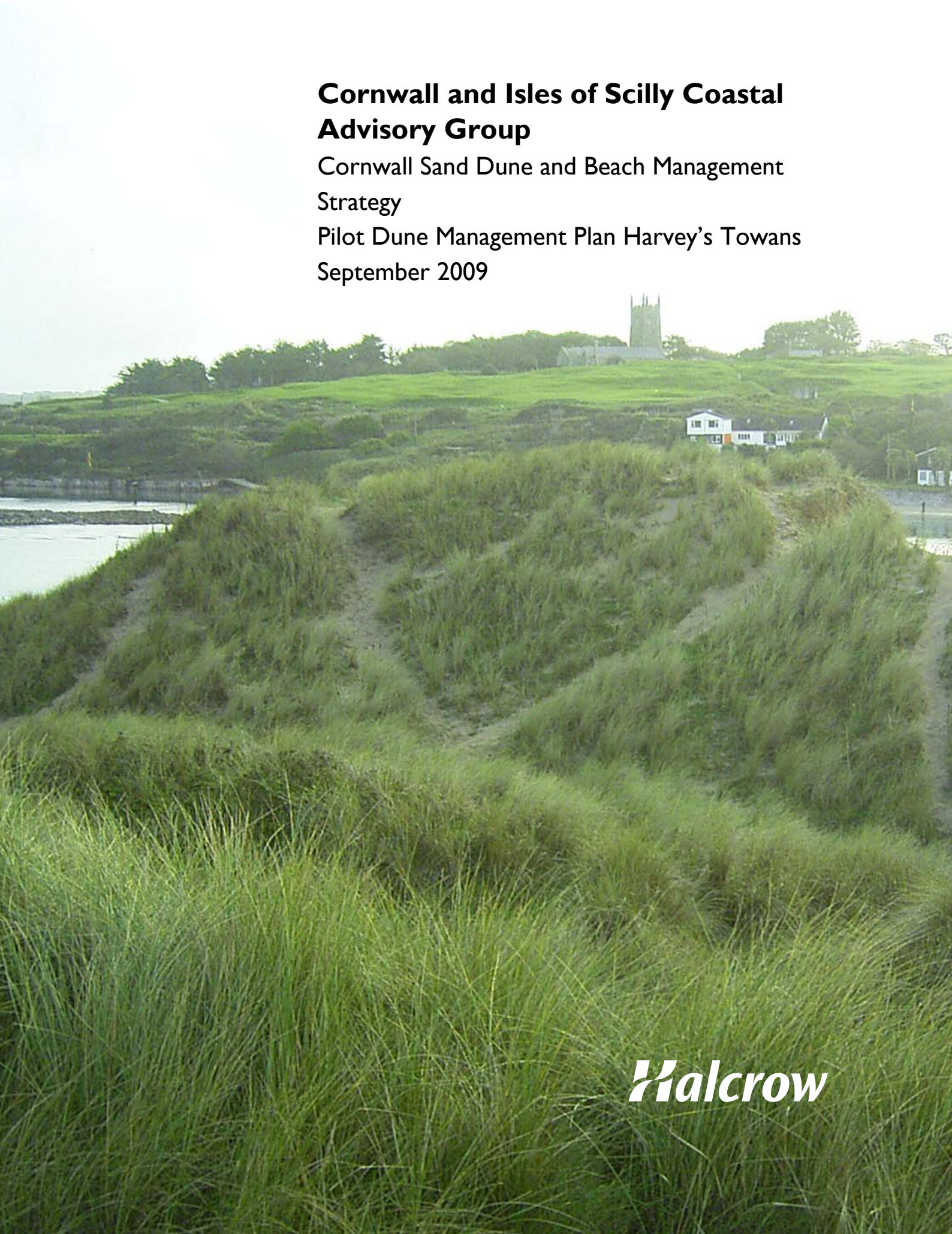
Cornwall and Isles of Scilly Coastal Advisory Group

