be overtopped or breached in a single event (Defra 2007). In addition, the presence and scale of blow-outs can significantly affect the coastal defence value of dunes. Without interventions, blowouts may enlarge through increased turbulence, funnelling and wind-scour although it should also be understood that these features may enhance the biodiversity value of the dune habitats and the development of dune slacks as well as supporting sand movement within the dunes, enabling a more naturally functioning system to evolve. Careful consideration and monitoring is needed to ensure that interventions to address blowouts, if undertaken, do not produce unforeseen or negative overall consequences.

Coastal flooding is also a complicated process, affected by a number of dependent and independent variables. Figure 2-5 illustrates the main components of sea-level variation that contribute to coastal flooding during a storm event. The base sea-level, often referred to as either the still water sea-level or total sea-level, is comprised of the underlying astronomical tide and the passage of a large scale storm surge, inducing a local atmospheric increase in water level due to wind set-up and low pressure. These two components determine the average sea level for a specific location at a particular time. Whilst this variable is very important in terms of coastal flooding, still water-induced flooding is normally limited to sheltered locations such as tidal rivers and harbours. In the case of the low-lying communities of Lytham and St. Annes, the risk of still water inundation is reduced due to the protective nature of the dunes. However, the sea is not still during a storm event, and there is the potential for waves to reach the shoreline causing erosion, overtopping or a breach of the natural sand dunes system.

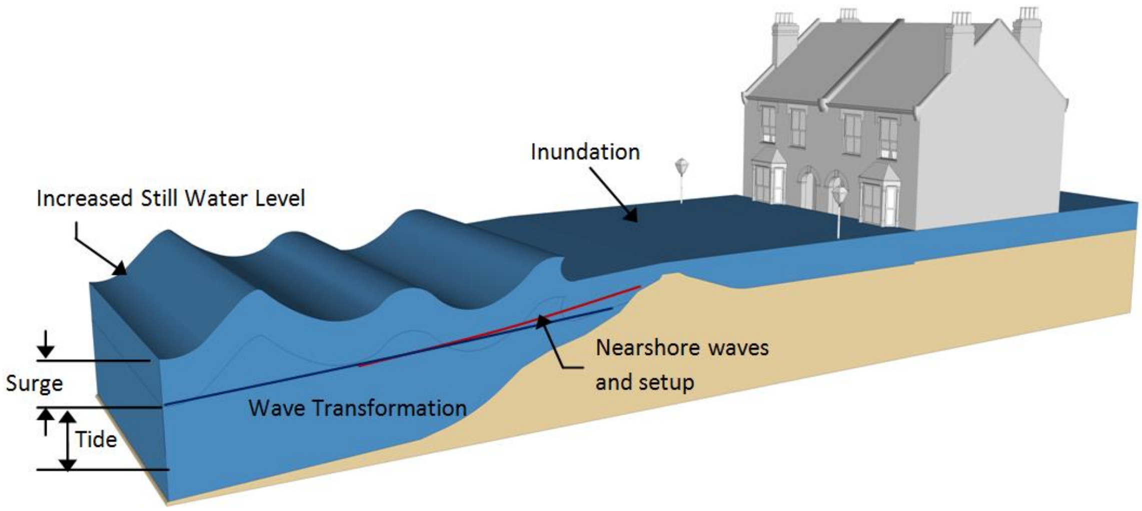


Figure 2-5: Components of sea-level variation that lead to typical coastal flooding

Wave action is a complex process controlled by a number of factors. The manner in which these factors combine determines the magnitude of any wave induced flood impacts. Waves generate in deep water and then propagate towards land. As they do so, they enter shallower bathymetry where wave transformation processes occur, including shoaling, diffraction, refraction, depth limitation and breaking. These waves are also subject to additional influence from wind. The consequence of these processes is that the properties of the waves, when they reach the base of flood defences or dunes, are quite different to the waves in deep water. It is these nearshore waves that are of most importance because they interact with beaches and defences and lead to erosion and wave overtopping.

Coastal erosion can be defined as the removal of material from the coast by wave action, tidal currents and/or the activities of man, typically causing a landward retreat of the coastline. Sandy coastlines are dynamic, with erosion and sedimentation processes impacted by wind and coastal currents, with seasonal variations. Coastal erosion is a combined process controlled by coastal processes; the net loss of coastal land under the impact of these processes can change over a long-term period. Observing the coastline for decadal periods enables scientists to understand the natural dynamic equilibrium that exists. Shorter observation periods (annual or seasonal) might erroneously conclude that there is a net erosion (or accretion) where a system is actually in equilibrium. Natural fluctuations in coastal dynamics such as erosion caused by a storm and followed by a period of storm recovery are upset by human activities. The construction of hard coastal defences, ports and breakwaters; all of which have impacts that can be experienced far away from the actual structure. The slow change introduced by sea level rise complicates matters, as on a short term, a dynamic coastline can still extend (accrete) even while the level of the sea goes up.

Wave overtopping and still water inundation depends on the stability of the natural coastline and the resilience for storm recovery. Overtopping is also a complicated process controlled by the state of the sea (depth, wave properties), the geometry of the beach and the stability of the local dune system.

2.4 The Fylde Dune system and its contribution to flood and erosion risk management

The Fylde Sand Dunes and foreshore overall offer a significant natural protection against wave overtopping and flooding from the sea, albeit with several vulnerabilities which will be described and examined later.

The dune structure tends towards transverse systems (Fig 2-4), with some embryo and foredune development, largely associated with interventions to encourage this. Over the northern extent of the study area, increasing maturity includes some evidence of star structures, blow-outs and some potential for dune slack formation (these are otherwise only found in the Lytham St Annes Local Nature reserve to the immediate east of Clifton Drive North, to the south of the former Pontins site).

The widths and heights of the dunes are critical to their value for flood and erosion risk management. With many sections barely exceeding 10m height and due to extensive coastal squeeze, there is very little scope to allow greater vertical accretion. Consequently dune width is the primary manageable factor in enhancing their ability to act as effective flood and erosion risk management features. Increasing dune width through seaward procession / advancement is therefore an extremely important factor in active dune management along this frontage.

In terms of sand budgets, there is evidence that the dunes are accreting, however coastal squeeze and limitations on landward migration, including sand clearance, are severely limiting the ability for this process to occur naturally. Some sections of the dunes are covering concrete sea walls, which may offer a last line of defence if dunes and foreshore are extensively lost or eroded during storm or surge events.

Vulnerabilities occur at several locations:

- The dunes opposite the former Pontins site are the widest and tallest dunes on the frontage, however there are a number of deep and long blowouts that may compromise resilience during sustained erosive and storm /surge conditions.
- Access roads cutting through the dunes at the sand-winning area, North Beach car park and St Annes North car park, both increasing flood risk and exacerbating sediment loss from the system.
- Cleared areas around the Coastguard station and kiting centre at North Beach car park.
- Narrow dunes sections adjacent to North Promenade.
- Pedestrian access routes through the dunes and adjacent to the pier.

There are also more general concerns of sand-blow across car parks, roads and into private property causing nuisance and some safety issues and requiring periodic clearance, with the sand being removed from the system.

2.5 Review of available information

A range of previous reports and coastal information is available concerning Fylde Dunes. The most useful source is the Fylde Sand Dunes Management Plan (2008) and reviews of subsequent management works, including regular beach surveys and photography. The CETaSS report (2010) also provides valuable information for the Irish Sea sediment cell. In addition to this information, other key data sources relating to the ecological or coastal processes includes the following:

Existing coastal defence information

- Site inspection observations and photographs
- Beach and sediment profile information
- LIDAR beach surveys

Planning

- Fylde Sand Dunes Management Plan
- North West England and North Wales Shoreline Management Plan SMP2 (2011)
- Fylde and Blackpool Local plans
- Lancashire Minerals and Waste Local Plan
- Lancashire Tidal Areas Benefitting from Defence study

Coastal extremes

- Astronomical tide levels
- Extreme sea and offshore wave levels
- Extreme nearshore wave conditions

This information is summarised below for use in calculations, assessments and the development of new management options.

2.5.1 Site inspection observations and photographs

A site inspection was carried out in June 2015. Areas inspected included:

- From the North Beach Car Park through to the St Annes Pier
- The Sand Winning and northern extent of the site.

Site inspection photographs are provided in Appendix D.

2.5.2 Beach and sediment profile information

Beach survey data and reports were collated from various sources by the Fylde Council and JBA Consulting. Historic photographs were supplied for 1966 and 1983. Reports gathered and referred to for the physical environmental study are:

- Fylde Sand Dune Management Plan (2008)
- Cell 11 Tidal & Sediment Study (2010)
- Fairhaven and Church Scar Coastal Defence Scheme PAR geomorphology appendix (2015)
- Ribble Estuary Process Report (2013)
- NW Estuaries Overview Report (2013)
- Blackpool & Fylde Coastal Processes Report (2012)
- Fylde Coast Data Collection Report (2014)

There are two main quantitative data sources utilised in this study: beach profile data and LIDAR data. The most comparable beach profiles were taken approximately twice a year, in the autumn and spring. Additional profiles were made available for the summer and winter in some years, but not all and therefore are not comparable. Beach profiles from 2004 to 2013 are available for the north Sand Winning Crusader Bank section of the site, and are less frequent in the southern Car Park and Amenity Beach section (e.g. 2010-2012 and 2014). LIDAR data is available for the following dates: 24 May 2010, 17 November 2011 and 23 April 2013. It should be noted that the length of data set available is not normally considered sufficient to draw detailed conclusions about the overall long-term change and is likely to only represent a snapshot of the evolution of the dunes at any one time.

2.5.3 Fylde Sand Dunes Management Plan (2008)

The main aims for management of the Fylde Sand Dunes are to:

- Enhance the nature conservation interest of the coastal habitats,
- Improve the efficiency of the dunes and saltmarsh as soft sea-defence
- Enhance public appreciation and enjoyment of the dunes.

Proposed management works to achieve these aims will include: enabling natural seaward accretion of the dunes by removing the current causes of man-induced erosion both to increase the area of wildlife habitat and to improve the efficiency of flood defence, together with grassland and scrub management works to enhance the nature conservation value of the existing dunes in conjunction with path creation and information signage. Education and interpretation materials will be produced to help promote the sand dunes and to publicise the wealth of biodiversity which lives there.

More recently, the Fylde Coastal Strategy (2015-2032) captures the original objectives of the Management and Plan, setting these in the wider context of economic, regeneration and social pressures and opportunities of the Fylde coast.

2.5.4 Local Plans

The current Fylde Borough Local Plan was adopted in 2005 and the current Local Plan (to 2030, revised to 2032) Issues and Options consultation closed in July 2012. Preferred Strategic Development Locations do not include frontages directly affecting the study area at St. Annes, although the Blackpool Periphery Strategic Location includes housing development land at the former Pontins site, adjacent to Blackpool airport (H5). Fylde Council is currently preparing a Revised Preferred Option of the Local Plan to include policies on strategic and non-strategic locations for development. A revised Scoping Report for the Strategic Environmental Assessment ((SEA) and Sustainability Appraisal (SA) (July 2015) has been published and refers to dune management in accordance with the Fylde Dune Management Plan and protection of the integrity of the dune system. A Revised Preferred Option underwent public consultation from October to December 2015.

On 19 December 2014, Blackpool Council's Local Plan and its supporting documents were submitted for independent examination to the Secretary of State for Communities and Local Government via the Planning Inspectorate. This examination has concluded and consultations on proposed modifications are programmed for summer 2015. Strategic sites include an employment growth zone to the east of the airport and Marton Moss Strategic Site (Neighbourhood Planning Approach). Overall, at this northern end of the study area there is a significant amount of proposed growth planned. The Strategic Environmental Assessment (SEA) and Sustainability Appraisal (SA) offer limited analysis of dune management, pressures and flood risk, albeit that the sites fall outside the Council's planning area.

Lancashire County Council's Minerals and Waste Local Plan Adopted Strategy (2009) is currently being reviewed (Scoping consultation completed 19 December 2014). The current Joint Local Aggregates Assessment (2015) describes beach sand being extracted on a small scale for aggregates use at St Annes foreshore. This is also referred to, although not addressed further in the Sustainability Appraisal Scoping Report (2014).

2.5.5 Lancashire Study

JBA Consulting, on behalf of the Environment Agency, has completed the Lancashire Tidal Areas Benefitting from Defence study. The study involved a large-scale coastal flood risk assessment in order to estimate the flood risk for the Lancashire area and to update the Environment Agency's coastal flood forecasting system. The four year study involved the creation of a wave transformation model of the Irish Sea to transform the offshore waves into the nearshore region, and to assess the susceptibility to flooding from sea and wind waves. Using the transformed nearshore waves, the flood risk from wave overtopping of coastal defences was calculated for over 300 individual flood defences along 400km of coastline. Models were used to test various scenarios including defended and undefended model simulations, scenarios with road and rail infrastructure removed and breach scenarios. The nearshore wave conditions were calculated for a number of joint-probability scenarios at the Fylde Sand Dunes and are summarised in Table 2-1.

While the study was undertaken at a local level, wave overtopping was calculated for key sections along the coastal frontage only. The exposure to wave overtopping risk along the Fylde Sand Dunes was initially reviewed based on site inspections, available topographic data and coastal extremes. Based on this data, the relative risk of wave overtopping was considered to be low, and was not assessed further along the frontage. It is possible that localised low level wave overtopping could be experienced at some points along the dune frontage, such as at the walkways through the dunes and areas suffering damage. Calculation of these small localised occurrences, as well as potential erosion or breaching of the dunes from wind-derived blow-outs, was not within the study scope but remain a potential area of vulnerability.

2.5.6 Tides and extreme coastal information

Tide levels

Admiralty Total Tide software was used to extract the underlying astronomical tide at Blackpool, and is shown in Table 2-1. The region experiences a macro-tidal climate, with an astronomic (mean spring) tidal range of 7.90m and (mean neap) tidal range of 4.23m. Tide levels are affected by environmental and atmospheric conditions such as changes in barometric pressure. The highest astronomical tide is 4.09mAOD. The conversion from ordnance datum Newlyn to local chart datum is +4.9m.

Extreme sea level estimates

Extreme coastal conditions were obtained from the Environment Agency (EA) *Coastal flood boundary conditions for UK mainland and islands* project, which produced the Coastal Flood Boundary Dataset (CFBD) (Environment Agency, 2011). The CFBD contains the estimated extreme sea levels throughout the UK based on research involving more than 40 Class A water level gauges. The predicted extreme still water levels (SWL) at Blackpool for a range of return periods are presented in Table 2-2.

The likely changes to tide and extreme sea levels were based on the latest UK Climate Projections (UKCP09) (Defra, 2009). A medium emissions scenario with a 95th percentile confidence interval is considered to result in a 0.70m rise in sea-level by 2115, which was added to the present day extremes.

Table 2-1: Astronomic tide levels at Blackpool.

Location	Present day (2015) water levels (mAOD)	2115 water levels (mAOD) (2015 level +0.7m)
200-year	6.3	7.0
100-year	6.2	6.9
50-year	6.1	6.8
20-year	5.9	6.6
10-year	5.8	6.5
5-year	5.7	6.4
1-year	5.4	6.1
Highest astronomical tide (HAT)	4.9	5.6
Mean high water spring (MHWS)	4.0	4.7
Mean high water neap (MHWN)	2.1	2.8
Mean sea level (MSL)	0.0	0.7
Mean low water neap (MLWN)	-2.1	-1.4
Mean low water spring (MLWS)	-3.9	-3.2
Lowest astronomical tide (LAT)	-4.8	-4.1

Local wind conditions

Wind is the primary force for locally generated sea waves and for the air-borne movement of dry sand within dune frontages (Skeltcher, 2008), known as aeolian transport. The highest wind speeds, recorded locally at Squires Gate, are from directions between south-west and north-west, with winds from these directions occurring for nearly 50% of the time.

Extreme wave height estimates

Extreme wave conditions have been estimated from two sources. Offshore wave conditions have been estimated within the EA *Coastal flood boundary conditions for UK mainland and islands* (Environment Agency, 2011) project for design swell waves. These are given for offshore locations, broadly given along a contour line of -50mAOD. Predicted extreme offshore swell waves for a range of return periods are presented in Table 2-1.

Table 2-1: Extreme offshore wave conditions at Blackpool for different return periods

Dominant condition	Return Period (years)							
	1	5	10	20	50	100	200	1,000
Offshore swell wave height (m)	2.40	2.72	2.83	2.93	3.05	3.13	3.20	3.34

Nearshore wave conditions

The nearshore extreme wave conditions calculated through the Lancashire Tidal Areas Benefitting from Defence study, and are shown in Table 2-2. For each return period, there are two combinations, showing either dominant water level or wave conditions. For any coastal design or erosion calculations, both potential scenarios should be used, and the worst-case adopted.

Table 2-2: Extreme nearshore wave and still water level conditions at Blackpool for different return periods

Return period	Dominant nearshore condition*	Wave height (m)	Spectral Peak Period (s)	Peak Direction (Deg/N)	Depth (m)	Water level (mAOD)
2	Wave	2.0	6.1	292.5	5.1	5.6
	Water level	1.8	5.6	292.5	5.2	5.7
5	Wave	2.0	6.3	292.5	5.1	5.6
	Water level	1.9	5.7	292.5	5.3	5.8
10	Wave	2.1	6.3	292.5	5.1	5.6
	Water level	1.9	5.6	292.5	5.4	5.9
20	Wave	2.1	6.5	292.5	5.1	5.6
	Water level	1.9	5.7	292.5	5.6	6.1
30	Wave	2.1	6.5	292.5	5.1	5.6
	Water level	1.9	5.7	292.5	5.6	6.1
75	Wave	1.9	5.6	292.5	5.8	6.3
	Water level	2.1	6.7	292.5	5.1	5.6
100	Wave	2.1	6.8	292.5	5.1	5.6
	Water level	2.0	5.7	292.5	5.8	6.3
200	Wave	2.1	6.8	292.5	5.1	5.6
	Water level	2.0	5.7	292.5	5.9	6.4
1000	Wave	2.2	6.5	292.5	5.3	5.8
	Water level	2.0	5.7	292.5	6.2	6.7
*Dominant nearshore conditions either reflect the largest waves or water levels for a return period. All conditions extracted at the -0.5mAOD contour. All peak wave directions are from 292.5ºN (west north-west).						

3 Sediment processes assessment

3.1 Introduction

The background information outlined in Section 2.4 has been reviewed to develop an understanding of the sediment processes occurring at Fylde Sand Dunes. This has included a site analysis, beach analysis, coastal processes assessment and the consideration of relevant environmental designations. This information has been used to support the development of mitigation strategies for the future management of the sand dunes.

3.2 Site analysis

A review of available oblique photography and historic photography has provided an evidence base for the sediment processes assessment. The historic photography was provided by Lancashire Wildlife Trust, originally sourced from slides and scanned by the Trust. This information is provided in Appendix D.

There is evidence of established dune systems in the Fairhaven Dunes in 1966 (E.1.1) that have reduced in size by 1983 (E.1.3). This is south of the area of interest for this study. Although the photographs are taken at different locations, the dunes look more natural in the 1966 images, and by 1983 the photographs highlight a considerable amount of change and construction along the seafront.

The Chestnut Palling image from 1966 (E.1.2) highlights that clear view from the residential property over the sand dunes and beach out to sea, to maintain this view the dunes are likely to have been removed. These properties are now provided sheltered by the dunes and are less exposed.

At the St Annes North area, there are sea walls and a prominent coastal defence structure (E.1.4). Additional car park walls and beach huts (E.1.5) are visible in the 1983 photographs. These structures have since been removed. During the site inspection bricks, tiles and concrete were evident in the intertidal area. There were railings and step entrances in historic photos that have now been partly or fully engulfed by the dune system.

Oblique aerial photography was taken 20 March 2012. These images provide a post-winter view of the beach and dune system at low tide. Particular areas of interest are the northern section dune "blowouts" and sand winning area (F.1.1 and F.1.2), the North Beach car park where the dunes are putting lateral pressure on the surrounding walls (F.1.3 and F.1.4), and the southerly amenity beach to the north of the pier (F.1.5).

3.3 Beach analysis

A beach analysis was undertaken using profiles data to understand the change in cross-section along the dunes, and LIDAR to understand the total volumetric change. These are described in the following subsections.