Cornwall Sand Dune and Beach Management Strategy

Pilot Dune Management Plan Harvey's Towans

September 2009



Halcrow

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Contents Amendment Record

This report has been issued and amended as follows:

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Executive Summary

This Pilot Dune Management Plan for Harvey's Towans has been produced as part of the Cornwall Sand Dune and Beach Management Strategy. The Pilot Dune Management Plan has two purposes:

1. To identify management issues and develop responses at the study site;

2. To provide a good practice example Dune Management Plan that can be used as a template for the production of other Dune Management Plans in Cornwall.

This report provides an introduction to the project and pilot Dune Management Plan, a summary of the characteristics and coastal process drivers at Harvey's Towans, a discussion of suitable management measures, development of the dune management plan and a recommended monitoring and response programme.

Harvey's Towans is a northwest facing dune system, with a small spit extension, located at the entrance to Hayle Estuary within St Ives Bay.

The possible management measures which can be implemented to support the dune system at Harvey's Towans are discussed. From this a dune management plan is provided to outline the key issues and recommended actions. Recommended actions at Harvey's Towans include:

- Boardwalks and steps along eroded access routes;

- Fencing and planting to stabilise bare sand areas;

- Educational signage and leaflets to inform users of the importance of the dune system and the damage that can be done;

- A small visitor centre manned by a dune warden, who can provide information to visitors and monitor the dune system;

- Planned and signed routes to reduce fragmentation of the dune system through the development of numerous footpaths;

- Continuation and further development of the existing monitoring scheme (as discussed below).

Monitoring and response are important elements of the Dune Management Plan. Regular topographic beach profiles and visual inspections are recommended, and the results should be used to identify when action and emergency trigger states are reached. When trigger conditions are reached (or exceeded), the recommended response should be implemented based on assessment of the specified criteria in the action and response tables provided in this report.

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1 Introduction

1.1 Project Background

This Pilot Dune Management Plan has been produced as part of the Cornwall Sand Dune and Beach Management Strategy. Sand dunes and their associated sandy beaches are one of the most important natural resources in Cornwall for a number of reasons, including:

- coastal defence function;
- tourism interest;
- habitat value.

Cornish dunes comprise 15% of the overall area of dune complexes in the UK, with 25 dune sites; varying from pocket systems, covering less than a hectare, to the extensive dune systems on the north coast of up to 550 hectares in size. Many of these dunes are currently experiencing erosion (Halcrow 2009a). In order to fulfil their role as natural coastal defences, the various pressures imposed by natural processes, such as sea level rise and wave action, plus those imposed by tourism (e.g. trampling) need to be managed in a sustainable fashion.

The Cornwall Sand Dune and Beach Management Strategy will assist in the development of sustainable management practices for sand dunes and beaches in Cornwall.

1.2 Project Aims

The main focus of the Cornwall Sand Dune and Beach Management Strategy is the management of dunes to ensure they fulfil their flood and coastal defence function, although the study has also considered the habitat and tourism value of the dunes.

The Cornwall Sand Dune and Beach Management Strategy includes the following documents:

- Site Visit Report (Halcrow, 2006);

- Post Storm Site Visit Report (Halcrow, 2007);
- Sand Dune Inventory and Guidance (Halcrow, 2009a);
- Sediment Budget Report (Halcrow, 2009b);
- Sand Dune Management Techniques (Halcrow, 2009c);
- Two Pilot Dune Management Plans, which are being produced for Harvey Towans (this report) and for Fistral Beach (Halcrow 2009d).

The two Pilot Dune Management Plans have been developed based on information gathered as part of the Strategy (included in the documents listed above), but will also provide information for the final version of the documents. The Sand Dune Management Techniques Report will be tested and refined though development of the two Pilot Dune Management.