3.3.1 Beach profiles

Beach profile data was supplied by Fylde Council, which is presented in Appendix G and summarised here. Due to the completeness of the profile data, each section has been collated into spring and autumn profiles for six main cross-shore profiles shown in Figure 3-1. The changes experienced at these profiles are presented below from north to south, named:

1. North extent of the study area / former Pontins (northernmost profile)
2. Sand Winning area
3. Kiting centre
4. North Beach Car Park
5. North Promenade
6. St Annes North Beach (southernmost profile)

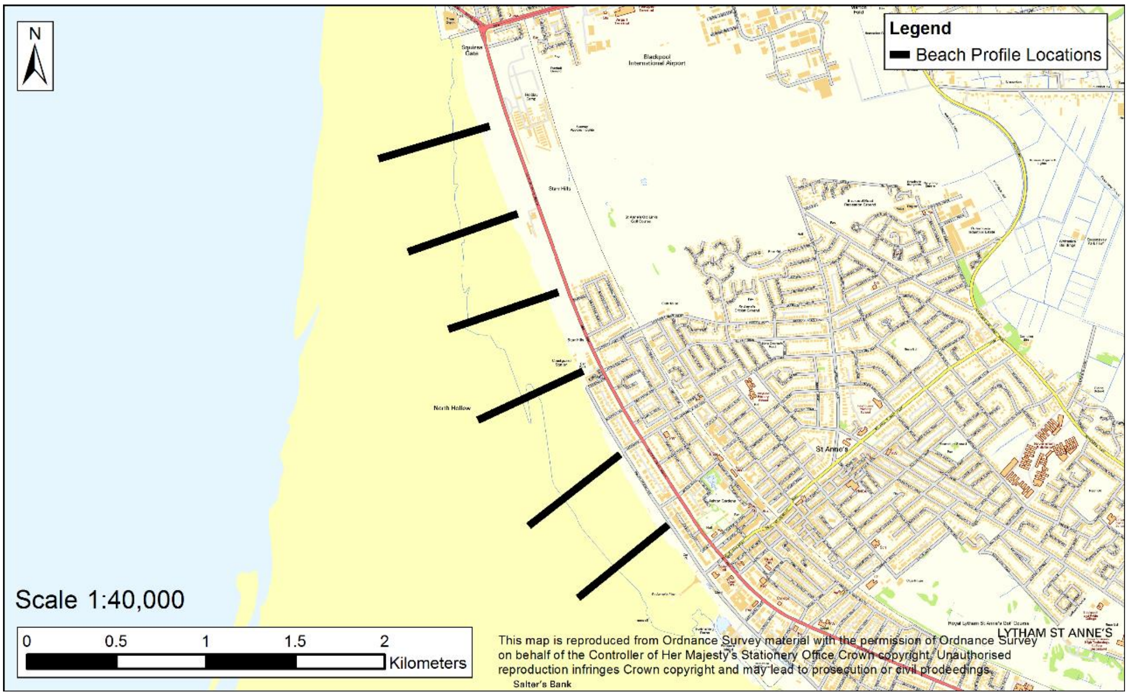


Figure 3-1: Beach profile locations

Table 3-1: Summary of beach profile analysis

Profile name	Description
North extent of the study area/former Pontins (northern most profile)	The dunes are widening, with the toe moving seaward. The dunes are generally increasing in height on their seaward side. The dunes are losing profile height on their landward side. Steepening of the dune's seaward face.
Sand Winning area	The dunes are widening, with the toe moving seaward. The dunes are generally increasing in height on their seaward side. The dunes are losing profile height on their landward side. Steepening of the dune's seaward face.
Kiting centre	A general increase in dune height and seaward migration. Little evidence of beach face steepening.
North Beach Car Park	A general reduction in dune height Some dune widening
North Promenade	Minor increase in dune height and width Note - reduced coverage of survey and profile data.
St Annes North Beach (southernmost profile)	Minor increase in dune height and width Note - reduced coverage of survey and profile data.

3.3.2 Volumetric analysis

Three years of LiDAR data from 2010 to 2013 have been analysed to establish an annual rate of sediment change throughout the study site. This analysis has been undertaken for the entire Starr Hill to St Annes site, in addition to four smaller sub-sections to identify any localised changes. Each of the four sub-sections has been split into an upper beach and lower beach, as shown in Figure 3-1. The change in volume has been analysed and is presented below in terms of volume lost, gained and overall change[1]. A simplified description of the change has been given based on the nominal classification that over 20,000m^3/year are large, over 10,000m^3/year are medium and below 10,000m^3/year are small. It should be noted that, relative to the overall scale of the frontage, that these change parameters represent quite modest variations.

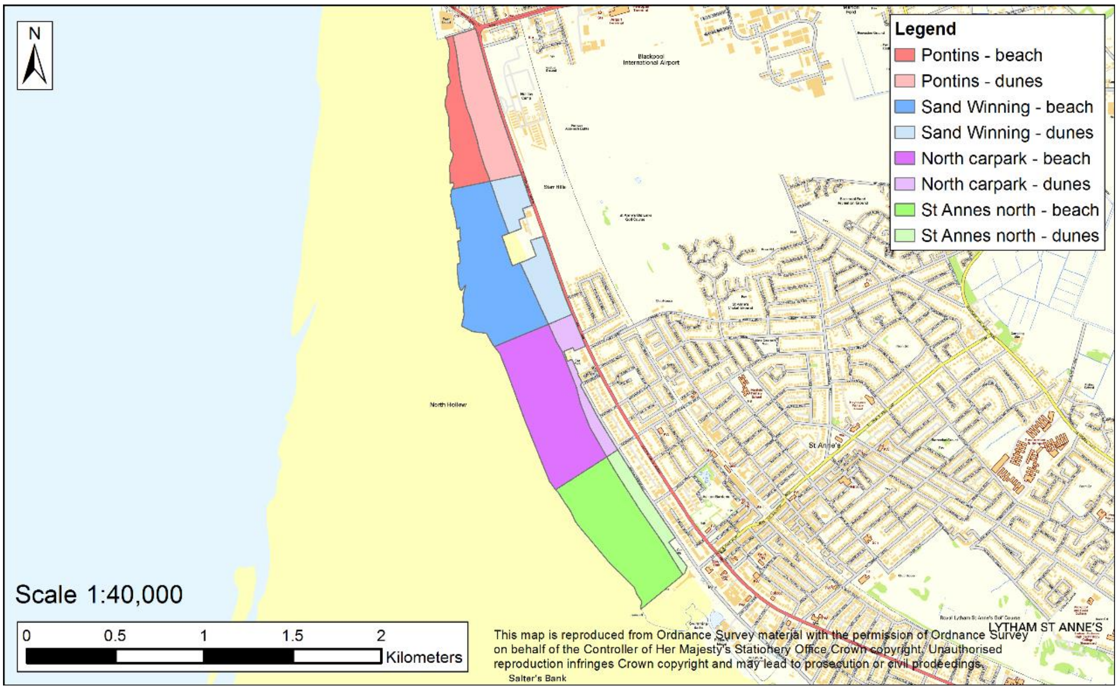


Figure 3-1: Beach analysis areas

The results of the volumetric analysis are presented in Table 3-2. The analysis shows the system is accreting as a whole, within an overall gain of approximately 70,000m^3 per year. The Sand Winning area experienced the greatest build-up, with an increase of 23,000 m^3 per year. It is noted that this rate would be higher due to the extraction of sand, which is taken off-site, and therefore not included within the volumetric analysis. Both sites adjacent to the Sand Winning area have experienced gains of 17-18,000m^3 per year, whilst the southernmost area at St Annes North (north of and adjacent to North Promenade car park) experienced the lowest gains at around 13,000m^3 per year.

[1] It should be noted, that a total of three years' worth of data is not sufficient to provide definitive evidence of the true long-term trend at Starr Hill – St Annes as this data may only represent a snapshot of the underlying net trend. It is recommended that this study be reviewed when additional data is available.

Table 3-1: Summary of beach profile analysis

Region	Profile Location	Average annual volume change - (m^3/yr)	Description
Total area	Whole profile	71,000	Large gain
	Upper (dunes)	26,000	Large gain
	Lower (beach)	45,000	Large gain
Former Pontins area	Whole profile	18,000	Medium Gain
	Upper (dunes)	11,000	Medium Gain
	Lower (beach)	7,000	Small Gain
Sand winning area	Whole profile	23,000	Large gain
	Upper (dunes)	8,000	Small Gain
	Lower (beach)	15,000	Medium Gain
North Beach car park area	Whole profile	17,000	Medium Gain
	Upper (dunes)	5,000	Small Gain
	Lower (beach)	13,000	Medium Gain
St Annes North (North Promenade car park) area	Whole profile	13,000	Medium Gain
	Upper (dunes)	3,000	Small Gain
	Lower (beach)	11,000	Medium Gain

3.4 Coastal processes assessment

A conceptual model of the coastal system has been developed to describe the behaviour of the Fylde Sand Dunes, based on the volumetric changes and the regional coastal processes. This describes the manner in which sediment is transported throughout the regional coastal system, how it moves within the site, and ultimately shapes the evolution of the dune system.

Regional processes bring an influx of sediment to the Fylde Coast, with an overall trend of accumulation within the local sediment cell (Pye & Blott, 2009). Studies undertaken to support the regional SMP2 indicate a net accumulation of approximately 750,000 m^3/year occurs within the Ribble estuary mouth (Halcrow, 2010). These are dominated by onshore directed transport of approximately 250,000m^3/year from the sea, and approximately 500,000m^3/year from the estuary itself. The sediment transport to the north and south are relatively minor, of the order of 30,000 to 60,000m^3/yr.

The net accumulation within the sediment cell provides a constant source of sand for the Fylde Sand Dunes. The local gains assessment between 2010 and 2013 suggests that for the 130ha study area an annual accumulation was approximately 70,000m^3/year. In addition, an estimated 78,000m^3/year is extracted from the beach through sand winning operations (see below and Figure 3-), giving a total estimated addition to the back beach and dune system of approximately 150,000m^3/year.

This sediment is distributed around the beach and dune system in a number of ways. Available cross-section profile data shows a general distribution over the beach itself, with increases of approximately 0.05m throughout the study site. Profile assessments show a trend of dune widening with a small change in height. This trend is not consistent throughout the whole region, with topographic profiles showing some dune steepening in the nearshore area. A beach and dune management programme has been underway since 2008 that has supported dune widening, through the installation of posts, thatch and planting. These sediment trapping measures have been submerged by sands (or planting established), allowing the embryo dune toe to extend seaward with new ridges forming. Dune migration is also being observed, such as at St Annes North Beach, where the dune system is migrating towards the pier, engulfing steps and railing features. The historic images show this area to previously have beach huts along this frontage.

There are several pathways for sediment to be lost from the Fylde Sand Dunes frontage. Commercial sand extraction is occurring based on planning permission granted in 1989, which allows the extraction of up to 150,000m^3/year and expires in 2049 (Sefton Council, 2013). During 2013 an estimated 300m^3 of sand was extracted on average per day, which equates to approximately 78,000m^3/year. Other losses include wind borne transport of sediment onto the roads, car parks and residential area which is removed by the council or residents to landfill, the volume of these losses remain unknown but are understood to be significant. There is a ramp effect of the sediment migration over the narrow dunes into the roads and residential areas, this sediment is lost to the system and is considered a sink.

There is no apparent evidence from this analysis to establish a clear transition point on this frontage, between dominant processes of the open coast and estuary it has not been possible to establish a correlation between such a potential transition and dune accretion. More data over a significantly longer timeframe would be required to develop this specific analysis further.

Based on these regional and local processes, a conceptual framework for the Fylde Sand Dune system is provided in Figure 3-3.

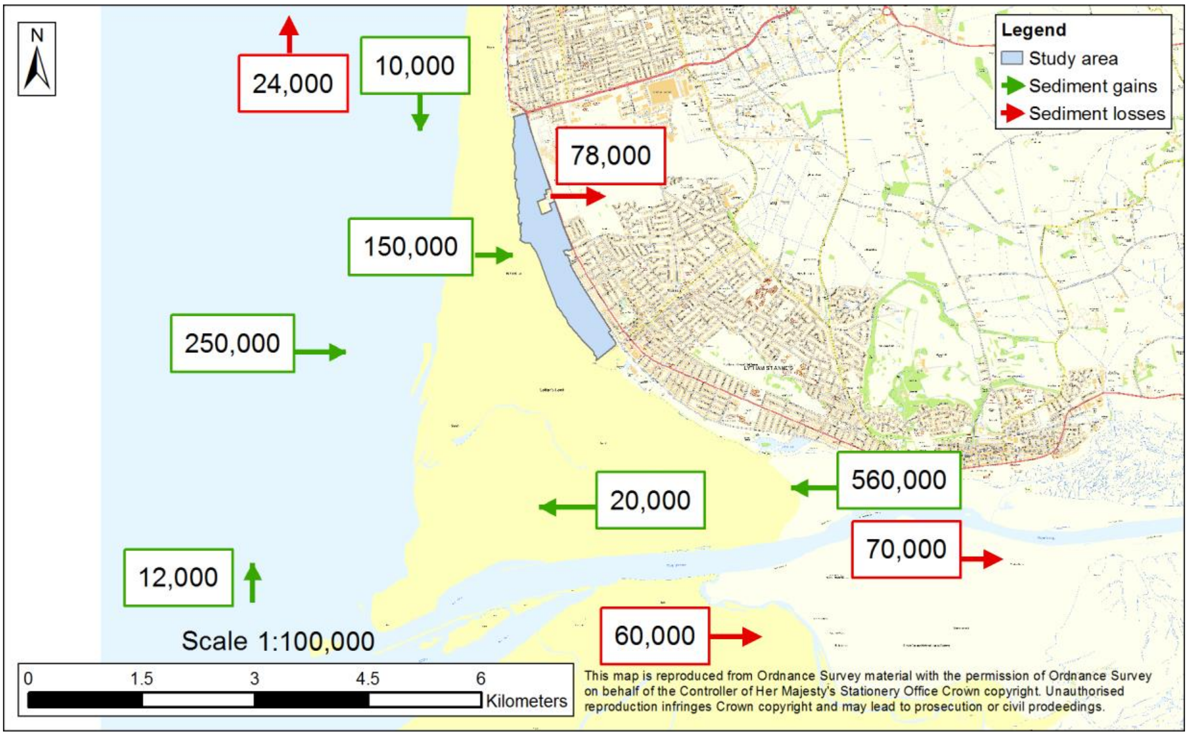


Figure 3-3: A conceptual framework for sediment gains and losses affecting the Starr Hill Sand Dune System and associated wider processes, adapted from previous sediment studies and the findings of this report.

3.5 Environmental considerations

3.5.1 Starr Hill Biodiversity

Sand dunes provide a vitally important habitat to a wide range of wildlife, including a large number of species which are incapable of surviving in any other habitat, and many of these are of national or international significance. Table 3-3 shows the site designations that aim to protect important habitats and species including sand dunes.

Table 3-3: Hierarchy of site designations

Level	Sites
International	Special Protections Areas (SPAs) Special Areas of Conservation (SACs) Ramsar sites
National	Sites of Special Scientific Interest (SSSIs), including National Nature Reserves (NNRs)
Local	Local sites, including Biological Heritage Sites (BHSs), Local Nature Reserves (LNRs), Local Geodiversity Sites (LGSs)

The value of sand dune for nature conservation has been recognised by its inclusion in Annex 1 of the EC Habitats Directive and by being listed as a Priority Habitat for conservation in the UK Biodiversity Action Plan. Fixed dune and decalcified fixed dune (i.e. dune heath) are additionally considered priority habitats in Europe under the EC Habitats Directive. On the Fylde Coast, an area of inland dune was declared a Local Nature Reserve in 1968, the Reserve and adjacent area of coastal dune at Starr Hill was designated a Site of Special Scientific Interest (SSSI) in 1991 and most of the remaining dune habitat was classified as a Biological Heritage Site (BHS) in 1997.

3.5.2 Local Site

3.5.2.1 Lytham St. Annes Local Nature Reserve

Local Nature Reserves (LNRs) are for both people and wildlife. They are places with wildlife or geological features that are of special interest locally. They offer people special opportunities to study or learn about nature or simply to enjoy it.

Over 280 different plant species have been recorded on the dunes from the mobile dunes on the coast to the fixed dunes of Lytham St. Annes Local Nature Reserve. This includes internationally rare plants such as the Isle of Man cabbage and the Dune Helleborine which only grow in Great Britain.

3.5.2.2 Lytham St. Annes Local Geodiversity Site

The Local Geodiversity Site (LGS) designation is assigned to sites of particular geological or geomorphological interest which is of regional importance. It is a non-statutory designation recognised by local planning authorities. The designated site includes all the dune land west of Clifton Drive North (A584) between Starr Gate in the north and the North Beach Car Park. It also includes the dune area east of Clifton Drive North.

The site represents the most extensive and comparatively intact example of coastal sand dune remaining in Lancashire. It also has regional significance. The site has a range of dune features including fore dune and high dunes (both stable and unstable) separated by slacks and shows the critical relationship between landform and vegetation. It also includes many example of blowout formation. It is the only place in Lancashire where dune geomorphology can be observed to any reasonable extent.

3.5.3 National Site

3.5.3.1 Lytham St. Annes Dunes SSSI

SSSIs give legal protection to the best sites for wildlife and geology in England under the Wildlife and Countryside Act 1981 (as amended).

At Starr Hill SSSI the dunes reach their maximum width and are important as the best example of a calcareous dune system remaining in Lancashire. In spite of past sand extraction, seasonal pressures from holidaymakers and the small size of the dune system, it still shows classic features of dune formation and ecological succession including the widest range of foredune, yellow dune, dune grassland, acid dune grassland, dune scrub and dune slack habitats found anywhere along the Fylde Coast. These support a rich and varied dune flora typical of southern and western Britain with over 230 species of higher plants, some of which are scarce nationally or uncommon locally, occurring on the northern and southern limits of their distribution range. The three management units within the SSSI are all determined as being in an unfavourable recovering condition (Natural England, SSSI Condition Assessment 07/07/2014).

A rich invertebrate fauna is also present including many species associated with coastal and dune habitats, which are rare or uncommon species. The foredunes and yellow dunes rise sharply from the foreshore and are composed of a highly calcareous sand supporting four types of plant community. Sand couch *Elymus farctus* dominates the lower levels of the foredunes, together with stands of lyme-grass *Leymus arenarius*. The yellow dunes are dominated by marram grass *Ammophila arenaria*, which is the main duneforming plant, and other characteristic species include sea holly *Eryngium maritimum* and sea spurge *Euphorbia paralias*, a nationally scarce species.

On the landward side of the dunes, large areas of dune grassland occur on levelled ground interspersed by a series of low hillocks and an intricate pattern of damp hollows or dune slacks, created during past sand-winning activities. Such areas support a number of herb-rich plant communities, which vary considerably according to various soil conditions, the effects of trampling and rabbit grazing. Notably, small areas of acid dry dune grassland are present dominated by marram grass, sand cat's-tail *Phleum arenarium* and red fescue *Festuca rubra* with wild pansy *Viola tricolor*, common mouse-ear *Cerastium fontanum* and the rare dune fescue *Vulpia membranacea.* Large-flowered evening primrose *Oenothera erythrosepala* also occurs where there is bare sand. Extensive areas of herb-rich calcareous dune plant communities surround these co-dominated by marram grass, red fescue and restharrow *Ononis repens* with locally abundant sand sedge *Carex arenaria*, bird's-foot trefoil *Lotus corniculatus,* lady's bedstraw *Galium verum*, mouse-ear hawkweed *Hieracium pilosella*, kidney vetch *Anthyllis vulneraria*, cat's-ear *Hypochaeris radicata* and eyebright *Euphrasia officinalis*. Wild thyme *Thymus praecox* is found on rabbit-grazed areas where carline thistle *Carlina vulgaris* and biting stonecrop *Sedum acre* also occur. Of particular note is the presence of the rare dune helleborine *Epipactis dunensis*, green-flowered helleborine *Epipactis phyllanthes* var. *pendula* and Isle of Man Cabbage *Rhynchosinapis monensis,* in addition to locally scarce species such as common broomrape *Orobanche minor*, Danish scurvy-grass *Cochlearia danica* and blue fleabane *Erigeron acer* which are present on the northern limits of their distribution range.

Dewberry *Rubus caesius* is a small wood plant occurring throughout the dune grassland whilst sea buckthorn *Hippophae rhamnoides* is the only species forming scrub in three small areas within the Nature Reserve and, as an invasive species, may be removed.

The series of exceptionally large and extensive dune slacks on either side of Clifton Drive North support a wide range of species, which vary according to the depth of water and degree of moisture retention in relation to the water table. In the drier slacks creeping willow *Salix repens* is the most common plant forming a hummocky carpet with red fescue and Yorkshire fog *Holcus lanatus* and other species including locally abundant yellow rattle *Rhinanthus minor*, harebell *Campanula rotundifolia*, yellow-wort *Blackstonia perfoliata*, grass-of-Parnassus *Parnassia palustris*, red and white clovers *Trifolium pratense* and *T. repens.* In addition, the rare seaside centaury *Centaurium littorale* and round-leaved wintergreen *Pyrola rotundifolia* are present as well as the less frequent bee orchid *Ophrys apifera* and pyramidal orchid *Anacamptis pyramidalis*, which are locally scarce and occur here on the northern limit of their distribution range. In damper areas large populations of common spotted and marsh orchids *Dactylorhiza fuchsii, D. incarnata and D. purpurella* occur with their hybrid *D. fuchsii praetermissa*. There are also abundant marsh helleborine *Epipactis palustris*, marsh pennywort *Hydrocotyle vulgaris* and knotted pearlwort *Sagina nodosa*, as well as the rare variegated horsetail *Equisetum variegatum* and the uncommon yellow birds' nest orchid *Monotropa hypopitys* and small-fruited yellow sedge *Carex serotina*. The largest slack in the south-west corner of the site is permanently wet. Its central zone of standing water is dominated by water horsetail *Equisetum fluviatile* and water-crowfoot *Ranunculus aquatilis* with fringing marsh pennywort, marsh bedstraw *Galium palustre*, water mint *Mentha aquatica*, water forget-me-not *Myosotis scorpioides*, lesser spearwort *R. flammula* and branched bur-reed *Sparganium erectum*. A large clump of the rare hybrid rush *J. balticus inflexus* is a notable feature as is common cottongrass *Eriophorum angustifolium*.

There is also a small stand of reed canary grass Phalaris arundinacea with several small bushes of willow *Salix alba* and *S. cinerea*.

Butterflies and moths are the most studied of the invertebrate fauna of the dunes and over 150 species have been recorded. Many of these are typical of coastal and dune habitats such as the Dark Tussock *Dicailomera fascelina* and the Portland Moth *Ochropleura praecox*, both nationally notable species. The vulnerable Sandhill Rustic *Luperina nickerlii gueneei*, once thought to be extinct from the area, has more recently been rediscovered. The occurrence of a small colony of common lizard *Lacerta Zootoca vivipara* is also of note, as are several pairs of nesting stonechat *Saxicola torquata* at their only breeding locality in the Fylde area.

Three species of bird, which regularly breed within the Fylde Sand Dunes, are listed as Priority species for conservation in the UK Biodiversity Action Plan and are on the RSPB's Red List of species of conservation concern; these are reed bunting *Emberiza schoeniclus*, skylark *Alauda arvensis* and linnet *Carduelis cannabina*. All of these breed principally on St. Annes Local Nature Reserve. House sparrow *Passer domesticus* and starling *Sturnus vulgaris* (both on the RSPB Red List and UK BAP Priority list) both utilise the dunes during the breeding season also.