1.3 Dune Management Plan

A Pilot Dune Management Plan has two purposes:

1. To identify management issues and develop responses at the study site;
2. To provide a good practice example Dune Management Plan that can be used as a template for the production of other Dune Management Plans in Cornwall.

The objective of this Pilot Dune Management Plan is:

To identify the needs of the site for dune management and identify appropriate long term dune management to manage the dune response to the high tourism pressures and natural processes at Harvey's Towans.

This Dune Management Plan is structured as follows:

- Section 1 – Introduction;
- Section 2 – Site Description;

- Section 3 – Factors Affecting the Beach Dune System
- Section 4 – Historical Changes
- Section 5 – Dune Management Plan;
- Section 6 – Monitoring and Response.

1.4 Key Contacts

The Strategy is led by Cornwall Council on behalf of the Cornwall and Isles of Scilly Coastal Advisory Group. The key contact for this work is:

Name: Mr Martin Clemo

Job Title: Principal Engineer

Postal Address: Cornwall Council
Council Offices
39 Penwinnick Road
St. Austell
Cornwall
PL25 5DR

2 Site Description

2.1 Location

Harvey's Towans is a north-west facing dune system, with a small spit extension, located along the eastern bank at the mouth of the Hayle Estuary, St Ives Bay (Figure 1). The beach and dunes are within the Cornwall Council region, but are privately owned by the Hayle Harbour Commission (down to Mean Low Water). Prior to Cornwall becoming a Unitary Authority in 2009, this was within the region of Penwith District Council.

2.2 Setting

The dune system at Harvey's Towans comprises high climbing dunes, fringing dunes and cliff top dunes and consists of approximately four hectares of active dune area and three hectares of inactive dune areas (Figure 2). The active dune area is defined as the currently mobile and dynamic portion of the dunes, which at Harvey's Towans is located along the seaward side of the dunes. The inactive dune area is defined as the area of dune that has become immobile, either due to human actions, such as building on the dunes, or the development of thick, permanent vegetation cover. At Harvey's Towans the land behind the dunes has been developed and there are a number of domestic dwellings which have been constructed behind the second dune ridge.

The dune system provides important recreational value. There are chalets both behind and within the dunes. There is also a car park and numerous access paths which lead from both the car park and Holiday Park to the beach through the dunes. A small extension of embryo dunes extends into the estuary and is a popular site for fishermen.