3.5.3.2 The Ribble Estuary National Nature Reserve

The reserve occurs further south of Starr Hill – St Annes frontage and is protected under:

- The National Parks and Access to the Countryside Act 1949
- The Wildlife and Countryside Act 1981 (as amended)

The reserve occupies over half of the total area of the Ribble Estuary (4520 Ha), including extensive areas of mud and sand flats and one of the largest single areas of saltmarsh in England. It has been described as a 'hotel-restaurant' for birds as it is a key site in the chain of wetlands which make up the east Atlantic flyway or migration route for wintering wildfowl and waders.

3.5.3.3 International Site

The Ribble and Alt Estuaries SPA is an EU designated Natura 2000 site, which is relevant to the proposed project, and the following paragraphs outline the legislation and obligations under the Habitats Directive.

3.5.3.4 European Legislative Context

Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora, known as the 'Habitats Directive' - provides legal protection for habitats and species of European importance. Article 2 of the Directive requires the maintenance or restoration of habitats and species of European Community interest, at a favourable conservation status. Articles 3 - 9 provide the legislative means to protect habitats and species of Community interest through the establishment and conservation of an EU-wide network of sites known as Natura 2000 sites. Natura 2000 sites are Special Areas of Conservation (SACs) designated under the Habitats Directive and Special Protection Areas (SPAs) designated under the Conservation of Wild Birds Directive (79 / 409 / EEC).

The Habitats Directive requires that measures taken under it, including the designation and management of SACs, be designed to maintain or restore habitats and species of European Community importance at "favourable conservation status" (FCS), as defined in Article 1 of the Directive.

3.5.4 Article 6 Assessment

Articles 6(3) and 6(4) of the Habitats Directive set out the decision-making tests for plans or projects affecting Natura 2000 sites. Article 6(3) establishes the requirement for Appropriate Assessment (Habitat Regulations Assessment). Article 6(4) deals with the steps that should be taken when it is determined, because of Appropriate Assessment, that a plan/project will adversely affect a European site. Issues dealing with alternative solutions, imperative reasons of overriding public interest and compensatory measures need to be addressed in this case.

Under Regulation 61 of the Conservation of Habitats and Species Regulations 2010 (as amended), there is a legal requirement to consider the impacts of a plan or project on a European site. In this context the term 'plan or project' includes planning strategies, development plans, development proposals or anything else that could impact on the integrity of a European site.

When undertaking an assessment of impacts at a site, all features of European importance (both primary and non-primary) need to be considered.

The statutory assessment process i.e. the Habitats Regulations Assessment, (HRA) includes the following steps:

- If a proposal is likely to have a significant effect on the features (species or habitats) of an SPA or SAC then the competent authority (i.e. the authority responsible for deciding whether a proposal should proceed) must carry out an assessment to establish whether the proposal will adversely affect the site.
- If it is shown that the proposal would not cause an adverse effect to the site, the proposal will be allowed to go ahead.
- If it is shown that the proposal would cause an adverse effect, consent may be refused, or the proposal may need modifying in order to proceed.

- If it is shown that a proposal may cause an adverse effect, but there are no alternative solutions, the proposal may be allowed to proceed, but only if there are imperative reasons of overriding public interest.

The HRA, if required, would be undertaken of the preferred options as part of the next stage of the process.

3.5.5 Ribble and Alt Estuaries SPA and Ramsar Site

The potential to impact on the Ribble and Alt Estuaries will largely depend upon the management option chosen (in combination with other activities and plans) and the potential effects on any of the designated features of the SPA either positively or negatively. Designated species such as sanderling and ringed plover may use beach and intertidal sandflats for foraging along with other waders. Indirect impacts on the saltmarshes, which support waders and wildfowl of the SPA, would also require consideration.

The Ribble and Alt Estuaries SPA forms part of the Natura 2000 network and lies on the coast of Lancashire and Merseyside in north-west England. It comprises two estuaries, of which the Ribble Estuary is by far the larger, together with an extensive area of sandy foreshore along the Sefton Coast. It forms part of the chain of western SPAs that fringe the Irish Sea. There is considerable interchange in the movements of wintering birds between this site and Morecambe Bay, the Mersey Estuary, the Dee Estuary and Martin Mere. A large proportion of the SPA is within the Ribble Estuary National Nature Reserve. The site consists of extensive sand- and mud-flats and, particularly in the Ribble Estuary, large areas of saltmarsh. There are also areas of coastal grazing marsh located behind the sea embankments. The intertidal flats are rich in invertebrates, on which waders and some of the wildfowl feed. The highest densities of feeding birds are on the muddier substrates of the Ribble, though sandy shores throughout are also used. The saltmarshes and coastal grazing marshes support high densities of grazing and seed-eating wildfowl and these, together with the intertidal sand- and mud-flats, are used as high-tide roosts. Important populations of waterbirds occur in winter, including swans, geese, ducks and waders. The SPA is also of major importance during the spring and autumn migration periods, especially for wader populations moving along the west coast of Britain. The larger expanses of saltmarsh and areas of coastal grazing marsh support breeding birds during the summer, including large concentrations of gulls and terns. These seabirds feed both offshore and inland, outside the SPA. Several species of waterbirds (notably Pink-footed Goose) utilise feeding areas on agricultural land outside the SPA boundary.

This site qualifies under Article 4.1 of the Directive (79/409/EEC) by supporting populations of European importance of the following species listed on Annex I of the Directive:

During the breeding season;

- Common Tern *Sterna hirundo*
- Ruff *Philomachus pugnax*

Over winter;

- Bar-tailed Godwit *Limosa lapponica*,
- Bewick's Swan Cygnus *columbianus bewickii*,
- Golden Plover *Pluvialis apricaria*
- Whooper Swan *Cygnus cygnus*

This site also qualifies under Article 4.2 of the Directive (79/409/EEC) by supporting populations of European importance of the following migratory species:

During the breeding season;

- Lesser Black-backed Gull *Larus fuscus*,

On passage;

- Ringed Plover *Charadrius hiaticula*
- Sanderling *Calidris alba*

Over winter;

- Black-tailed Godwit *Limosa limosa islandica*
- Dunlin Calidris *alpina alpina*
- Grey Plover *Pluvialis squatarola*
- Knot *Calidris canutus*
- Oystercatcher *Haematopus ostralegus*
- Pink-footed Goose *Anser brachyrhynchus*
- Pintail *Anas acuta*
- Redshank *Tringa totanus*
- Sanderling *Calidris alba*
- Shelduck *Tadorna tadorna*
- Teal *Anas crecca*
- Wigeon *Anas penelope*

Assemblage qualification: A seabird assemblage of international importance

The area qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting at least 20,000 seabirds

During the breeding season, the area regularly supports 29,236 individual seabirds including: Black-headed Gull *Larus ridibundus*, Lesser Black-backed Gull *Larus fuscus*, Common Tern *Sterna hirundo*.

Assemblage qualification: A wetland of international importance.

The area qualifies under Article 4.2 of the Directive (79/409/EEC) by regularly supporting at least 20,000 waterfowl

Over winter, the area regularly supports 301,449 individual waterfowl (5 year peak mean 1991/2 - 1995/6) including: Grey Plover *Pluvialis squatarola*, Whooper Swan *Cygnus*, Golden Plover *Pluvialis apricaria*, Bar-tailed Godwit *Limosa lapponica*, Pink-footed Goose *Anser brachyrhynchus,* Shelduck *Tadorna tadorna*, Wigeon *Anas penelope*, Teal Anas crecca, Bewick's Swan *Cygnus columbianus bewickii*, Oystercatcher *Haematopus ostralegus*, Curlew *Numenius arquat*a, Knot *Calidris canutus*, Sanderling *Calidris alba*, Dunlin *Calidris alpina alpina*, Black-tailed Godwit *Limosa limosa islandica*, Redshank *Tringa totanus*, Cormorant *Phalacrocorax carbo*, Common Scoter *Melanitta nigra*, Lapwing *Vanellus vanellus*, *Pintail Anas acuta*.

3.5.6 Sand Dune Management and Maintenance of Biodiversity

Under most natural conditions, coastal dune environments contain a range of vegetation types and habitats whose distribution and extent is continually changing in response to sediment movement and mobility of the landforms. Many species have evolved and adapted specifically to these conditions and are dependent on the existence of a mosaic of habitats for their survival. Many of these species and associations are now legally protected by a variety of conservation designations, and consequently the management options in relation to biodiversity will require closer analysis and monitoring

It has become increasingly recognised that over-stabilised dune systems can be detrimental to nature conservation and biodiversity objectives, since there is a close link between geomorphological dynamics and ecological diversity. Moreover, it has been recognised that a policy of 'hold the line' in the context of frontal dune management is likely to be unsustainable in the face of rising sea levels and global climate change. Consequently there has been a move internationally towards integrated coastal dune management, which takes into account the flood defence, conservation, recreational and other interests in coastal dunes and designs intervention strategies, which are appropriate to the management objectives.

In this regard, the impacts of coastal squeeze on the dune and foreshore habitats of the Starr Hill – St Annes frontage along with the net sediment budget for the area are critical in determining the optimal management regime to meet biodiversity objectives. A strategy that promotes dune widening, based on creating additional dynamic embryo and foredunes, in the context of a positive sediment budget and generally accretive forces, at least in the short term, is one that can both usefully support both enhanced biodiversity and improved resilience and adaptive capacity in the medium term.

The intertidal sand flats are not only a source of material for dune formation but also sustain their own ecology whilst provide roosting and foraging sites for breeding and overwintering birds. Whilst outside of the scope of this study, which focuses on morphological processes, an holistic view of the interaction and interdependencies between the of dune and foreshore habitats will help to improve understanding of change and potential vulnerabilities across the frontage in the light of pressures from amenity, climate change, development and wider coastal dynamics to the north and south.

Ongoing survey and monitoring will help to identify how species and habitats respond to interventions, however in principle a deeper and more structurally diverse dune system, with physical connections to existing core habitats should enable valuable dune habitat development.

4 Management options appraisal

4.1 Introduction

The analysis of the inherent coastal processes show that while the underlying trend seems to show the dunes accreting and migrating seaward, a number of locally focussed areas of erosion or 'blow-outs' were noted that breached the dunes and reduced the width and height. The development of blow-outs clearly needs to be managed to reduce the risk of still water level flooding to the property and infrastructure behind the dunes. Several significant constraints where hard infrastructure (properties, roads) has created very narrow dunes or gaps are also identified.

Additional further dune management issues have arisen due to the underlying accretive trend detailed above. Windblown sediments have built-up against property and infrastructure requiring regular interventions to prevent unwanted accretion. Some evaluation of volumes of sand requiring mechanical removal may form part of a wider monitoring programme.

However, it is important to consider the management of the frontage as a whole, where primary objectives point towards ensuring that the net positive sand budget supports procession and the formation of embryo and foredune features, benefitting future flood and erosion risk, biodiversity, landscape and amenity and to enable the dune to evolve as a natural form of defence, in line with SMP policy. Whilst detailed and location-specific interventions are considered below, a Multi-Criteria Analysis (MCA) examines options on a whole-frontage basis.

4.2 Location specific issues

In addition to the main issues facing the Fylde Dunes frontage (detailed above), further site-specific issues have been highlighted. Table 4-1 summarises the main issues at along the overall frontage and within each sub-frontage, their current management practices and recommended options for future management. A number of the key recommended site-specific interventions have been discussed below.

4.2.1 Dunes opposite former Pontins site

A new development under construction at the old Pontins site is likely to increase recreational pressures on the most physically diverse part of the dune system. As part of the planning process, it is recommended that this be reviewed, to ensure adequate provision of robust walkways to limit the negative effects of dune trampling, and limit health and safety implications of informal access routes and misuse from digging, barbecues etc.

In addition, localised blow-outs in this area are significant. While they have been considered to contribute to negligible coastal risk by the Client, they are likely to become an increasing problem in the future with climate change, sea level rise and increased storminess.

4.2.2 Sand winning area

The Sand-Winning area is used as an extraction site by the local aggregates company. While the dunes are currently showing accretive trends, it is recommended that this abstraction license is reviewed in detail. Dunes typically display cyclical trends of accretion and erosion. It is paramount that during these cycles of accretion, dunes are allowed to grow as large as possible, to ensure that there is sufficient buffer during erosive cycles. By abstracting sand at this location, dunes are not being allowed to accrete sufficiently and may risk breach and increased flood risk during erosive periods.

The extraction of sand at this location may provide an opportunity to artificially nourish the dunes at key locations. This will aid in promoting dune procession in areas where there is a lack of supply of sand. One location that could benefit from this could be the area fronting North Beach Car Park. However, it should also be noted that excavated or scraped sand from the lower beach must not be viewed as a substitute to wind-blown sand. Its composition, including particle size, physical and chemical composition and organic content will be substantially different from "blown" sand and will likely offer a less effective structure on which to build a dune. There are also a wide range of environmental impacts in removing sand by this means. However, in critical areas where some accelerated dune-promotion is required, this approach could offer a stop-gap measure but should not be construed as a rationale to sustain or extend sand-winning. This should be explored in more detail by Fylde Council.

4.2.3 North Beach car park

North Beach car park is experiencing issues from wind-blown sediment accumulation against property and infrastructure. This has resulted in several health and safety issues regarding the build-up of sediments against walls that were never designed to retain large depths of sand and windblown sediments covering access tracks and roads. Sand has previously been mechanically cleared back from this area; however, such an approach is not sustainable in terms of flood and erosion risk management, dune ecology, longer-term safety and nuisance from blown sand.

In general, the effects of these issues can be reduced by promoting foredune accumulation to enable dune procession. This will reduce the volume of wind-blown sand further inland and its accumulation against property and infrastructure. It will not, however, eliminate blown sand from the car park, roads and property

However, while this must be considered a longer term policy, this is a natural process that takes a long time, even with sediment-trapping measures; embryo and foredune establishment needs to achieve a degree of stability and structure and to start to naturalise. In the meantime, to mitigate the health and safety risks associated with sand build up, several management options could be adopted:

- Redesign walls in order to retain large depths of sand, reducing the risk of failure of the walls.
- Reduce or remove walls and accept that sand will overblow and require periodic clearance, but avoid the creation of sand "cliffs" by this process.
- Limit vehicular access to essential traffic only, reducing the volume of traffic using the access roads. Monitor and consider whether any vehicular access at all is required (emergency vehicles can access the beach to the south of the pier).

To the south of North Beach car park and adjacent to North Promenade, there is a small area of privately owned dunes, coincident with some of the narrowest widths. Some privately commissioned work has been undertaken to reprofile this section, lowering and widening the dune. Whilst this action may pose some localised issues, the primary focus of dune procession seaward of the private frontage should remain a priority.

4.2.4 St Annes North Beach / North Promenade Car Park

Similar to North Beach Car Park, overblown sand builds up against retaining walls and affects the adjacent "Les Dawson" garden as well as properties to the landward side of North Promenade. Beach access and the steps adjacent to the pier are also liable to sand infilling. Sustained sand clearance and its removal from the system is not a preferred long-term solution and whilst promoting dune procession may offer some reduction in overblown sand, the footfall over the dunes is very high at this point. This, combined with a relatively abrupt transition point from dune to the cleared frontage of the Amenity Beach to the south of the pier, will inevitably require some degree of ongoing maintenance and clearance.

Table 4-1: Summary of dune management issues

Location	Issue	Summary of existing management issues	Current management methods	Proposed future management methods
Wider study area	0.1	Blow-outs reducing impermeable defence crest level increasing flood risk to surrounding property and infrastructure.	Varying range of techniques.	Reduce front face erosion and promote dune building through trapping of sediment.
	0.2	Residual landward sand-loss	Periodic mechanical clearance of over-blown sand on roads, car parks and public spaces	Sustain some clearance measures for safety and nuisance purposes but reduce the extent and volume of overblown sand and its impacts through sediment trapping, access realignment and dune procession.
Dunes opposite former Pontins site to Sand-Winning area	1.1	Recreational pressures from extensive new housing development at former Pontins site.	No current dune management operations. Pending mitigation identified in Environmental Statement includes allocation of 1.3ha open space on site; fencing sensitive areas during construction; signposts and dune paths defined and linked to new pedestrian crossing; dog-paths to reduce erosion; dog bins; biodiversity information packs to new householders	Examine resources available from planning (s.106 or CIL) to enable active dune management programme to reduce erosion and habitat damage/disturbance issues. Consider dedicated access points and reinforcing some of the more heavily used desire lines whilst restricting others, through signage, boardwalk or fencing. Undertaken alongside public information provision (including information in homeowner packs) and wider engagement.
	1.2	Large blow-outs in dunes. Environmental Impact Assessment for development considers overall a negligible increase in risk from coastal processes due to the current height and width of dunes However it may become an increasing issue in the future with climate change scenarios.	No current dune management operations.	Monitor scale of blow-outs and potential flood and erosion risk they may pose. Sediment trapping within the dune limits and foreshore to promote dune procession and manage erosion of blow-outs where necessary.
	1.3	Nursing and convalescent care homes located within dune system may become vulnerable to future erosion and flood risk.	No current dune management operations. Sand storage area (sand-winning) provides some additional erosion protection whilst sand is stockpiled, although this also limits opportunities to promote procession.	Monitor resilience of this frontage and sand-winning access track (2.2 below). Promote dune procession and requirement for beach access, pending outcome of sand-winning licence review.
Sand-Winning area	2.1	Land use issues relating to industrial compound sited within dunes, including: - Wide access track used by heavy plant	Removal of sand by heavy machinery (responsibility of aggregates company and Fylde BC; Lancs CC is the local planning	Re-evaluate sand extraction licence and impacts of sand-winning on foreshore, dunes, amenity and flood risk management, review

Location	Issue	Summary of existing management issues	Current management methods	Proposed future management methods
		- Weighbridge and compound within dunes - Sand storage near seaward toe of dunes	authority).	risks associated with this infrastructure and operating processes.
	2.2	Access track may create erosion and flood risk vulnerabilities, both to the road (Clifton Drive North) and to the nursing and convalescence homes within the dunes to the immediate north.	Stored sand has been moved to block the access road during storm or surge conditions as a precautionary measure.	Promote dune procession and requirement for beach access, pending outcome of sand-winning licence review.
Sand-Winning area to North of North Beach Car Park	2.1	Dune accretion and procession to the north of North Beach Car Park.	Marker posts to limit the extent of mechanical beach cleaning near to the toe of the dunes. LOVEmyBEACH works with community beach cleaning group St Annes BeachCare for litter-picking on frontage.	Cease mechanical cleaning unless detritus poses a public health hazard. Sustain voluntary approaches to beach cleaning and incentives to minimise littering problems. Extend this approach northwards. Sediment trapping within the dune limits and foreshore to promote dune procession.
	2.2	Informal access routes through dunes and recreational pressures	No current dune management operations	Consider reinforcing some of the more heavily used desire lines and restricting others, through signage, boardwalk or fencing
North Beach Car Park and access road	3.1	Accretion of wind-blown sand on beach access road, restricting vehicular access to the Kiting centre and beach. Funnelling of sand blown through to Clifton Drive North and adjacent properties.	Informal clearance of sand by Kiting centre staff.	Sediment trapping within the dune limits and foreshore to promote dune procession and reduce the extent of windblown sand to landward of the dunes
	3.2	Accretion of wind-blown sand on Kiting centre premises and up against walls	Informal clearance of sand by Kiting centre staff	Sediment trapping within dune limits and on foreshore to promote dune procession and reduce the extent of windblown sand
	3.3	Accretion of wind-blown sand into car park restricting access and egress.	Removal of sand to landfill site (sand assumed to be contaminated) by Fylde BC	Continue some sand clearance where it represents a safety issue or significant nuisance
	3.4	Accretion of wind-blown sand against car park walls	Removal of sand to landfill site (sand assumed to be contaminated) by Fylde BC	Consider redesigning walls to retain some sand but allow a safe landward slip-face profile of the dune to stabilise.
	3.5	Sand accumulation at Lytham Coast Guard Station raises safety and management concerns.	Removal of sand from seaward face of wall (now ceased) by Fylde BC.	Sediment trapping on foreshore to promote dune procession and reduce the extent of windblown sand accumulation directly against the wall. Monitor for safety issues.

Location	Issue	Summary of existing management issues	Current management methods	Proposed future management methods
South of North Beach Car Park to St Anne's North Beach	4.1	Dune procession and accretion to the south of North Beach Car Park though the use of chestnut paling, thatch, marram and lyme grass planting.	Chestnut paling fencing in places. Mixed success of lyme and marram grass planting. Christmas tree thatch in places.	Continue sediment trapping within the dune limits and foreshore to promote dune procession. Continue to monitor and rates of infill or windblow and realign paling fencing to limit hazards.
	4.2	Pedestrian access routes through paling fencing infilling with sand resulting in health and safety issues associated with trip hazards. Alignment of access routes promotes wind-blown sand	Re-orientation of access routes to limit windblown sand problems. Monitor and manage chestnut paling to limit hazard as the dune accretes over them.	
	4.3	Lowering of dunes privately owned, adjacent to properties at Northern end of North Promenade.	Sediment trapping and dune procession encouraged beyond seaward extend of private ownership	Continue to promote dune procession along whole frontage.
St Anne's North Beach / North Promenade Car Park	5.1	Accretion and procession of dunes around car park	Chestnut paling fencing and marram grass planting.	Sediment trapping within the dune limits and foreshore to promote dune procession. Consider redesigning walls to retain sand. Maintain a "clearway" close to the pier and steps for public access.
	5.2	Sand accumulation against car park walls. Additional loading causing failure and blockages of drainage within walls.	Removal of sand to landfill site (sand assumed to be contaminated) by Fylde BC.	
	5.3	Sand accumulation on and around access steps to St Anne's North Beach resulting in health and safety issues associated with safe access and egress.	Removal of sand to landfill site (where sand is assumed to be contaminated) by Fylde BC.	

4.3 Frontage options appraisal

The summary of issues at Fylde Dunes, provided in Table 4-1, shows that while a few localised issues on the frontage can be resolved by site specific solutions, the majority of issues can be addressed by attempting the following:

1. to reduce the risk of blow-outs; and
2. to reduce the likelihood of accretion in unfavourable locations.

With this in mind, the options appraisal on the Starr Hill to St Annes frontage needs to consider the performance of any proposed options against these key performance criteria.

While dunes are transient features, where morphological responses are inherently difficult to predict, in general, the risk of adverse development of blow-outs can be reduced through a twofold methodology:

- Trapping sand to increase the size of the dunes, and/or
- Provide a surface protection to the exposed dune face to reduce the expected scale of losses during a storm event.

In order to reduce the likelihood of accretion in unfavourable locations, the best solution is to aim to limit windblown sediments from moving past the mid-dune and accreting on property and infrastructure. This can be achieved through sediment trapping and promoting seaward dune procession.

4.3.1 Options considered

A number of options to manage the dunes, reduce the risk of blow-outs, promote accretion and increase sediment trapping have been provided below:

- Option 1 - No active intervention
- Option 2 - Dune fencing
- Option 3 - Dune thatching
- Option 4 - Dune planting

The options appraisal initially considered all options available, from do nothing to large-scale interventions. However, a number of these options were discounted at the initial screening stage due to the likely negative impact on the environment and the large associated costs.

Table 4-2: Discounted options for management of dunes

Option considered	Reason for discounting
Beach recharge	Large associated ongoing cost and unsuitable on long exposed frontage.
Revetment toe	Hard engineered solution that will likely have a negative impact on the landscape and environment
Rock armour/timber groynes	Large associated costs
Fishtail groynes	Large associated costs
Offshore breakwater	Very large associated costs

The relative advantages and disadvantages of those options that were considered appropriate at Fylde Sand Dunes are discussed in each section below. The applicability of these options, within the Fylde Sand Dune system, is discussed in more detail in Section 4.4.

4.3.2 Option 1 – No active intervention

In many cases dune accretion may be best managed by not interfering with the natural processes, but instead accepting that adaptation and backshore management may be required. This approach involves relocation and monitoring costs, but in some instances these can be significantly lower than the costs associated with protection.

Advantages

- Allows the natural processes to occur and supports biodiversity
- No expensive ongoing management costs

Disadvantages

- Possible increase in flood and/or erosion risk
- Long-term geomorphological effects difficult to predict
- Need to promote dune procession while cycling shows accretive trend to ensure sufficient dune width during erosive cycles.
- Coastal squeeze against significant hard infrastructure and property restricts landward/downwind migration of the dune system.

4.3.3 Option 2 – Dune fencing

The construction of semi-permeable fences along the seaward face of dunes, encourages the deposition of windblown sand, reduces trampling and protects existing or transplanted vegetation. This not only promotes dune procession, but also increases sediment trapping, reducing the likelihood of the build-up of unwanted sediments at property and infrastructure. For dune fencing to be effective the void to solid ratio should be between 30% and 50% to achieve effective sand accumulation, meaning that one third to a half of the fencing should be open.

Advantages

- Minimal impact on natural system
- Can be used to control public access and improve dune recovery
- Straightforward to install and move, enabling an adaptive approach to siting

Disadvantages

- Hard structure; visually intrusive
- Maximum design life of 5 years
- Fences need regular maintenance

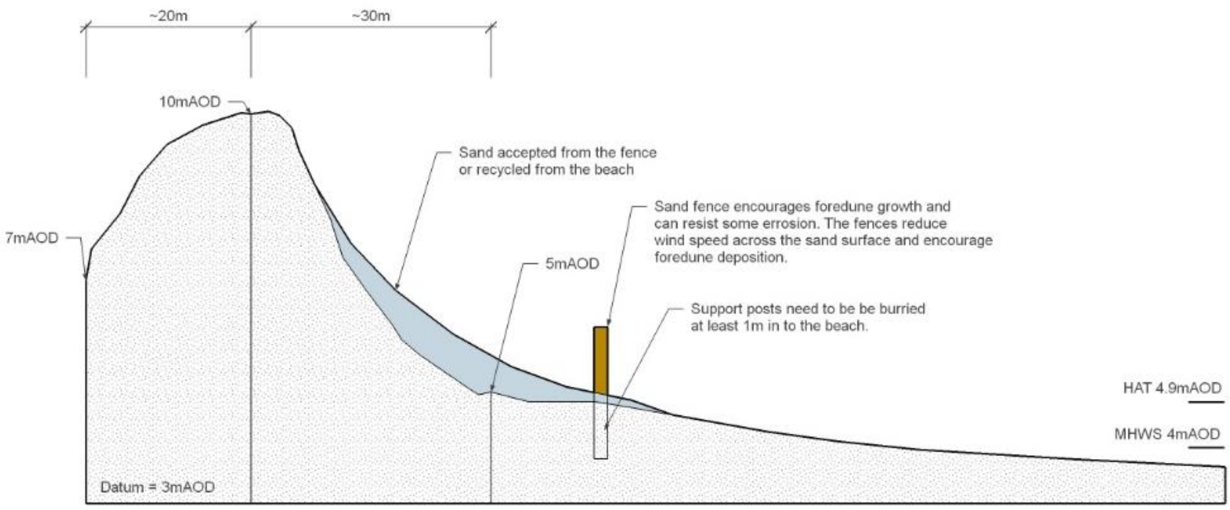


Figure 4-1: Schematic of Option 2 - Dune fencing

4.3.4 Option 3 – Dune thatching

Thatching is the covering of brushwood laid down to protect dune grasses and help trap sand, using materials such as forestry cuttings (e.g. Christmas trees), seaweed or biodegradable mats. This is a traditional way of stabilising sand, reducing trampling and protecting vegetation. Well laid thatch will encourage dune recovery and will resist some erosion, but cannot prevent erosion where wave attack is frequent and damaging. The thatch reduces surface wind speeds, encouraging deposition of blown sand, with the success relying on the amount of blown sand, the frequency of wave attack and the availability of vegetation. For this to be most effective the thatch should be laid to cover 20%-30% of the exposed sand surface.

If materials are locally available then this would be considered a low cost solution and minimal machinery and skilled labour is required to achieve success. However, continual maintenance is required to ensure the longevity of the scheme.

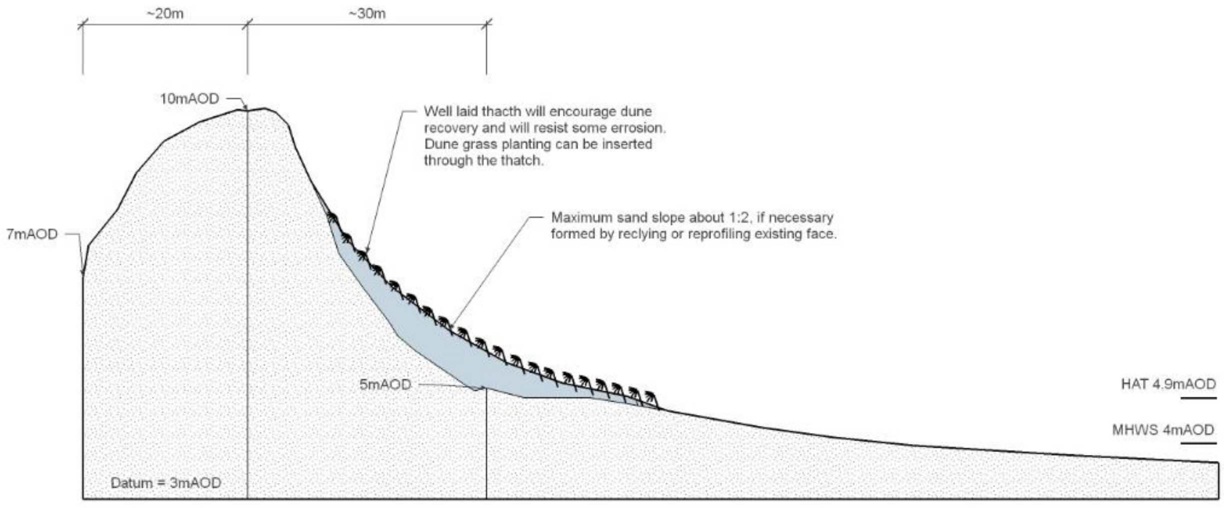


Figure 4-2: Option 3 - Dune thatching

Advantages

- No visible hard structure
- Uses low-cost and locally available materials
- Minimal negative ecological and visual effects

Disadvantages

- Requires continual maintenance and can be liable to washing out or blowing away if inappropriately positioned
- May limit access routes
- Materials may be used to build bonfires, introducing new hazards

4.3.5 Option 4 - Dune planting

Vegetation encourages the growth of the dune by trapping and stabilising blown sand. Natural dune grasses act to reduce wind speeds across the surface, promoting both vertical and horizontal accumulation of sand. They do not prevent erosion but will help the natural recovery after storm damage. Used in conjunction with additional stabilisation methods provides the best chance for success, as well as planting in the spring to maximise potential growth and minimise the risk of storm erosion.

There are two common dune grasses that could be used, marram grass and lyme grass. Marram grass is tolerant of salt spray but not immersion and should be planted above the expected run-up limit of storm waves. Whereas, lyme grass can tolerate occasional inundation and can be transplanted down to the beach dune face. Sand sedge could also be considered in combination with marram and lyme grass, in areas of limited exposure to salt spray such as blow-outs.

It will be important that access to a seed source and that propagation facilities are secured or there are suitable sites locally to enable minimally-disruptive transplanting. The forward programme will need to look at estimating quantities of seedlings of all 3 species required each year, sources of plan materials, propagation options, labour for planting, available time and associated costs.

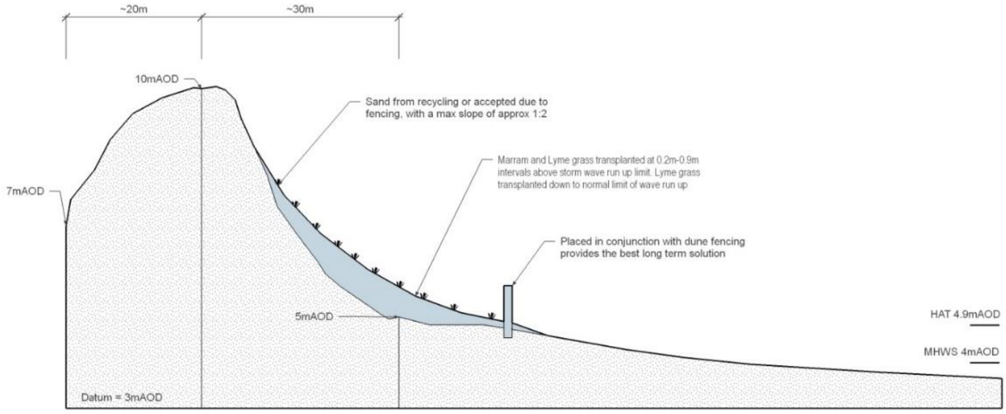


Figure 4-3: Schematic of Option 4 - Dune planting

Advantages

- Minimal negative ecological and visual effects
- Encourages natural development of the dune
- Potentially self-sustaining

Disadvantages

- Large projects may be costly and labour consuming
- May be lost to storm erosion
- Normally requires accompanying fencing or thatching to be successful

4.3.6 Critical success factors for establishing embryo dunes on the foreshore

As previously stated, the morphology of dune and foreshore are directly interrelated. Dune development is dependent upon a supply of sand from the foreshore and the extent of this is limited by the gradient of the foreshore/beach and particularly where the "toe" of the established dune is situated, relative to Mean High Water Spring tide levels (Figures 4.1 - 3 above). Install fencing, planting or thatch too far down the beach and you risk losing the material, position it too high up into the dune and you risk limiting the possible benefits from aeolian accretion and simply stabilising or extending an existing foredune rather than for example generating a new embryo (transverse) dune with a developing slip face. Unfortunately, there is no absolute rule to set out just where the "sweet spot" is for a given locations. Variables include the storminess of an area, vulnerability to wave attack (and scale), prevailing wind directions, net supply of sand and consistency of supply, extent of stability of the established dune etc.

Thus these interventions require a certain degree of persistence, monitoring and learning from local experience to determine just where and how to position fencing and thatch or to plant lyme or marram grass or sand sedge. The current activities along the Starr Hill to St Annes frontage have generally proved successful in supporting dune procession, with some mixed results from marram planting (tolerant of salt spray but not immersion), more successful with lyme grass (more tolerant of immersion) and some good examples of in-combination results including fencing and thatch.

Whilst work can be undertaken at any time of year, best results tend to be in springtime, reducing the risks from frost, storm damage, or drought. Planting may have to be repeated, fencing repositioned or replaced or new thatch dug in. As a rule of thumb, if marram planting is extensively failing, it is probably too close to MHWS levels; if infill and accretion is happening rapidly and remaining within and in advance of a paling fence, then the line can probably be taken forward to encourage wider dune formation sooner. It is important not to rush and to monitor carefully the extent of both planted and naturalised vegetation established in the new and existing dune structures.

It is strongly recommended that the learning from these successes is taken forward in new interventions along the Starr Hill to St Annes frontage and some capacity is maintained to ensure that both voluntary and contracted activities are well recorded and monitored, including any changes and adaptations that may have been made. Similarly, good publicly available information to help people to understand what might be expected from these dune management approaches will help to manage expectations and hopefully encourage wider participation to support future management and the importance of safeguarding a dynamic dune system.

4.3.7 General policy for access management

Aside from the general options to promote dune growth and reduce windblown sediment, the dunes can be better managed from a public usage perspective by improving the access routes through the dunes. Dedicated access routes are essential to reduce the risk of trampling and footpath erosion to the sensitive dune vegetation.

The footpaths on the Starr Hill to St Annes frontage are predominately aligned SW-NE. This is in the direction of windblown sediments promoting sand accumulation. It is therefore suggested that there is a frontage wide realignment of access paths to reduce the volume of sand build up. This could be through a straightforward realignment or through the incorporation of dog legs into the pathways. This approach is already being adopted at key locations along the frontage.

In addition, the long-term viability of numerous access points must be considered. It may be more suitable to have fewer, well-maintained access points, rather than more numerous access points with larger health and safety issues.

4.4 Multi-criteria analysis and stakeholder consultation

The options available at Fylde Dunes all have their relative advantages and disadvantages when measured against the performance criteria outlined in Section 4.2. However, in addition to these performance criteria, several other key issues need to be considered when selecting the preferred option.

A MCA has been undertaken on the options proposed. The purpose of the MCA was to help determine the preferred option to better manage the dune system. The categories that form the MCA have been developed to assess the options against key criteria that have been deemed appropriate at this site. The four primary categories under which the options have been assessed are Technical, Environmental and Social, Economic and Climate Change Adaptation. These are further broken down into subcategories that have been used for scoring purposes, shown in Table 4-3.

The MCA process was undertaken for each of the options which have been ranked and scored against one another to identify the best option. It should however be noted that this is primarily a qualitative assessment, to give an initial idea of the preference of the options based on a selected assessment criteria. The scoring of each option is purely comparative and should be considered as an initial estimate of the options ranking against one another.

In addition to the MCA process, a stakeholder event was held on 2nd October 2015 at St Annes, both with officers and elected Members from the responsible organisations and with members of the local community and householders directly affected by the dunes and their management. This helped to understand more clearly the views and concerns held explore alternative approaches suggested and support a constructive dialogue to underpin ongoing projects along the coast. The results of the workshop are set out in Appendix B and have been used to develop the options set out in this report.

Table 4-3: Multi-criteria analysis considerations

Category	Sub-category	Objectives
Technical	Design	Design longevity - material properties
		Efficiency in promoting accretion and trapping wind-blown sediment
		Efficiency in reducing erosion during a storm event
	Construction & Maintenance	Ease of construction
		Future maintenance required minimised
	Risk	Low technical risk of option (either construction risk or long term risk of doing nothing)
Environmental and social	Natural Environment	Minimal impact on natural environment
		Capable of incorporation of additional habitat features that benefit flora and fauna
	Landscape & Visual Amenity	No adverse impact on habitat
		Minimise impact on landscape character and visual amenity of the local environment
		Public acceptability and potential for adverse public opinion
Economic	Cost	Low capital cost
		Low maintenance cost
Climate change adaption		Design minimises carbon footprint during construction (concrete & steel usage and delivery)

4.5 Most Favourable Options

The results of the MCA, shown in Table 4-4 and Figure 4-4, highlight that, based on the categories selected and scoring criteria adopted, the most favourable option is Option 3, Dune thatching. This option scored higher than the other options across the majority of the categories that have been defined within the MCA, outperforming all of the other options across the majority of the categories.

Table 4-4: Multi-criteria analysis scoring

Design option	Total Score	Ranking
1 - No active intervention	48	4
2 - Dune fencing	51	3
3 - Dune thatching	58	1
4 - Dune planting	52	2

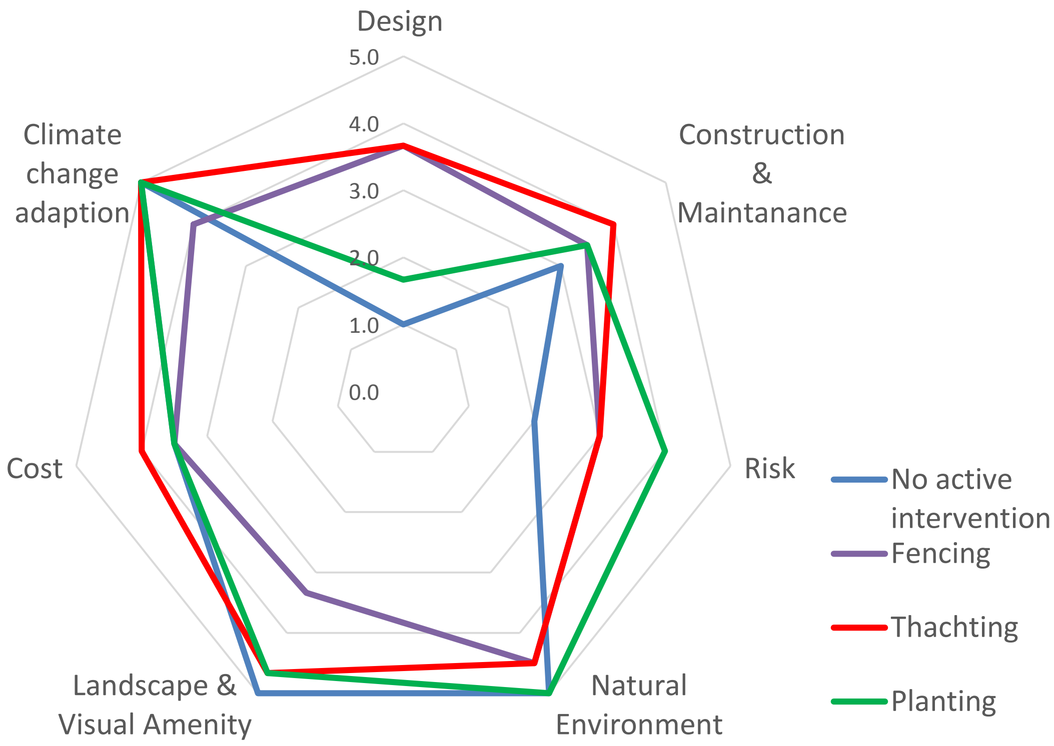


Figure 4-4: Multi-criteria analysis radar plot

Dune thatching scored the highest in the MCA, due to the fact that it provides the highest efficiency in promoting accretion, trapping windblown sediment and reducing erosion during a storm, factors that are crucial to this site. Both these performance criteria are achieved by the thatching, reducing surface wind speeds and encouraging deposition of blown sand and providing protection to the erodible front face.

Dune fencing scores lowest of the interventions due to its larger visual impact on the landscape and ongoing maintenance requirements. However, this remains a valid method to increase dune width and trap aeolian sediments. In addition, if the dune planting could be used in conjunction with the fencing, potentially the largest benefits in terms of promoting sand retention, reducing erosion and restoring of natural habitats can be achieved. Dune fencing has the additional benefit of zoning off parts of the dune, preventing members of the public from trampling on the sensitive vegetation. For these reasons, while it scores poorly on the MCA, this is still considered a very viable option on the Fylde Dunes' frontage.

Dune planting scores well on a number of key criteria (natural environment, landscape etc.) and has the added benefit of being able to self-sustain once the grasses becomes well established, reducing the requirements for planting in the future. However, while it promotes accretion of the dunes and traps windblown sediment, it offers very little in the form of erosion protection and so does not reduce the risk of breach during a storm event.

However, whilst dune thatching holds the highest overall score, it is considered that the combined effect of fencing and planting will exceed the performance of thatch alone. Thatching in association with fencing may also provide an economical though less robust alternative to the installation of multiple lines of fencing.

5 Conclusions and recommendations

The site specific and MCA findings highlight the wide and varied problems facing the Fylde Dunes' frontage and it is recommended that the actions set out in Table 4.1 are followed through. However, for the most part, it is believed that a significant number of these problems can be addressed over the medium term by promoting dune growth in both height and width - especially the latter and enabling embryo and foredune formation through sediment trapping measures. While the dunes are currently accreting, the cyclical nature of dune development may result in a switch to an erosive trend in the future. Consequently it is important to compound the growth of the dunes while the sediment feed is plentiful. Dune growth can be increased by promoting accretion and dune procession within the dunes and trapping sediments with the mid-dune, particularly where vulnerabilities associated with blow-outs are showing signs of increasing. In addition, this will aid in preventing the loss of sediment on to the grounds of property and infrastructure and enable constructive dune formation.