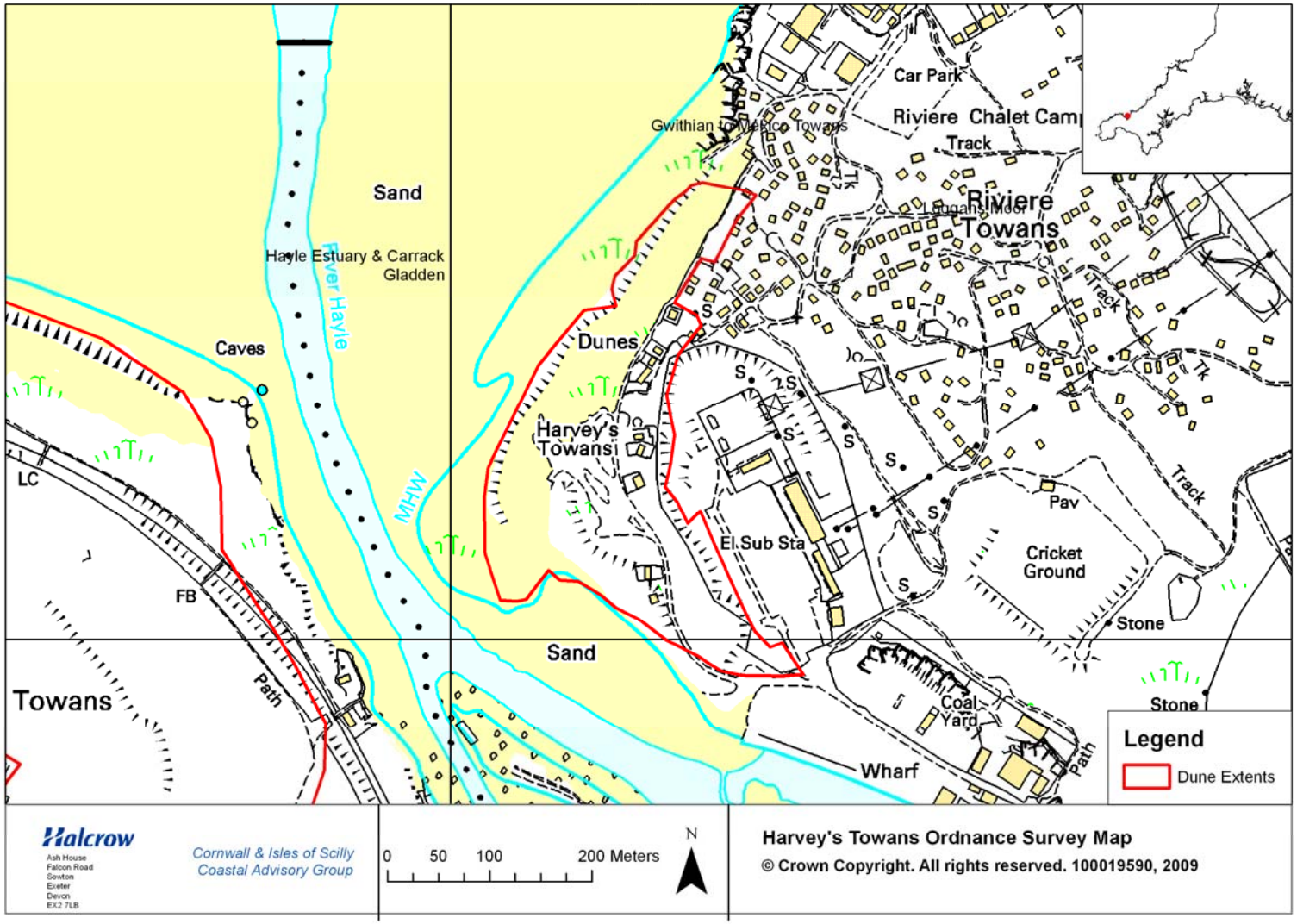


Figure 1– Location and OS Map of Harvey's Towans

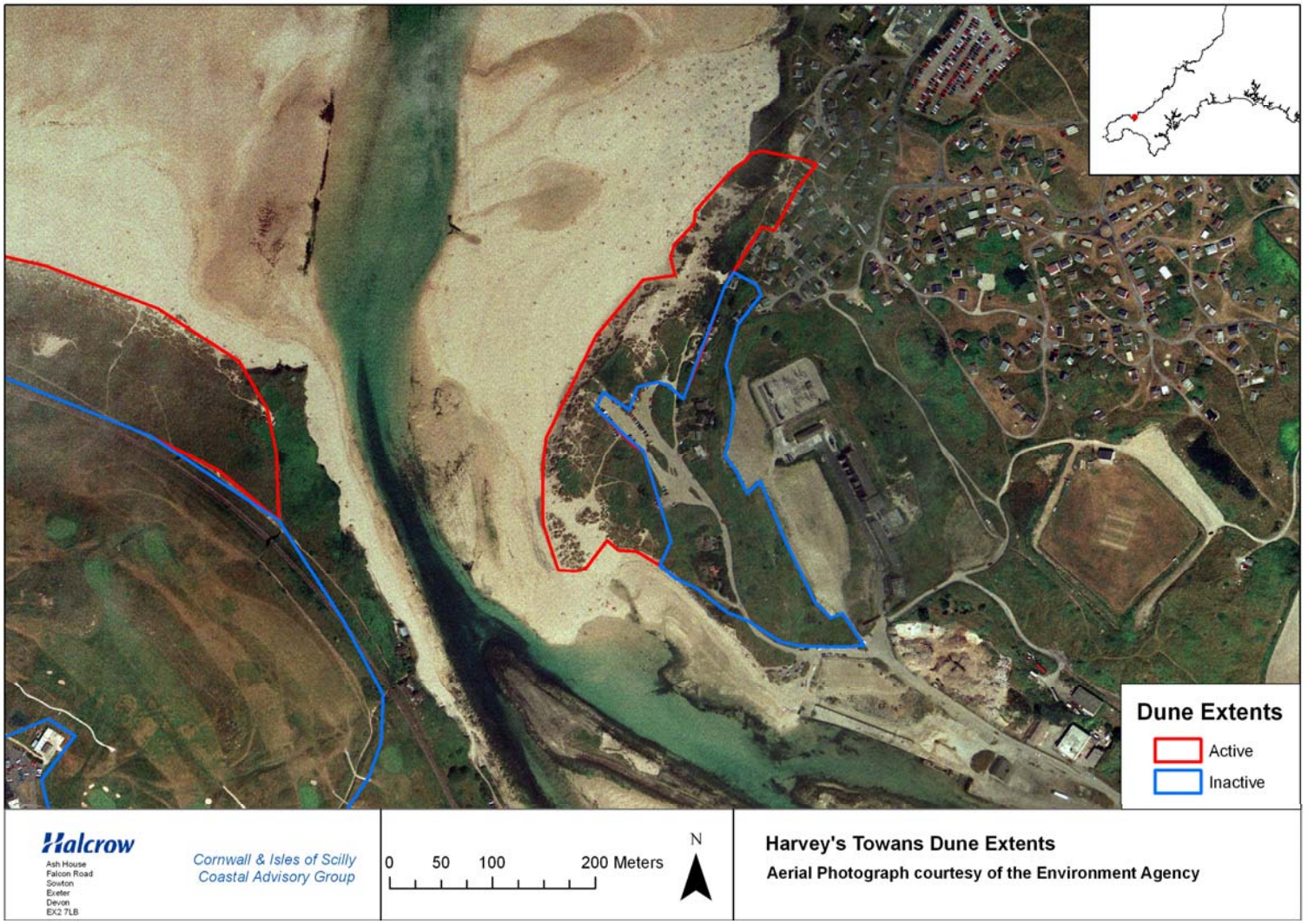


Figure 2– Aerial Photograph of Harvey's Towans (2000) indicating the active and inactive dune area

2.3 Key Characteristics

2.3.1 Present State

The principal characteristics of the present beach system are as follows:

- Harvey's Towans beach comprises of a very wide flat sandy foreshore backed by low head (till) cliffs and climbing dunes;
- The beach and dune system is composed of shell material with some material derived from erosion of the adjacent till cliffs;
- The beach is located at the mouth of the Hayle Estuary forming part of the dynamic estuary system.

The principle characteristics of the dune system are:

- Dunes are west and south facing, near the entrance of the estuary mouth;
- High climbing dunes with steep front face;
- The front edge of the dunes has a number of very steep sections with little vegetation and some exposed rock in cliffed sections;
- Foredune[1], yellow dune[2] and grey dune[3] vegetation are present within the dunes. Scrub and non native species are also present (Halcrow 2007);
- Marram grass is beginning to establish on some areas of bare dune face;
- Much of the dune habitat is dominated by non native species (scrub). The back of the dunes is well established with vegetation such as brambles, Ivy and Japanese Rose;

[1] Foredune - unstable low ridges of sand on the foreshore where there is a characterising community of open, often sparse vegetation.
[2] yellow dune - successional stage after fore dune.
[3] grey dune - sand ridges almost completely vegetated.