The options appraisal and MCA analysis highlighted three viable options: dune planting, thatching and fencing. However, the success of any one of these options can be increased when used in combination with another option. Due to the issues with land use and dune trampling, it is recommended that dune fencing is used in combination with planting. Thatching remains a viable option, but it is believed that the combined effects of fencing and planting will exceed the performance of thatch alone over a longer time period. Thatch can usefully complement fencing and planting as an economic alternative to installing multiple lines of fencing.

In addition, fencing and planting can show increased efficiency when placed in multiple layers to increase the likelihood of trapped sediment. The efficiency of this system is critically dependent on maintaining a continuous line or multiple lines of fencing.

At a number of locations throughout the frontage (e.g. to the south of North beach car park), dune planting and fencing have been implemented. However, the success of these options has been limited due to the intermittent placement of the fencing. This highlights the need for a frontage wide approach to dune management to ensure a linear build up and dune procession.

The long term wear and tear from aeolian abrasion as well as loading from high sand levels is likely to result in a relatively short design life of any sediment trapping option, so the scheme needs to make allowance for sustained maintenance costs associated with replacing or reinstating measures on a five yearly or perhaps decadal basis.

Inevitably no sediment trapping option is going to be 100% effective and some sediment dispersal is to be expected and is indeed beneficial towards supporting the ecology of the dunes, maintaining habitats dependent upon disruptive factors and diverse profiles. At the Starr Hill to St Annes frontage therefore, the following approach to physical dune management is recommended:

- A frontage wide approach to dune management involving a scheme of multiple layers of dune fencing, thatching and planting of marram and lyme grass (and potentially sand sedge at appropriate locations) to enable procession seawards and the establishment of new transverse ridges of embryo and foredune.
- Localised options to address localised problems, including realignment of access routes
- A formalised sand clearance programme, centred on public safety, at public property and infrastructure on a biannual basis or needs basis.
- Reorientation and inclusion of dog legs in access routes to avoid sand accumulation and wind-blow onto property car parks and roads.
- A five yearly fence maintenance programme to ensure fences are adequately maintained to maximise sediment trapping.

In terms of habitat management and it is important to take an approach that supports ecosystem resilience. Wherever possible, coastal dune and beach systems should be allowed to respond naturally to changes in forcing factors and sediment supply conditions. Where accommodation space exists and conditions are favourable, frontal dune sediments should be allowed to roll back to establish a new equilibrium. However, every locality is different and a number of significant constraints are present at Fylde Dunes, including the presence of infrastructure such as roads, car parks, residences and other developments creating coastal squeeze and effectively truncating any prospect of landward migration and naturalisation. Consequently a strategy that enables dune procession to extend embryo and foredune habitat seawards, whilst there is a positive sediment budget in the system, is likely to offer an effective approach towards improving the ecological condition of the protected sites and associated mosaic of habitats and species.

Removal of invasive species such as sea buckthorn will also continue to play a useful part in supporting the natural development of dune habitats.

In such a dynamic environment, subject to such a broad range of pressures, sustained and consistent monitoring will be essential to gauge the effectiveness of interventions and learn from them:-

- to monitor habitat and species dynamics and their responses to change;
- to monitor vulnerable areas and blow-outs and the risks from erosion, overtopping or flood risk;
- to review the community's perceptions of the importance of the dunes as part of their lifestyle, well-being or business interest;
- to ensure an adequate and sustainable budget to enable sound maintenance practices to continue and avoid pressures for high-cost and potentially inappropriate large-scale hard engineered interventions.

Many of the recommended activities can (and are) supported by volunteers. This has the added advantage of increasing people's understanding and appreciation of the habitats, the dynamic nature of the environment and the history behind the establishment of a community that is inextricably linked to the landscape of moving sands that constitute the Starr Hill - St Annes dune system.

Appendices

A Glossary and Abbreviations

Term	Definition
Accretion	Accumulation of sand or other beach material due to the natural action of waves, currents and wind; a build-up of sand.
Adaptation	A change in the way that a feature, such as a community or a habitat, functions to fit a changed environment.
AOD	Above Ordnance Datum. Sea level relative to mean sea level at Newlyn, Cornwall (See Ordnance Datum)
BAP	Biodiversity Action Plan
BBC	Blackpool Borough Council
BC	Borough Council
Benefits (related to issue)	The service that the feature provides. In other words, why people value it or use a feature. For example, a nature reserve as well as helping to preserve biodiversity and meet national legislation, may also provide a recreation outlet much like a sport centre provides a recreation function.
BHS	Biological Heritage Site – see also SNCI.
Biodiversity	Biodiversity is a term which simply means "the variety of life on earth". This variety can be measured on at the genetic level, the species level, and at the ecosystem level
Biodiversity Action Plans (BAPS)	A strategy for conserving and enhancing wild species and wildlife habitats in the UK.
CC	Climate Change
CD Chart Datum:	Approximately the lowest astronomical tidal level, excluding the influence of the weather.
CETaSS	Cell Eleven Tide and Sediment Transport Study
CFBD	Coastal Flood Boundary Dataset
Chainage	An imaginary line along which a distance is measured
CIL	Community Infrastructure Levy
Cliff	High steep bank at the water's edge; often used to refer to a bank composed primarily of rock
Climate change	Long term changes in climate (patterns of average weather) specifically linked to those changes resulting from human intervention in atmospheric processes through, for example, the release of greenhouse gases to the atmosphere from burning fossil fuels; the results of which may lead to increased rainfall, tide levels, etc. Its relevance to shoreline management concerns its effect on sea levels, current patterns and storminess.
Coastal squeeze	The reduction in habitat area which can arise if the natural landward migration of a habitat under sea level rise is prevented by a fixation of the high water mark.
Competent Authority	An authority or authorities identified under the Habitats, Birds or Water Framework Directives (or transposing legislation), responsible for responsible for the application of the rules of the Directive.
Concern	This is a stated actual or perceived problem, raised by an individual or stakeholder. A concern can be strategic or local.
Conservation	The political/social/economic process by which the environment is protected and resources are used wisely.
Defra	Department for Food, Environment and Rural Affairs
Defra Procedural Guidance	The Shoreline Management Plan (SMP) Procedural Guidance produced by Defra to provide a nationally consistent structure for the production of future generation Shoreline Management Plans.

Term	Definition
Dredging	Excavation, digging, scraping, drag-lining, suction-dredging to remove sand, silt, rock or other underwater sea-bottom material.
EA	Environment Agency
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Ecological status	Under the WFD, ecological status applies to surface water bodies and is based on the following quality elements: biological quality, general chemical and physico-chemical quality, water quality with respect to specific pollutants (synthetic and non-synthetic), and hydromorphological quality. There are five classes of ecological status (high, good, moderate, poor or bad). Ecological status and chemical status together define the overall surface water status of a water body.
Ecosystem	Organization of the biological community and the physical environment in a specific geographical area.
Environment Agency	England non-departmental government body responsible for delivering integrated environmental management including flood defence, water resources, water quality, pollution control.
Epoch	A period of time. Used in Shoreline Management Planning to define long term strategic management periods
Equilibrium	State of balance.
Erosion	Wearing away of the land, usually by the action of natural forces.
Estuary	Mouth of a river, where fresh river water mixes with the seawater.
EU Habitats Directive	European legislation on the conservation of habitats.
FBC	Fylde Borough Council
FCS	Favourable Conservation Status
Feature	Something tangible that provides a service to society in one form or another or, more simply, benefits certain aspects of society by its very existence. This will be of a specific geographical location.
Flood defence	A structure (or system of structures) for the alleviation or management of risk of flooding from rivers, estuaries or the sea.
Foreshore	Zone between the high water and low water marks.
FSDMP	Fylde Sand Dunes Management Plan
Geomorphology / Morphology	That branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
GIS	Geographic Information System: A computer system for managing spatial data and associated attributes.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
HAT	Highest Astronomical Tide
High water mark	The highest reach of the water at high tide. It is sometimes marked by a line of debris, e.g. seagrass, pieces of wood.
Hinterland	The area landward of the flood defences.
Hold the Line (HTL)	Hold the existing defence line by maintaining or changing the standard of protection.
HRA	Habitats Regulations Assessment: Regulation 48 of the Habitats Directive (92/43/EEC) requires that an assessment is undertaken for plans or projects that will have a significant effect on a European site (e.g. sites designated as SPA or SAC), where the plan is not directly associated with the management of the site. The Habitat Regulations Assessment essentially assesses the implications of the plan in respect

Term	Definition
	of the site's conservation objectives.
Inter tidal habitat	Habitat between mean low water mark and mean high water mark.
Inter tidal zone	The range of depths between highest and lowest extent of the tides.
Isostatic adjustment	Vertical changes of the land brought about by geological processes that have occurred locally.
LAT	Lowest Astronomical Tide
LIDAR	Light and Radar – some consider an abbreviation of Light Detection and Ranging
LNR	Local Nature Reserves. These are established by local authorities in consultation with English Nature under the National Parks and Access to the Countryside Act 1941. These sites are generally of local significance and also provide important opportunities for public enjoyment, recreation and interpretation
Local Development Framework (LDF)	A collection of local development documents that outlines how a local authority will manage Town and Country Planning in their area.
Longshore current	A movement of water parallel to the shore, caused by waves
Longshore transport	Movement of material parallel to the shore, also referred to as longshore drift.
Low water mark	The highest reach of the water at low tide
LWT	Lancashire Wildlife Trust
Macro-tidal	Coastal areas where the tidal range is in excess of 4m, where tidal currents dominate the active processes.
Managed realignment	Allowing the existing shoreline to move to a new line (natural or manmade) in a controlled manner to provide land to reduce overall flood or erosion risk.
MCA	Multi-Criteria Analysis
MDSF	Modelling and Decision Support Framework. Mapping linked computer tool used in the evaluation of assets at risk from flooding or erosion.
Mean sea level	Average height of the sea surface over a 19-year period (and other mean levels as below).
MHW	Mean High Water. The average of all high waters observed over a sufficiently long period.
MHWN	Mean High Water Neap
MHWS	Mean High Water Springs. The average height of the high waters of spring tides.
MLW	Mean Low Water. The average of all low waters observed over a sufficiently long period.
MLWS	Mean Low Water Springs. The average height of the low waters of spring tides.
MSL	Mean Sea Level
Multi-Criteria Analysis (MCA)	An analysis that combines qualitative and quantitative descriptors of impacts and aggregates them into a single, common measure of impact or a reduced number of impacts indicators. A wide range is included, from highly sophisticated methodologies to simple rating systems.
NAI	No Active Intervention: Assumes that existing defences are no longer maintained and will fail over time or undefended frontages will be allowed to evolve naturally.
NNR	National Nature Reserves. Designated by English Nature. These represent some of the most important natural and semi-natural ecosystems in Great Britain, and are managed to protect the conservation value of the habitats that occur on these sites. This is a statutory designation.

Term	Definition
OD / ODN	Ordnance Datum: A universal zero point used in the UK, equal to the mean sea level at Newlyn in Cornwall.
Ramsar	Designated under the, "Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat." 1971. The objective of this designation it to stem the progressive encroachment onto, and loss of wetlands
Revetment	Shore protection structure made made of a wide variety of materials (including concrete, masonry or timber) laid on a sloping face.
RSPB	Royal Society for Protection of Birds
SA	Sustainability Appraisal
SAC	Special Area of Conservation. This designation aims to protect habitats or species of European importance and can include Marine Areas. SACs are designated under the EC Habitats Directive (92/43/EEC) and will form part of the Natura 2000 site network. All SACs sites are also protected as SSSI, except those in the marine environment below the Mean Low Water (MLW).
Scour	Removal of underwater material by waves or currents, especially at the toe of a shore protection structure. Wind scour is a factor in dune erosion and transformation.
SEA	Strategic Environmental Assessment: An environmental assessment of certain plans and programmes, including those in the field of planning and land use, which complies with the EU Directive 2001/42/EC.
Sea level rise	The rise and fall of sea levels throughout time in response to global climate and local tectonic changes.
Seawall	Substantial structure built along the shore to prevent flooding, erosion and damage by wave action.
Sediment	Particles of rock covering a size range from clay to boulders.
Setback	Prescribed distance landward of a coastal feature (e.g. the line of existing defences).
Shoreline	Intersection of a specific water height with the shore or beach, e.g. the high water shoreline is the intersection of the high water mark with the shore or beach.
SMP	Shoreline Management Plan. It provides a large-scale assessment of the risks associated with coastal processes and presents a policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner.
SNCI	Site of Nature Conservation Importance. These sites are defined by the Wildlife Trusts and Local Authorities as sites of local nature conservation interest. These are non-statutory but form an integral part of the formulation of planning policies relating to nature conservation issues. See also BHS.
SoP	The Standard of Protection that a flood or erosion defence provides. This is typically expressed as the frequency of the storm that the defence is expected to withstand. For example, a defence can have a standard of protection of 1 per cent per year.
SPA	Special Protection Area. These are internationally important sites, being set up to establish a network of protected areas of birds
Spectral peak [wave] period	The wind-generated wave period with the highest energy (see Wave period).
Spit	Accretionary deposit of sand or stones located where a shoreline changes direction, formed by wave action and joined to the shore at one end only.
SSSI	Site[s] of Special Scientific Interest. These sites, notified by Natural

Term	Definition
	England, represent some of the best examples of Britain's natural features including flora, fauna, and geology. This is a statutory designation
Stakeholder	A person or organisation with an interest in the preparation of a project, plan or strategy or affected by the policies produced. This broad interpretation has been taken to include agencies, authorities, organisations and private persons.
Sustainability [in flood risk management)	The degree to which flood risk management options avoid tying future generations into inflexible or expensive options for flood defence. This usually includes consideration of other defences and likely developments as well as processes within catchments. It will take account of long-term demand for non-renewable materials.
SWL	Still Water Level
Tidal current	Movement of water in a constant direction caused by the periodic rising and falling of the tide. As the tide rises, a flood-tidal current moves in one direction and as the tide falls, the ebb-tidal current moves in the opposite direction.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth. Spring tides occur at full or new moons each month, when the sun, moon and earth are aligned, producing the greatest range between high and low water. Neap tides (smallest range) occur at the first or last quarter of the moon each month when the sun and moon are at right angles to the earth and their combined gravitational forces are weakened.
Toe protection	Material, usually large boulders, placed at the base of a sea defence structure like a seawall to prevent wave scour.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Wave direction	Direction from which a wave approaches.
Wave period	The time it takes for two successive wave crests to pass a given point.
Wetlands	Low-lying areas that are frequently flooded and which support vegetation adapted to saturated soils.
WFD	Water Framework Directive: A European Directive that aims to establish a framework for the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater.

B Stakeholder Workshop

B.1 Workshop Agenda

Geomorphological Study Workshop – Friday 2nd Oct 2015

WORKSHOP AGENDA – Morning Session- Officers/ Members 10-12

Introductions – Chair…. why are we here.. a simple presentation and discussion of dune processes generally, and specific to the area; key findings that have emerged and options to consider, based on the workshop sheets.

1. Summarise findings and short discussion
2. Next steps – Explain pm session expectations
3. Thanks and close

WORKSHOP AGENDA – Afternoon Session- Users / Residents 1 - 4

1. Introduction – Chair Inc domestics; why are we here and what do we want out of the day; any limitations on what is not up for discussion – Presentation – 5 mins
2. Simple explanation of dune processes and importance of dune systems (flood protection, ecosystems, landscape character, leisure & tourism, wider economic benefits) – Presentation and short Q&A 10 + 5 mins
3. Overview of findings of sediment/and processes along the frontage, explanation of possible trends in the context of limitations of available data. Presentation and Q&A – 30 + 10 mins
4. Short Break - 20 mins
5. Overview of considered options for future management and introduction to workshop session – 20 + 5 mins
6. Each table to examine options and evaluate/score whether or not it meets key objectives (ecology, landscape, leisure, flood risk, infrastructure management, development & regeneration, cost, adaptability, nuisance, etc). Alternative options proposed by the tables to be similarly scored. Facilitated per table plus spokesperson/scribe - 30-45 minutes
7. Tables to feedback ranked options, areas of consensus and where they found it difficult to rank or agree - 15 mins
8. Summarise findings and short discussion – 10 mins
9. Next steps – 5 mins
10. Thanks and close
11. On departure, post-it notes to pick up other observations or questions or support offered

B.2 Options Workshop Summary of Scores

Starr Hill – St Annes Dune Management Options – Scores Average (4 responses – range in italics where relevant)

Score 1(low benefit) ………… 5 (high benefit)

Highlighted cells show the management options against which stakeholders chose to respond.

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	**Protect and enhance wildlife and habitats**	**Support leisure and amenity**	**Support development and regeneration**	**Landscape and visual improvements**	**Supports sustainable tourism**	**Supports cost-effective management of facilities**	**Other**
Study Area overall	Coastal Squeeze. Blow-outs reducing impermeable crest level.	Reduce seaward face erosion and promote dune-building through trapping of sediment within dune limits	4.5 *(4-5)*	3.5 *(2-5)*	2 *(1-3)*	2.5 *(1-4)*	3 *(2-4)*	1.5 *(1-2)*	4 *(3-5)*	
		No active intervention – allow natural processes to continue	1	2	1	4	4	1	5	
		Minimise or cease mechanical beach cleaning activities.	1.5 *(1-2)*	1.5 *(1-2)*	1.5 *(1-2)*	2.5 *(1-4)*	2.5 *(1-4)*	1.5 *(1-2)*	3.5 *(2-5)*	
		Embryo and fore-dune creation through "soft" management techniques	4.5 *(4-5)*	4 *(3-5)*	1	4	4	1	5	
	Residual Landward sand-loss	Sustain periodic mechanical clearing	2 *(1-3)*	2 *(1-3)*	2 *(1-3)*	2.5 *(1-4)*	3 *(2-4)*	1	5	
		Recycling of uncontaminated sand to foreshore	3.5 *(2-5)*	2	2	2	3	2	3	
	Unranked Stakeholder Feedback	*Sell contaminated sand for building instead of taking from beach*								
St Annes - North Promenade Car Park	Sand accumulation in and around car park	Recycling of uncontaminated sand from slip face to foreshore. Removal of contaminated sand to landfill.								

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	Protect and enhance wildlife and habitats	Support leisure and amenity	Support development and regeneration	Landscape and visual improvements	Supports sustainable tourism	Supports cost-effective management of facilities	Other
		Embryo and fore-dune creation through "soft" management techniques. Over time will reduce the activity of the slip face	5	5	3	2	2	2	5	
	Build-up of sand causing high loading and stress on walls	Remove or reduce seaward walls	2						1	
		Raise and strengthen seaward walls	5				3			
	Sand accumulation around steps and beach accesses	Redesign access points to enable temporary solutions								
		Define moveable walkways / boardwalks at angles to the prevailing winds	2	4	3	3	4	2		
		Extensive sand clearance to maintain as open a beach access as possible								
	Stakeholder Feedback	*Remove dune at rear of "Les Dawson" Garden to a level of 1.5m, with existing rear wall, to a flat area. Save on costs of sand removal and improve the area of park and damage to Majestic Apartments. Net score = 5*								

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	**Protect and enhance wildlife and habitats**	**Support leisure and amenity**	**Support development and regeneration**	**Landscape and visual improvements**	**Supports sustainable tourism**	**Supports cost-effective management of facilities**	**Other**
St Anne's North Beach to North Beach Car Park	Pedestrian access tracks infilling with sand	Define moveable walkways / boardwalks at angles to the prevailing winds and allow sand to infill across frontage	3.5 *(2-5)*	2	2.5 *(1-4)*	4	4	3 *(1-5)*	5	
		Clear back sand to define and sustain low level beach access pathways	1	1	5	3	5	3	1	
	Infilling of sand around paling fencing creating trip hazard	Monitor depth buried and remove or move paling fencing seawards along with other soft interventions	3							
		Monitor and allow fencing to become fully buried. Define safe pathway.	2							
	Sustain dune accretion and advancement	Embryo and fore-dune creation through "soft" management techniques	4	5					5	
		Sediment trapping within dune limits and allow embryo dunes to form naturally.								
		Allow natural processes without physical intervention to seaward side of dunes		5	3					

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	**Protect and enhance wildlife and habitats**	**Support leisure and amenity**	**Support development and regeneration**	**Landscape and visual improvements**	**Supports sustainable tourism**	**Supports cost-effective management of facilities**	**Other**
North Beach Car Park	Accumulation of wind-blown sand on beach access road	Sustain current sand removal activities to keep roadway clear	5		3					*Comment – include dog-legs to prevent blown sand*
		Restrict vehicular movements and manage essential access through use of temporary ground protection mats	5							
		Realign access road to minimise through-blown sand								
	Accumulation of wind-blown sand against walls and premises	Embryo and fore-dune creation through "soft" management techniques								
		Recycling of uncontaminated sand from slip face to foreshore. Removal of contaminated sand to landfill.								
		Raise and strengthen seaward walls	4		4					
		Remove or reduce seaward walls or temporary structures								

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	Protect and enhance wildlife and habitats	Support leisure and amenity	Support development and regeneration	Landscape and visual improvements	Supports sustainable tourism	Supports cost-effective management of facilities	Other
		Regularly clear sand from frontage to sustain a "clear" access and line of sight from car park to the beach								
North Beach Car Park to Sand-winning area	Informal access routes through dunes and recreational pressures	Embryo and fore-dune creation through "soft" management techniques								
		Fencing, boardwalks and access restrictions	4.5	3						
	Sustain dune accretion and advancement	Embryo and fore-dune creation through "soft" management techniques								
		Sediment trapping within dune limits and allow embryo dunes to form naturally.								
		No active intervention – allow natural processes to continue								
Sand-winning area	Removal of beach material from the system	Re-evaluate impacts on dune and foreshore systems	3 *(1-5)*	1			2		2	

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	Protect and enhance wildlife and habitats	Support leisure and amenity	Support development and regeneration	Landscape and visual improvements	Supports sustainable tourism	Supports cost-effective management of facilities	Other
	Access and infrastructure	Review alignment, scale and design of access road, facilities and compound	5							
		Sustain existing access and infrastructure for the duration of the operation	1							
Dunes opposite former Pontins site / Persimmon Development	Additional recreational pressure and erosion within dunes	No active intervention	1	2	2	2	4	3	3	
		Development mitigation includes:- Fence sensitive areas Open space within development Signpost and Define (dog-legged) paths through dunes New pedestrian crossing linked to paths Dog bins Wildlife information packs to householders								*Comment – is this the s106 scheme?*
		Embryo and fore-dune creation through "soft" management techniques	4	5						

Location	Management Issue	Management Option	OPTIONS EVALUATION CRITERIA							
			Flood and erosion Risk Management	Protect and enhance wildlife and habitats	Support leisure and amenity	Support development and regeneration	Landscape and visual improvements	Supports sustainable tourism	Supports cost-effective management of facilities	Other
		Consider s106 or longer term developer-funded dune management scheme	4	4	*"Depends on the scheme"*					
	OTHER ISSUES	**OTHER MANAGEMENT OPTIONS**								

B.3 Notes of the Workshop

Attending	Cllr Ben Aitken	Fylde Council	BA (FC)
	Cllr Susan Fazackerley	Fylde Council	SF (FC)
	Cllr Tony Ford	Fylde Council	AF (FC)
	Cllr Carol Lanyon	St Annes Town Council	CL (FC)
	Cllr Cheryl Little	Fylde Council	CL (StA)
	Darren Bell	Fylde Council	DB (FC)
	Phil Bennett-Lloyd	JBA Consulting	PB-L (JBA)
	Charlotte Billingham	Environment Agency	CB (EA)
	Amy Bradshaw	Lancs Wildlife Trust	AB (LWT)
	Richard Camp	Lancs County Council	RC (LCC)
	Fiona Crayston	Blackpool Council	FC (BC)
	Margaret Dickinson	Natural England	MD (NE)
	Andrew Dickson	Fylde Council	AD (FC)
	Amanda Lord-Knowles	Environment Agency	AL-K (EA)
	Paul McWilliams	Fylde Council	PMcW (FC)
	Tim Mitcham	Lancs Wildlife Trust	TM (LWT)
	Clare Nolan-Barnes	Blackpool Council	CN-B (BC)
	Gary Sams	Fylde Council	GS (FC)
	Andy Shore	Environment Agency	AS (EA)
	Geoff Willetts	Fylde Council	GW (FC)
	Matthew Williams	JBA Consulting	MW (JBA)
	Kathy Winstanley	Fylde Council	KW (FC)
	Kim Wisdom	Lancs Wildlife Trust	KW (LWT)

Local residents and other interested parties attended the afternoon Workshop

The Morning Workshop

PB-L gave a presentation addressing:-

- An introduction to dune processes
- The value and benefits of dune systems
- Sediment and beach & dune profile analysis
- Management Options

Discussion Points – Morning Session with Councillors and Officers

1. Concern raised where the dune crest has been removed. Issues to address may be overall resilience and stability of the frontage and how it may recover after storm events.

2. The dune systems are generally very active with significant sand mobility along much of the frontage and many narrow areas next to “hard” infrastructure. So overall the dune frontage is being squeezed with little space for landward movement. A wider and deeper dune system will provide a more robust flood protection to low-lying land behind. A broader frontage with successional vegetation will reduce mobility of sand inland. Successive ridges and troughs with “slip-faces” for sand deposition and increasing vegetation and stability to leeward of the prevailing wind is the basic process for dune formation. Various types of dune formations were explained and discussed.

3. The foreshore at Fairhaven is changing (due to Preston Docks no longer being dredged). The data examined is not able to demonstrate or refute such a cause or effect. Much more specific information and studies would be required to analyse this suggestion. Noted that this area is outside of the study area

4. Alignment of access tracks SW-NE in line with prevailing winds likely to be exacerbating wind-blown sand problems inland. Noted that Fylde Council is reorienting access provision, incorporating dog-legs. Note – be aware of “desire lines” – the access provisions need to be sufficiently practical and located where people will want to use them.

5. Sand removed from the highway is recycled and used in building products. Are there areas where uncontaminated cleared sand could be recycled back into the system? FC to examine extent.

6. Planting of marram and lyme grass has successfully taken in some areas and less so in others but are clearly contributing to advancing the done frontage. Monitoring and perseverance needed! Use of Christmas tree thatch and chestnut paling to support stabilisation and limit access will also continue to be important to sustain. Move paling when necessary.

7. Some indication of slight beach lowering shown around sand-winning area towards low tide. Reasons should be explored (eg sandwinning; sea-front development to the north, natural processes etc). Overall, more research is needed around the sand-winning impacts. Licence is operating on an annual renewal basis since 2005. Noted that Fylde Council can direct operators to deposit sand in areas where needed on the frontage.

8. Methods of flood risk management options not considered include beach re-nourishment from offshore dredging, concrete/rip-rap or rock armouring or concrete embankments. Both costly and likely to introduce new management or safety problems. Aim to keep as naturally functioning foreshore and dune as possible long the frontage.

9. Flood gates are only present at Starr Gate. Note that they may have their own erosive footprint or a surge may take water around the back.

10. An approach taken of infilling blow-outs at Fairhaven as their presence may induce antisocial behaviour. Noted that blow-outs were natural dune features and increased overall biodiversity of the system and wider “ecosystem services”. Some infilling or stabilising may be needed where flood risk is increased in narrower dune sections.

11. Safety concerns of steep and tall sand accumulations behind car park walls and pavements. Potentially examine whether the walls could be the primary safety issue if they are is not designed to be able to support the extent of inevitable wind-blown sand. Consider wall removal, reinforcement or sustain sand clearing. An advanced frontage with greater dune stability on the leeward faces should reduce the extent of issues with windblown sand. But in the interim, sustained sand clearance and monitoring of “cliffs” will be needed.
12. Concern over sand clearance around the wind-sports centre at North Beach car park, where continuous clearing may exacerbate flood risk and, without fore-dunes being able to get established may even increase the and frequency of extent of sand build up against the buildings. How important is it to sustain vehicular beach access. Could temporary ground protection mats be used when necessary?
13. HM Coastguard station. Built in 1982. How important is it to keep it in its present location?
14. Aim to be adventurous in aims to advance the dune line. If the system is currently “in credit” then capitalising on this now will support more resilient flood protection in the future.
15. Public information, signage in building awareness of dune management is important. Low key approach – review messages from time to time, “little and often” but a sustained and responsive approach likely to work best.
16. Noted that mechanical beach cleaning is now significantly limited and managed through Fylde’s Coast & Countryside Service to ensure that operations are consistent with wider beach and dune management concerns.
17. Restrict unnecessary beach access points for vehicles which may create unnecessary vulnerabilities and funnelling of blown sand. Realign paths as soon as possible.
18. Explore the use of Community Infrastructure Levy (CIL) or s106 to support dune and foreshore management (eg; associated with the developments at the former Pontins site. Also important to consider the wider impacts of increased pressure on the dunes and sustainable mitigation measures.
19. Comments about the importance of “future-proofing” the area against flood risk and impacts of climate change.
20. Overall it is considered that the current interventions, monitoring and review of actions is positive supporting constructive management of the frontage. Important to keep monitoring beach levels as they feed the dunes and keep a perspective of the whole frontage.

2.0 Discussion - Afternoon Session with residents and wider stakeholders

PB-L gave a repeat of the morning’s presentation, as above

1. Comment that 15 years ago a sand hill was removed next to the Coastguard station which has increased windblown sand down Highbury Road. Especially last year.
2. If sandwinning is removing 70-80,000m^3 per year then if it was stopped this would provide an overall benefit to the sand budget and dune accretion.
3. Question about timescales to establish a comprehensive / sufficiently stable dune system in the face of climate change. Not possible to answer as so many variables. Ultimately it depends upon a feed of sand from the foreshore and room to develop.
4. Agreement with the need for dunes to grow.
5. A concern expressed about the use of chestnut paling because of soft sand accumulation. Soft sand is the main “building block” of sand dunes. The material blown off the fore shore is what it is and the paling won’t change this. Dunes stability increases with vegetation cover.
6. Comment about the dune creating a ramp or more sand to blow inland, particularly

at North Promenade. Explained that successive ridges to windward will enable more sand deposition on the slip-faces. Increased vegetation reduces wind velocity nearer to the ground and the consequent volume of sand that may be carried further inland.

7. There are 2 or 3 major blowouts between the Coastguard station and the pier which are unmanaged now due to a change in Council policy. PBL suggested that the primary objective is to widen the dunes and then the blow holes may naturally in fill. It was suggested that previously all blow holes were previously filled up at the front to prevent them getting worse.
8. Observation that an area of dune in front of North Promenade now gave an efficient sea barrier, a stable dune, has stopped wind-blown sand and supports rare wildlife. It was achieved by pushing the dune forward but keeping the grasses on top so that it rises from the high tide level. Suggested that if the sand removed from the roads was put in front of the dunes it would accrete the dunes very quickly. Noted that this intervention was over a very small area and observed a relatively short period of time.
9. Can “uncontaminated” sand be recycled in front of the dunes, especially around the Coast Guard station? Possibly, depending on where is has come from.
10. General feeling that the North Beach car park and access was a particular area which needed to be addressed.
11. It was questioned whether the sandwinning material could be used to put in front of the dunes in order to build up the areas more quickly. It was also suggested that if sand from the existing dunes is used it will contain vegetation which will help to stabilise the dune. Noted that removing vegetation from existing more stable dunes will increase their instability and potentially increase wind-blown material.
12. Concern expressed that flood risk needed to be addressed now rather than slowly accreting the dunes.
13. 1978 a bad storm eroded around 25% of the dunes and caused extensive road flooding.
14. Need for Coastguard access to the beach questioned.
15. Support of introducing dog-legs to access paths to reduce wind-blown effects.
16. Questions around funding for significant flood defence structures. Noted that Shoreline Management Plan doesn’t describe this type of intervention. Achieving national Grant-in-Aid funding support is highly competitive, requires partnership funding and a significant cost-benefit ratio. Very unlikely that this frontage would score sufficiently highly to justify a costly intervention.
17. Question about “geostatic rebound” [Glacial Isostatic Adjustment] and whether a rising land level will compensate for sea level rise. Climate change induced sea level rise will remain a critical factor to understand and address.
18. Could sand-winning material be used to replenish the beach and dunes? Theoretically possible.
19. Around £40—50,000 pa spent on sand clearance. Reduce this bill by reducing the amount of sand blown inland. Question from resident whether property owners can charge Fylde Council for their own sands clearances - This is not possible and this liability remains with the householders.
20. Concern expressed about hazard of sand cliffs above pavements and walls. Are the dunes getting too high and should they be reduced? Cutting the tops of the dunes could introduce greater instability. Main focus needs to be on enabling a broader dune frontage and foreshore. Regraded landward slopes will still steepen over time as the slip face evolves and if not allowed to move inland. Need to separate out management of facilities for safety reasons and the overall objectives of dune and foreshore management. Short term regrading may be needed but this might be able to be reduced as fore-dunes get established and the prospect of more stability on the landward slopes increases.

21. Sand clearances at Summerfields and North Promenade taken to the beach at Salters Bank
22. Important to plug gaps and vulnerabilities and to encourage dune growth over time. Value of plugging blow-holes discussed and value where they support flood resilience.

Workshop

Those present were invited to complete a scoring matrix to feedback their values of different management options in terms of:-

- Flood and erosion risk Management
- Protecting and enhancing wildlife
- Supporting Leisure and amenity
- Supporting development and regeneration
- Landscape and visual improvements
- Supporting sustainable tourism
- Supporting cost-effective management of facilities.
- Any other points that individuals wished to raise

Participants and those who were not able to attend were also given the opportunity to submit responses and feedback after the event.

A summary of scoring responses is attached (4 responses received)

Further written responses below:-

1. I understand that the Fylde Council are working with partners to implement a DEFRA funded project to enhance the nature conservation of the Coastal Habitat, improve the efficiency of the dunes as a sea defence and enhance public appreciation and enjoyment of the dunes.
   In addition I believe the Council should consider

   Effect of windblown sand
   Height of dunes
   Access to the beach
   Gaps in the dunes

2. I suggest that there will always be a problem with windblown sand, but some actions or lack of action may make this worse and a risk assessment of effect on windblown sand should be taken for any proposed works. Windblown sand may be a bigger problem where there are gaps in the dunes.
   Properties and structures facing the dunes will act as a barrier to windblown sand which in turn places the responsibility for sand disposal on the property owner, this disposal can create a secondary wave of windblown sand inland of the properties.

3. Height of dunes is not often mentioned but it should not be assumed that the efficiency of a dune is in proportion to its height. To be an effective sea defence the dune would need to have a height greater than the height of water. Continuous width at this height and vegetation would be important.

4. At the moment there is probably insufficient accessible access to the beach for pedestrians and push chairs and signage of access points should be considered. Due to the nature of the sand it may not be possible to maintain many access points and it may be more economical to have a few well maintained access points.

5. Gaps in the dunes may fill themselves over time, but man made gaps may require some intervention. The council should review which gaps are needed and which should be encouraged to fill. Gaps which face an open-space or road opposite would increase the occurrence of inland windblown sand.

6. In addition to the above general points there is some local action I would ask the council to investigate.
7. Sand dunes at rear of Summerfield and Car Park are very high, more than twice as high as ten years ago. There is no reason for this increased height as the previous height was 3m above high tide level, but probably happened when clearance of sand on landward side of dunes was ceased.

8. The height creates a few safety issues:

9. The retaining wall behind the dune is unstable as sand is now against the wall

10. Pedestrians leaving the beach via the dunes would find themselves on top of a very high peak with steep drop to car park, whilst adults mighty understand the risk a child may not, due to the difference between the beach and land levels it would not be easy to determine the actual drop.

11. We have seen no decrease in the amount of windblown sand in our properties so conclusion is that height of dunes has no impact upon the amount of windblown sand generated.

12. It would be possible to reduce the height by half and place the resulting sand in front of the dune (seaward side) which would have effect of widening the dunes at that point.

13. Chestnut fencing used in the dunes is dangerous as it contains sharp wire and stakes with pointed ends. The wooden stakes appear safer, maybe future plans could just involve use of woods stakes. Looking further down the beach they seem to have had similar effect to the fencing.

14. There is a gap by the coastguard station which is open to metalled road, not sure who needs access at this point now If gap not required this could be closed.

15. Litter bins have disappeared in some areas, rubbish is left by visitors in bags and seagulls and crows open the bags, therefore more bins less litter.

D Data Review; Site Inspection Photographs

D.1 Photographs taken at North Beach Car Park walking south during site inspection

1. North Beach Car Park beach access

2. North Beach Car Park Kiting Centre

3. North Beach Car Park

4. North Beach Car Park

5. South of North Beach Car Park	6. South of North Beach Car Park
	
7. South of North Beach Car Park	8. South of North Beach Car Park
	

D.2 Photographs taken at the St Annes North Beach walking south during site inspection

9. St Annes North Beach dune	10. St Annes North Beach access from North Promenade car park
	
11. St Annes North Beach and North Promenade car park	12. St Annes North Beach and North Promenade car park
	
13. St Annes North Beach and pier	14. St Annes North Beach and St Annes Pier Car Park
	

D.3 Photographs taken South of the North Beach Car Park, walking north during site inspection

15. South of North Beach Car Park	16. South of North Beach Car Park
	
17. South of North Beach Car Park	18. South of North Beach Car Park
	
19. Sand Winning	20. Sand Winning
	

E Data Review; 1966 and 1983 Photography

E.1.1 Historic photos from 1966 labelled Fairhaven dunes south of pier (top), and dune toe north of pier (bottom)

E.1.2 Historic photos from 1966 labelled Chestnut paling

E.1.3 Historic photos from 1983 labelled Fairhaven Dunes (south of the study area, south of the pier)

E.1.4 Historic photos from 1983 labelled Summerfields NBC North Promenade (at the mid-section of this site, north of the St Annes Pier)

North Beach car park and southwards adjacent to North Promenade

E.1.5 Historic photos from 1983 labelled Beach Huts North of Pier

Car park and beach huts north of pier

F Data Review; 2012 Aerial Photography

F.1.1 North extent of Starr Hill to St Annes Sand Dunes

North extent of Starr Hill –St Annes Sand Dunes	North extent of Starr Hill – St Annes Sand Dunes
	

F.1.2 Sand winning area

North extent to the Sand Winning area	Sand Winning activity site and beach storage area
	

F.1.3 Sand Winning activity area to North Beach Car Park

Sand Winning activity area to North Beach Car Park	North of the North Beach Car Park
	

F.1.4 North Beach Car Park

North Beach Car Park	South of the North Beach Car Park, private dunes area
	

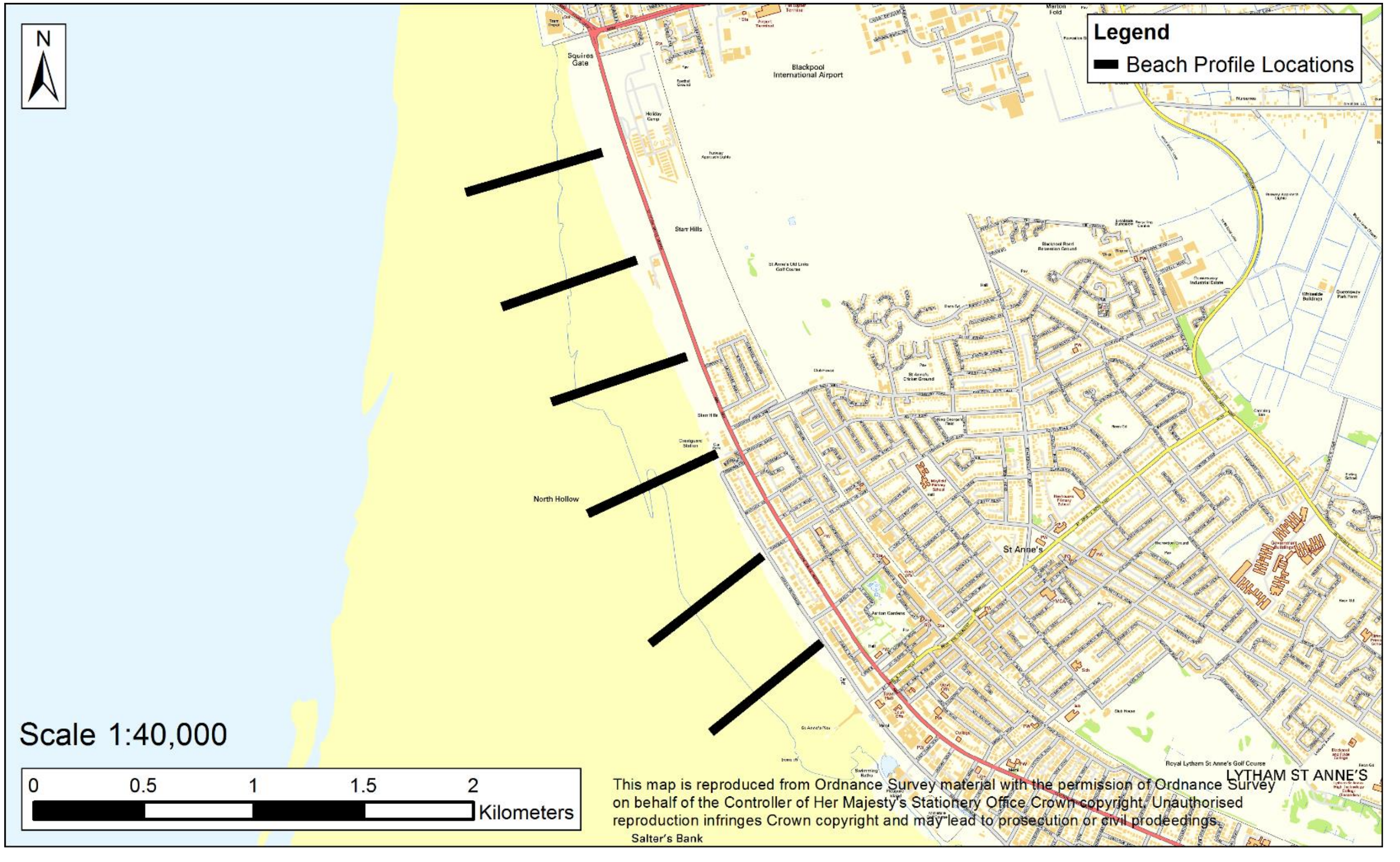
F.1.5 North Beach Car Park to the Amenity Beach