- Some gulleying and erosion along the paths is evident;
- There is exposed debris (rubble/ metal) at base of dune including remains of WW2 defences.
- A former landfill/dump site is thought to be located in the area of the existing car park within the dunes;
- Along the centre of the small sand spit feature, which extends into the mouth of the Hayle Estuary, there are small, low embryo dunes.

2.4 *Natural and Historic Environment*

Harvey's Towans is situated on the western side of the River Hayle and is not subject to any national or international designations. There are, however, a number of Site of Special Scientific Interest (SSSI) designated sites in the nearby area. SSSI sites are nationally designated sites, selected for being the best examples of our natural heritage in terms of wildlife habitats, geological features or landforms. A SSSI area is notified as being of special interest under the Wildlife and Countryside Act 1981. Figure 3 shows the three SSSI sites located near to Harvey's Towans. These sites and reasons for their designations are:

- Hayle Estuary and Carrack Gladden:
    - wintering wildfowl and wading birds within the estuary;
    - wildfowl and diving birds at Carsnew Pool;
    - migrant and rarer bird species, in particular North American vagrant species (due to extreme south westerly location of the estuary);
    - dunes, dune grassland and dune scrub at Lelant which provide a rich diverse flora;
    - maritime heath and grassland at Carrack Gladden.
- Gwithian to Mexico Towans:

- An important site showing successive erosional and depositional phases in coastal development. Each of these stages has characteristics which contribute to the SSSI designation;
- The dune system supports a number of rare native plant species;
- The dune system of importance for its butterfly and moth species.

- Loggans Moor:
  - A particularly species rich meadow site.

The impact of dune management options on the nearby SSSI sites will need to be considered, in particular the impacts upon the Hayle Estuary and Carrack Gladden SSSI which is closely linked to Harvey's Towans via Hayle Estuary (see Section 3.2).

Harvey's Towans is not a designated site but does have important coastal Biodiversity Action Plan (BAP) habitat. Impacts of dune management measures on BAP habitat should be considered in accordance with local authority responsibilities towards BAP habitat (Defra, 2007).

There are a number of sites and monuments located within the area and these are shown in Figure 4. Sites and Monuments are historic and archaeological sites, historic landscapes, historic settlements and historic buildings collated from a range of sources by the Cornwall Historic Environment Service (HES). These sites need to be considered when designing and implementing management measures for the dunes.