North Beach Car Park to St Annes North	North Promenade Car Park to the Pier
	

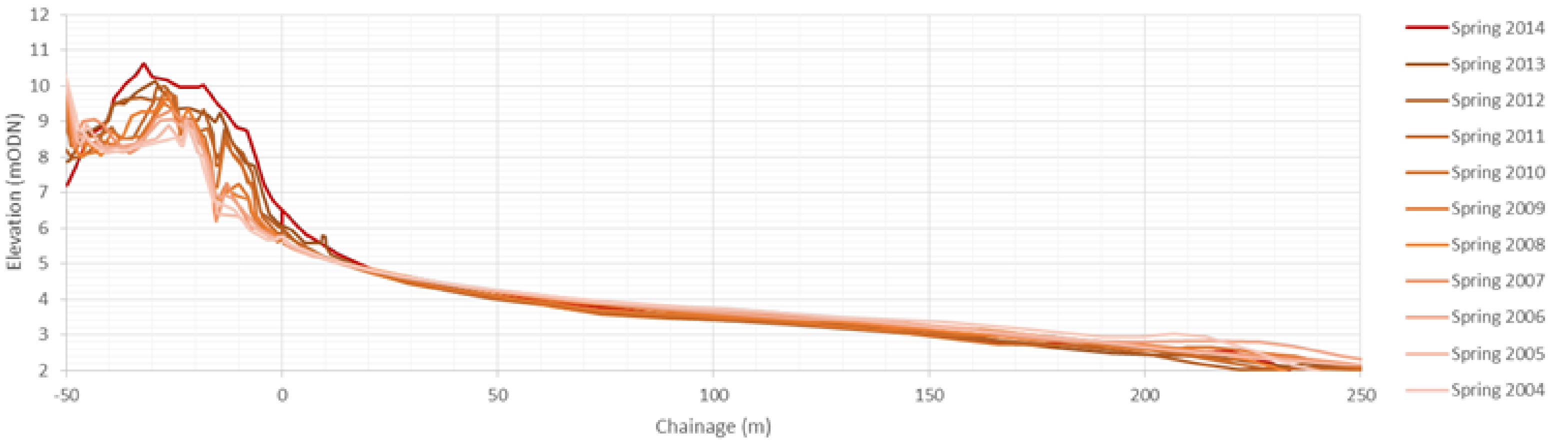
G Data Review; Beach Profile Data

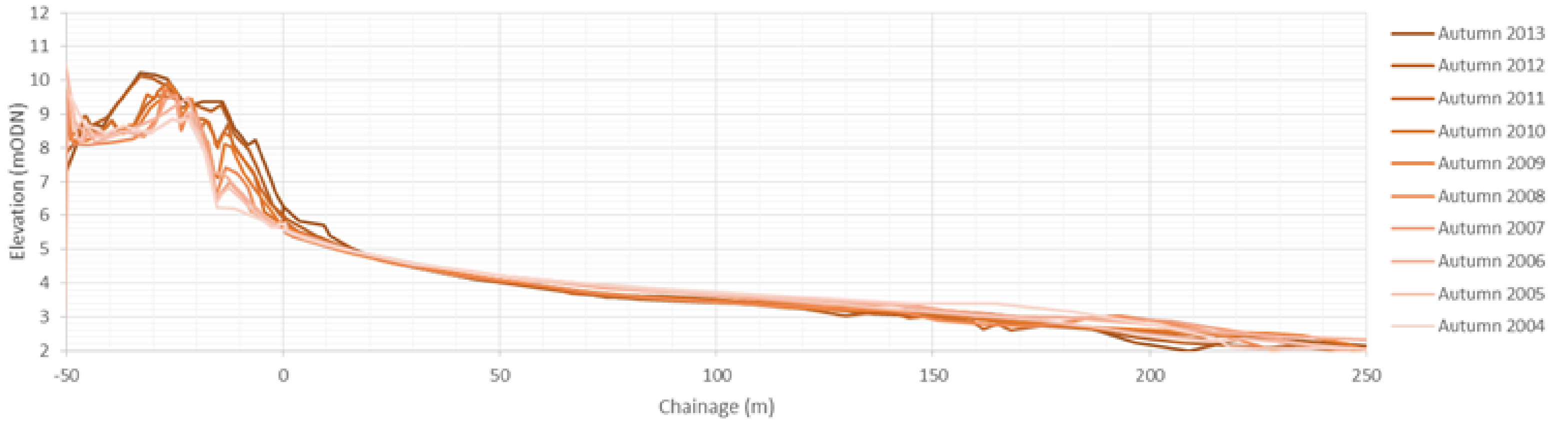
G.1 Beach Profile Data

G.1.1 Overview of all beach profile data

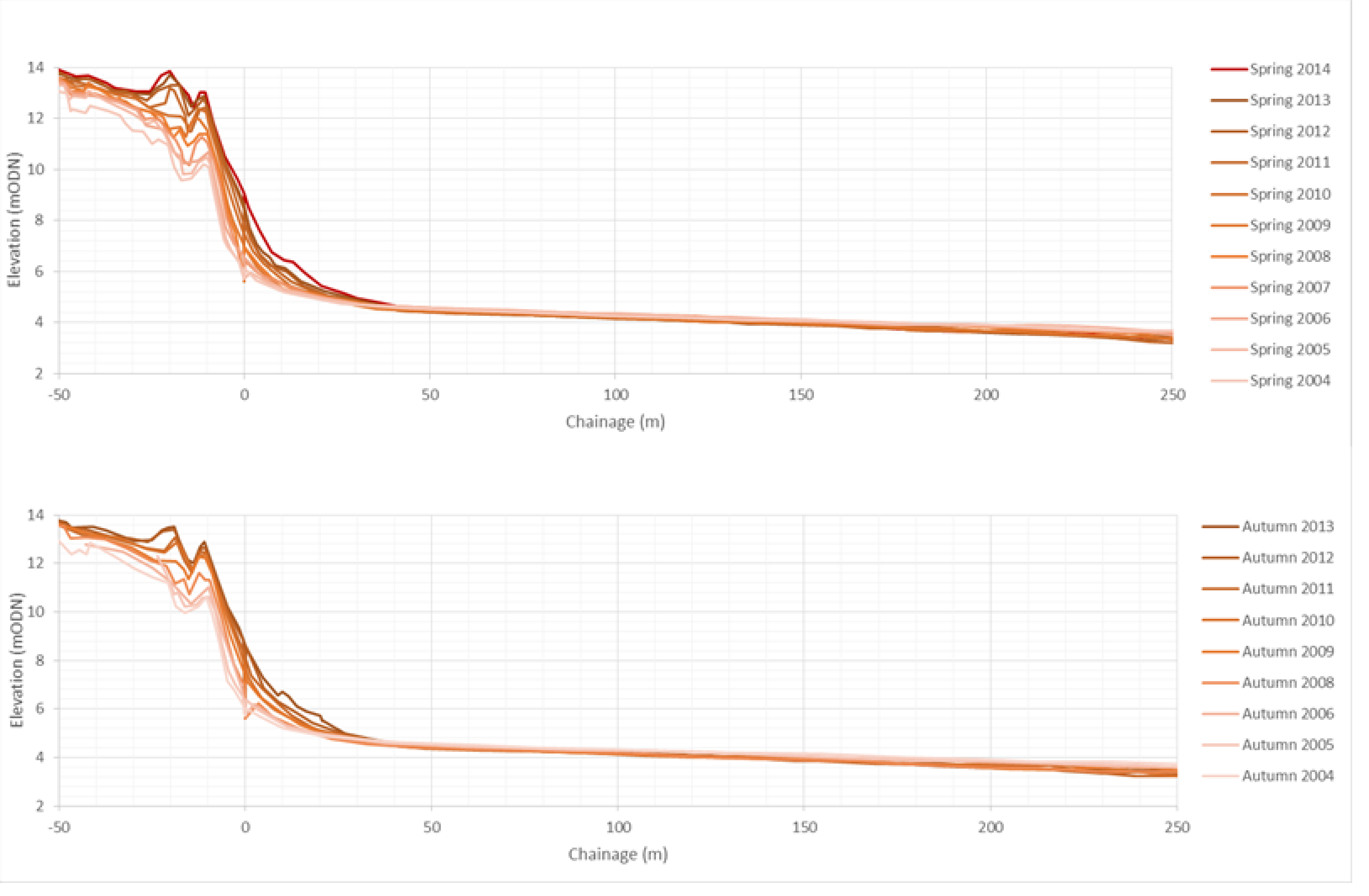


G.1.2 North extent of the study area

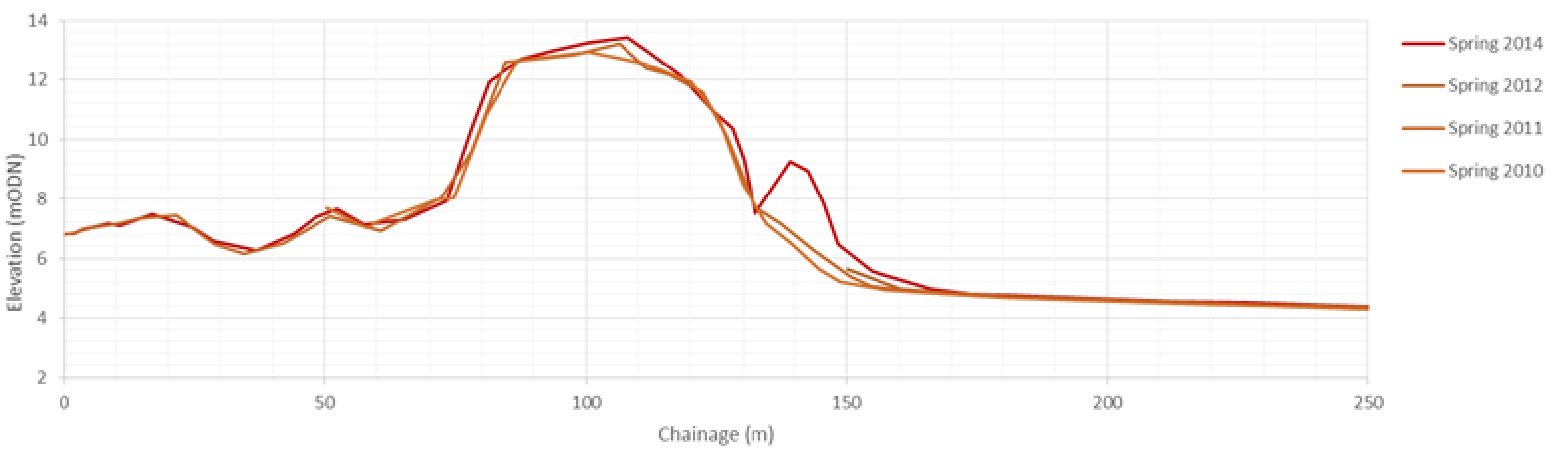


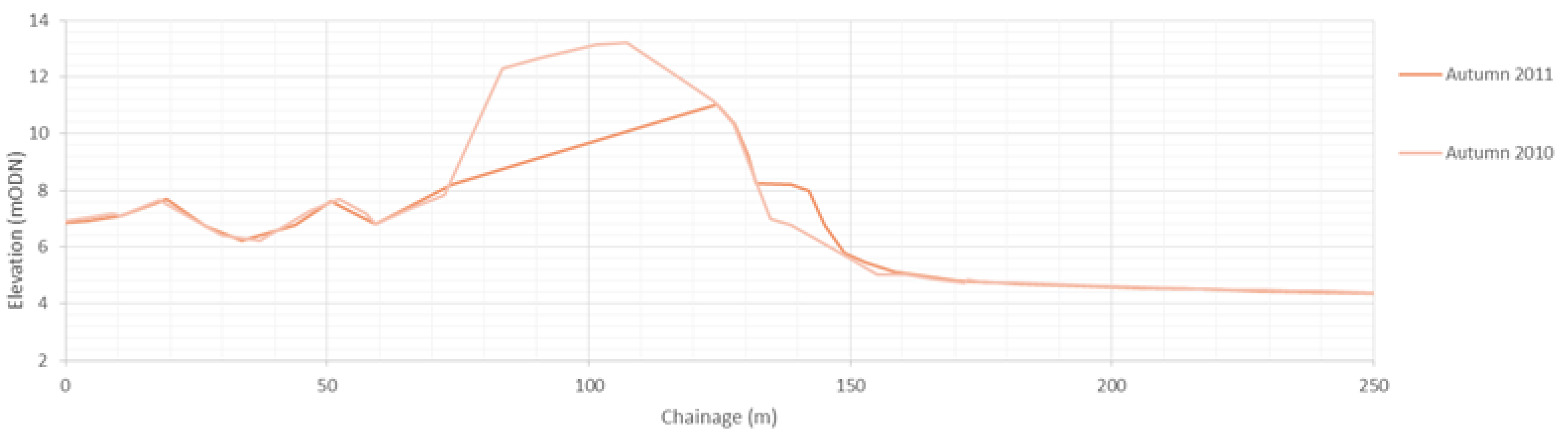


G.1.3 Sand Winning area

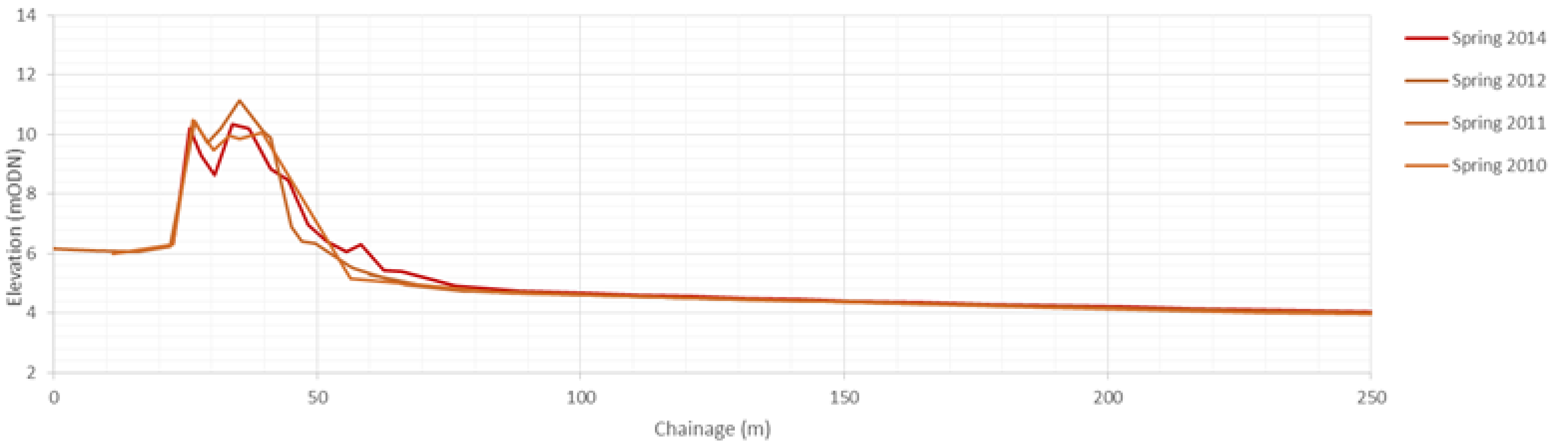


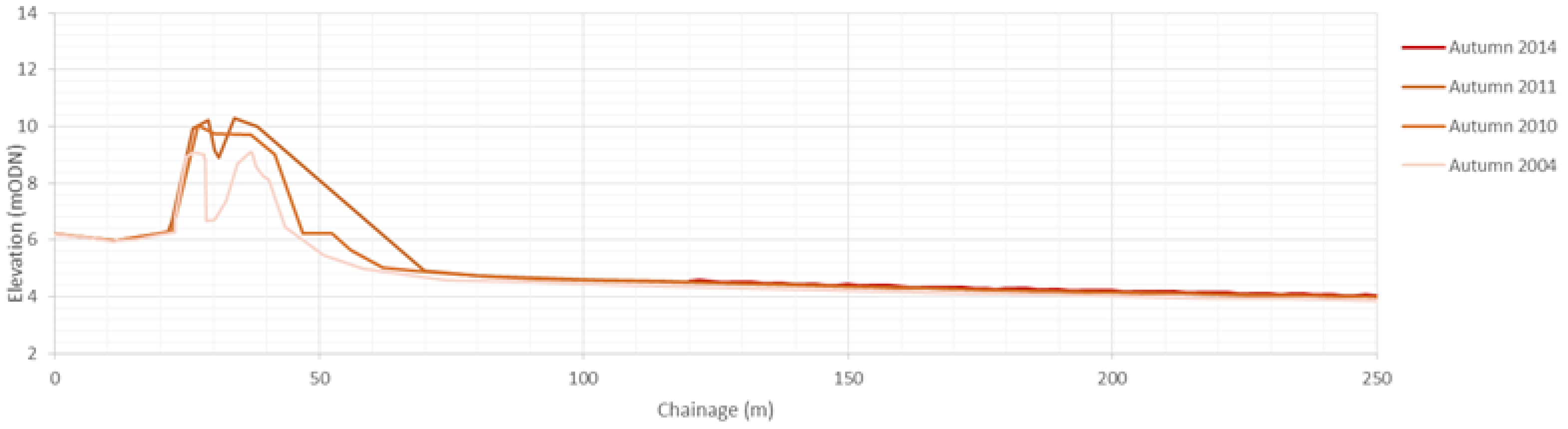
G.1.4 Kite surfing and buggy centre



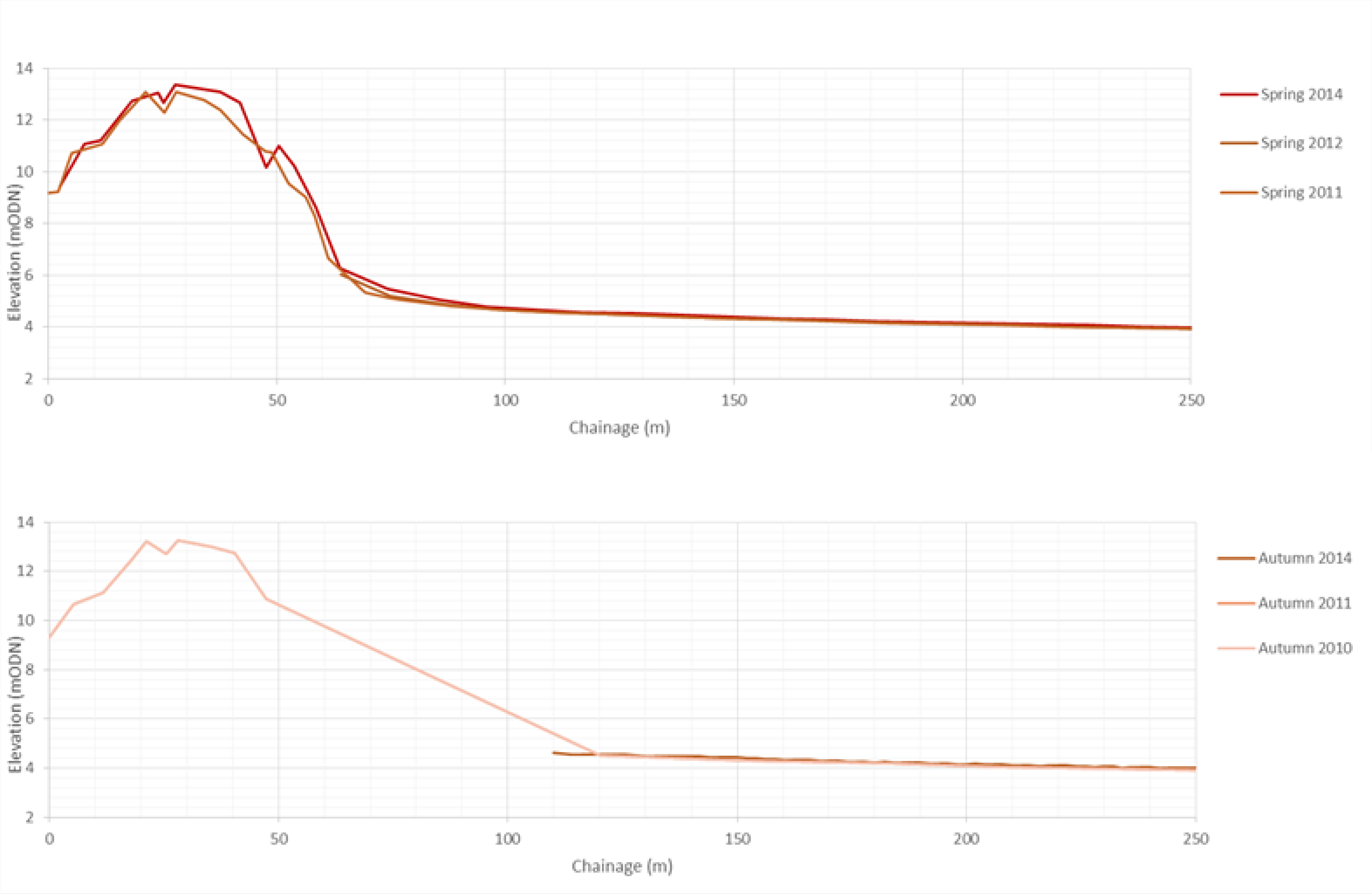


G.1.5 North Beach Car Park

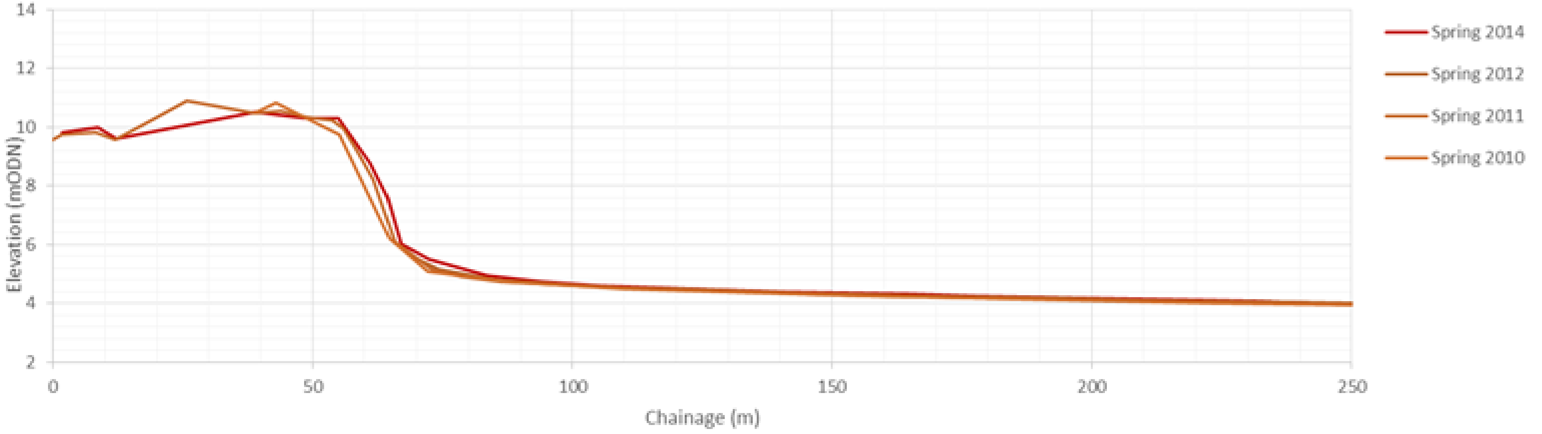


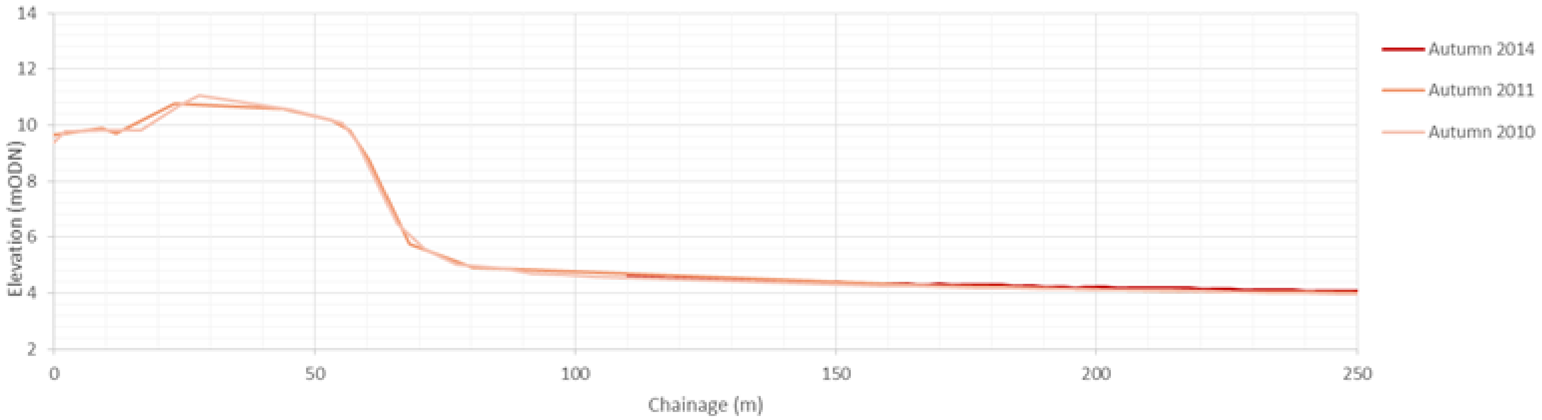


G.1.6 North Promenade

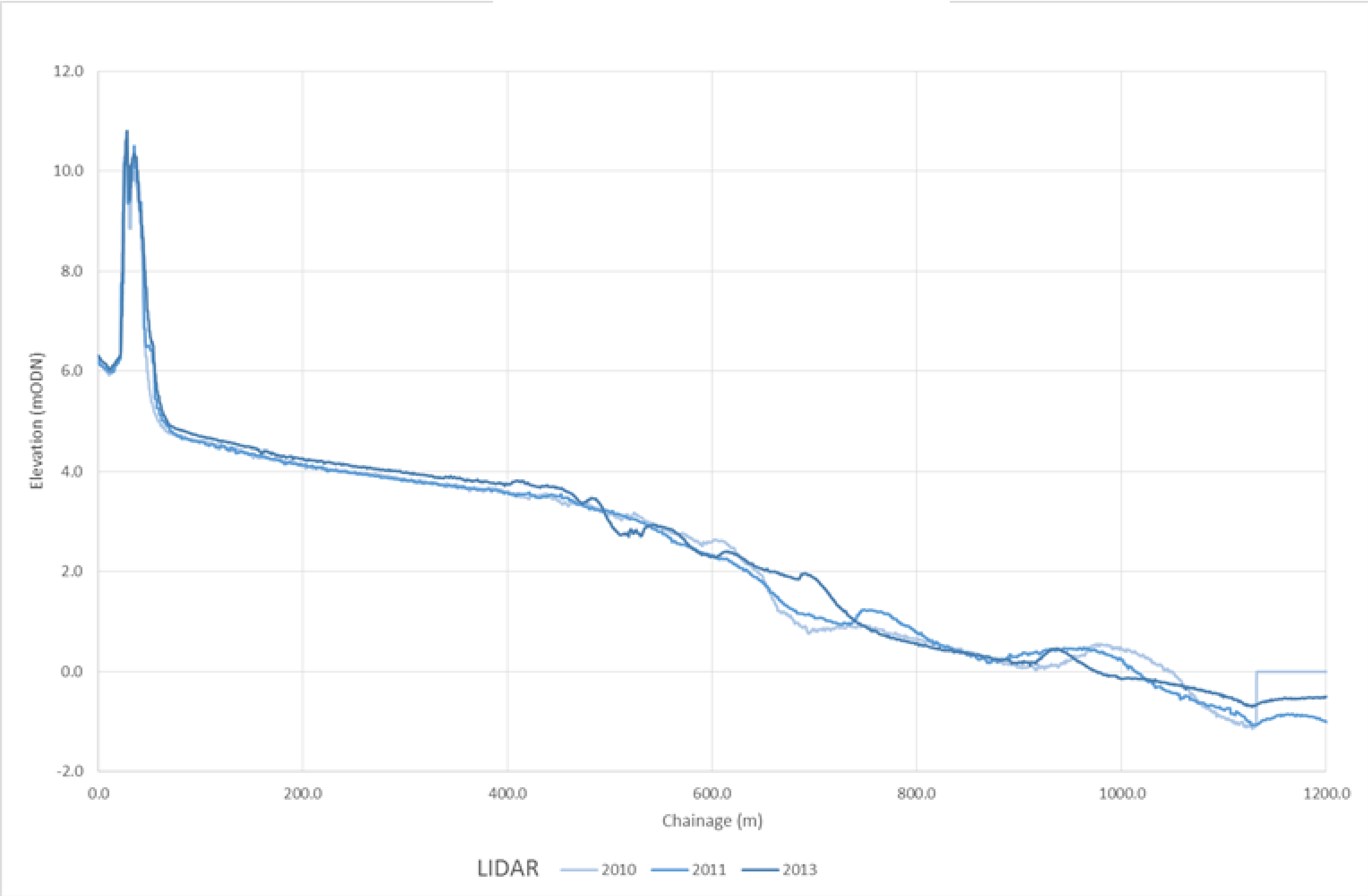


G.1.7 St Annes North Beach

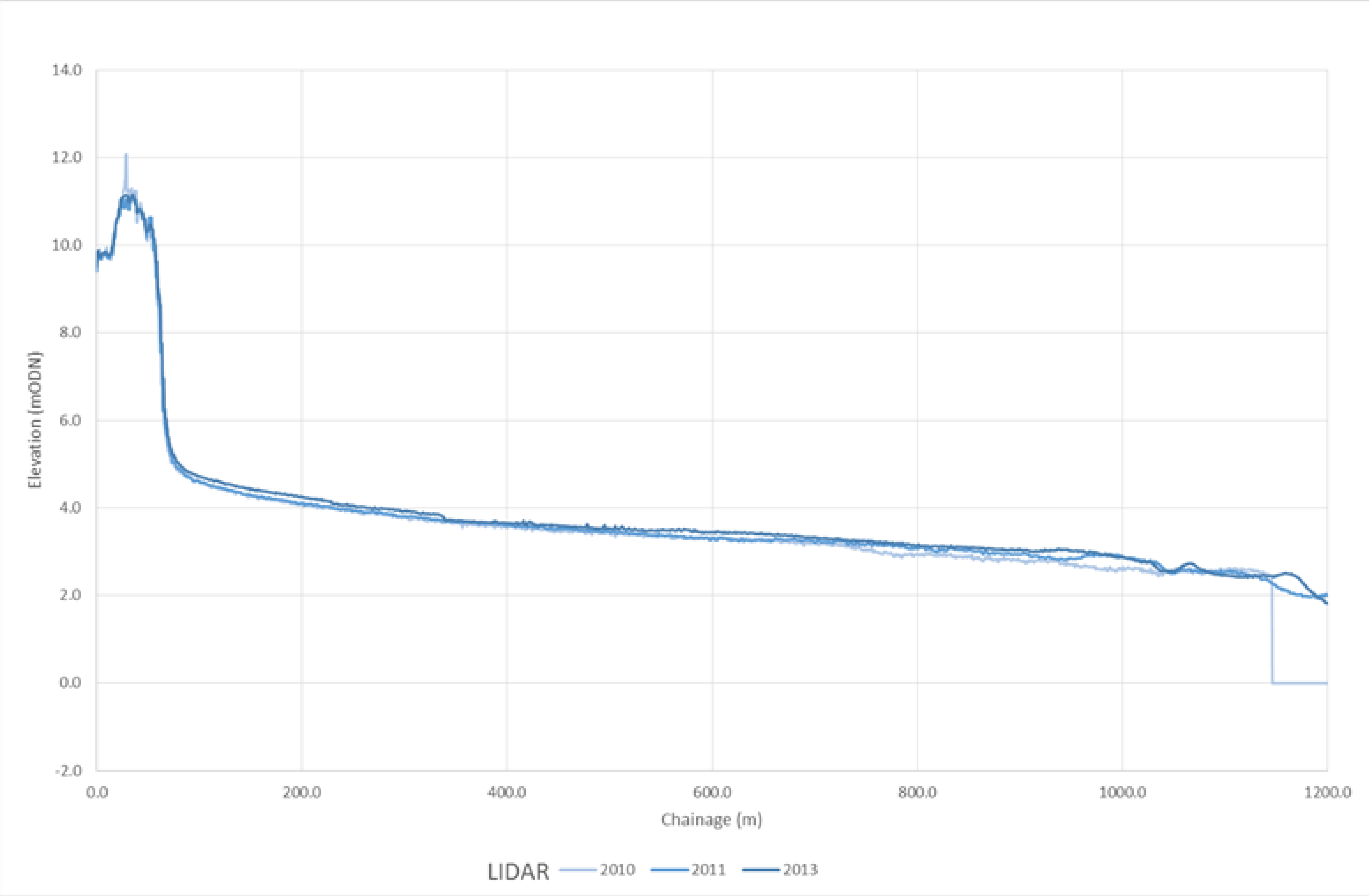




G.1.8 Profiles through the 2010, 2011 and 2013 LiDAR data at the North Beach car park

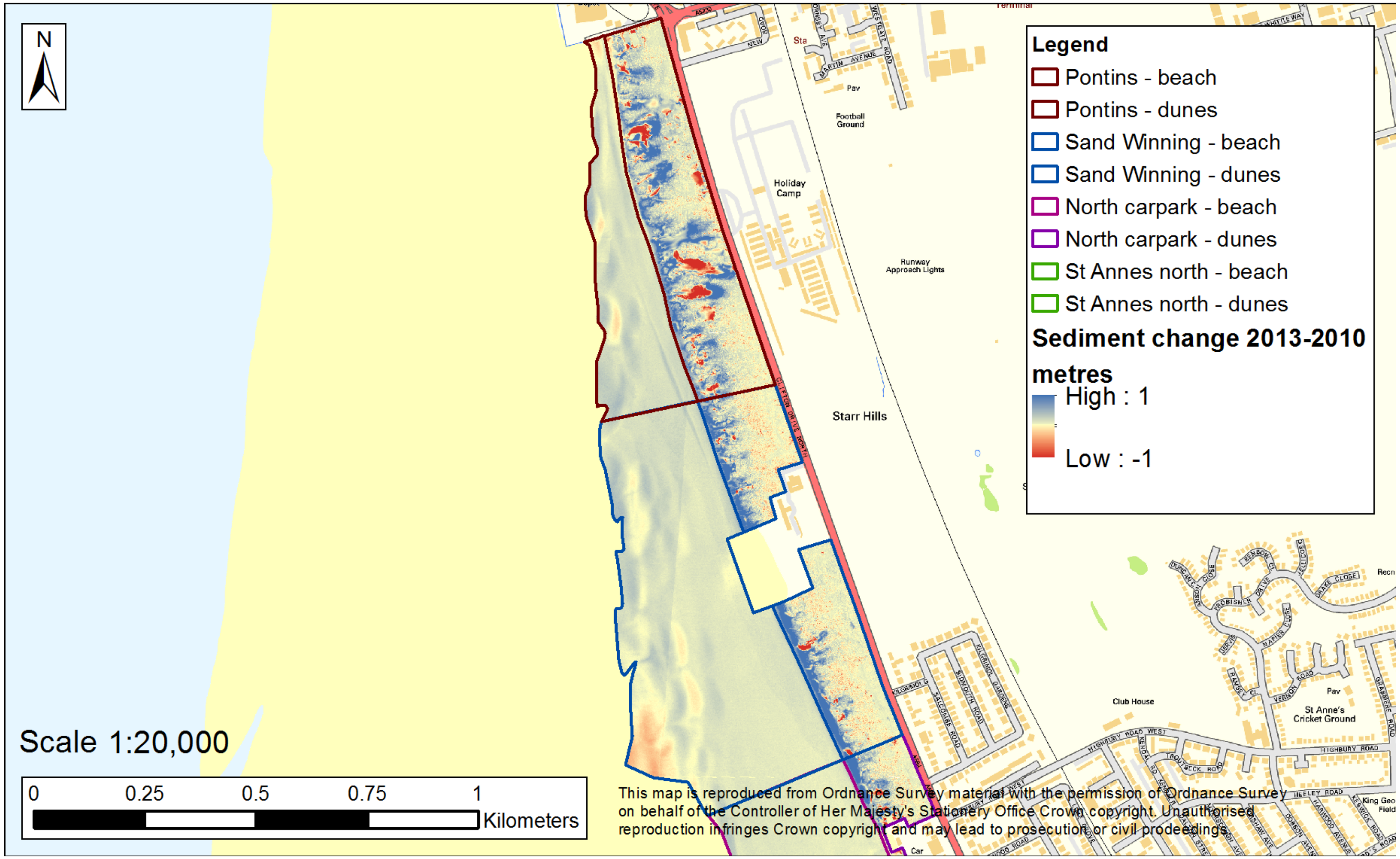


G.1.9 Profiles through the 2010, 2011 and 2013 LiDAR data at the St Annes North Beach

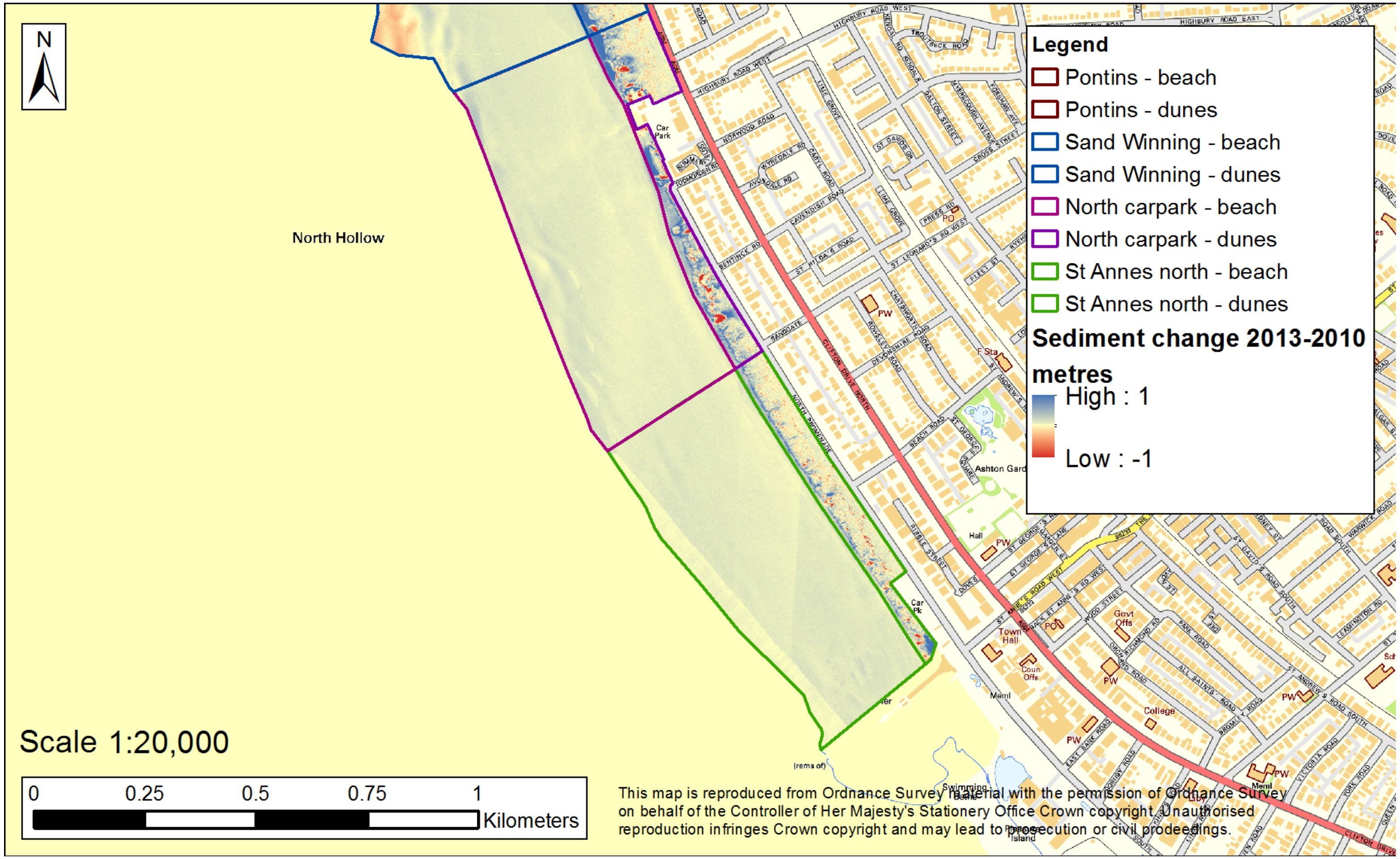


H Volumetric change of LIDAR topography

H.1.1 North of site between 2010 and 2013



H.1.2 South of site between 2010 and 2013



6 Bibliography

Blackpool Council, 2006. *Blackpool Local Plan 2001/2016,* Blackpool: Blackpool Council.

Clarke, D. & Sanitwong, S., 2010. Predicted effects of climate change, vegetation. *Journal of Coastal Conservation,* Volume 14, pp. 115-125.

Council Directive, 1949. *National Parks and Access to the Countryside Act.* London: s.n.

Council Directive, 1981. *The Wildlife and Countryside Act.* s.l.:s.n.

Defra, 2007. *Sand dune processes and management for flood and coastal defence, R&D Technical Report FD1302/TR,* London: Defra.

Defra, 2009. *UK Climate Projection.* [Online]
Available at: http://ukclimateprojections.metoffice.gov.uk/
[Accessed 16 December 2015].

Environment Agency, 2011. *Coastal flood boundary conditions for UK mainland and islands. Project: SC060064/TR5: Practical guidance swell waves,* Bretton: EA.

Everard, M., Jones, L. & Watts, B., 2010. Have we neglected the societal importance of sand dunes? An ecosystem services perspective. *Aquatic Conservation: Marine and Freshwater Ecosystems,* 20(4), pp. 476-487.

Fylde Borough, 2005. *The Fylde Borough Local Plan (As Altered) ,* s.l.: Fylde Borough.

Fylde Council, 2015. *Fylde Council Coastal Strategy 2015-2032,* Blackpool: Fylde Council.

Geocaching, 2014. *the phenomenal Lagg sand dune field.* [Online]
Available at: https://www.geocaching.com/geocache/GC5FEWQ_the-phenomenal-lagg-sand-dune-field
[Accessed 15 December 2015].

Halcrow, 2010. *2010c. North West England and North Wales Shoreline Management Plan SMP2. Supporting Studies. Cell Eleven Tide and Sediment Transport Study (CETaSS) Phase 2 (ii). Main Report – Summary of Findings.,* s.l.: Halcrow.

Halcrow, 2013. *North West Estuaries Processes Report,* York: CH2MHILL Halcrow.

Lancashire Councty Council, 2009. *Joint lancashire Minerals and Waste Development Framework Core Strategy DPD. Managing our Waste and Natural Resources,* s.l.: Lancashire County Council.

Livingstone, I. & Warren, A., 1996. *Aeolian Geomorphology: In Introduction.* Harrow: Longman.

North West & North Wales Coastal Group, 2011. *North West England and North Wales Shoreline Management Plan SMP2,* Swindon: Halcrow Group Ltd.

Packham, J. & Willis, A., 1997. *Ecology of Dunes, Salt Marsh and Shingle.* London: Chapman & Hall.

Provoost, P. et al., 2010. Seasonal and long-term changes in pH in the Dutch coastal zone. *Biogeosciences,* Volume 7, pp. 3869-3878.

Pye, K. & Blott, S., 2009. *Potential Implications of Future Sea Level Rise for Estuarine Sediment Budgets and Morphology in Northwest England and North Wales. Report to Halcrow Ltd. in connection with Cell Eleven Tidal and Sediment Transport Study (CETaSS) Stage 2.,* s.l.: Kenneth Pye Associates.

Pye, K. & Tsoar, H., 1990. *Aeolian sand and sand dunes.* London: Unwin Hyman Ltd.

Sefton Council, 2013. *North West Estuaries Processes Report,* York: CH2MHILL Halcrow.

Sevinik, J., 1991. Soil development in the coastal dunes and its relation to climate. *landscape Ecology,* 1(6), pp. 49-56.

Skeltcher, G., 2008. *Fylde Sand Dunes Management Action Plan,* s.l.: Flyde Sand Dune Project Steering Group.

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t:+44(0)1756 799919
e:info@jbaconsulting.com

Jeremy Benn Associates Ltd
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