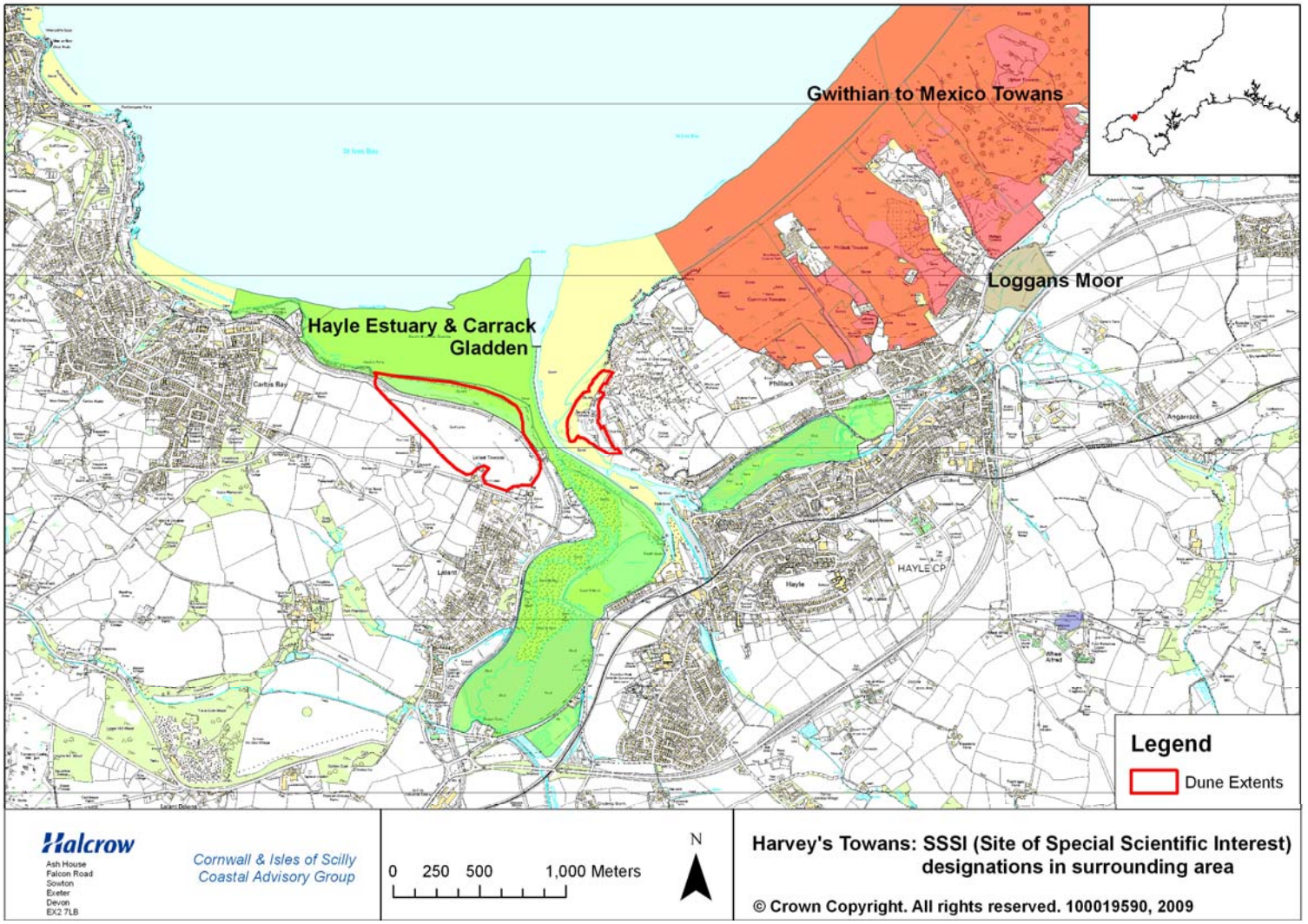


Figure 3– SSSI designations in the area surrounding Harvey's Towans

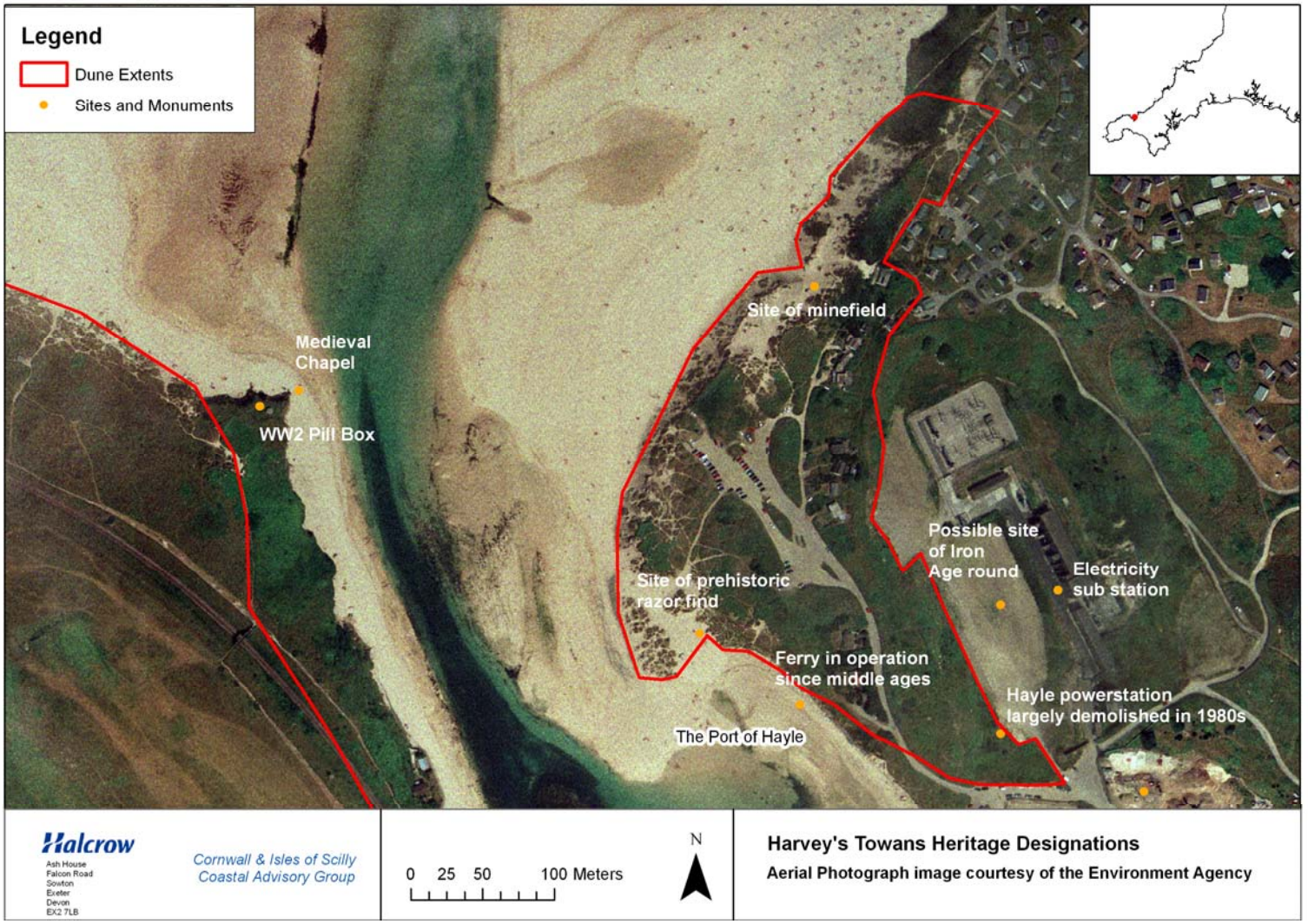


Figure 4– Sites and Monuments located at Harvey's Towans and the surrounding area

Harvey's Towans is located immediately adjacent to the Cornwall and West Devon World Heritage Site 'The Port of Hayle' (Figure 5). English Heritage defines World Heritage Sites (WHS) as '*places of outstanding universal value to all humanity and are of great importance for the conservation of mankind's cultural and natural heritage. They need to be preserved for future generations, as part of a common universal heritage*'. The Port of Hayle has been designated for its historic mining culture. More information can be found at http://www.cornish-mining.org.uk/sites/hayle.htm. The impact on the setting of the WHS will need to be considered when designing and implementing management measures for the dunes.

The process of Historic Landscape Characterisation (HLC) was undertaken for Cornwall as part of a general Landscape Assessment for the County in 1996. HLC enables the historic dimension of the landscape to be characterised and considered alongside the natural landscape and also aids understanding of the evolution of the landscape. One of the Cornwall Historic Landscape character types mapped is 'Rough Ground, Sand Dunes'. The key characteristics of dune sites defined by HLC should be considered in the development of management measures for the dunes. The HLC for dunes considers (Herring 1998):

- Evidential Value;
- Historic Value;
- Communal Value;
- Aesthetic Value;
- Potential for amenity and education.

2.5 Land Use

Holiday Chalets are located within and behind much of the dune site and a car park has been constructed on the dunes. Industrial developments back the eastern part of the dune site.

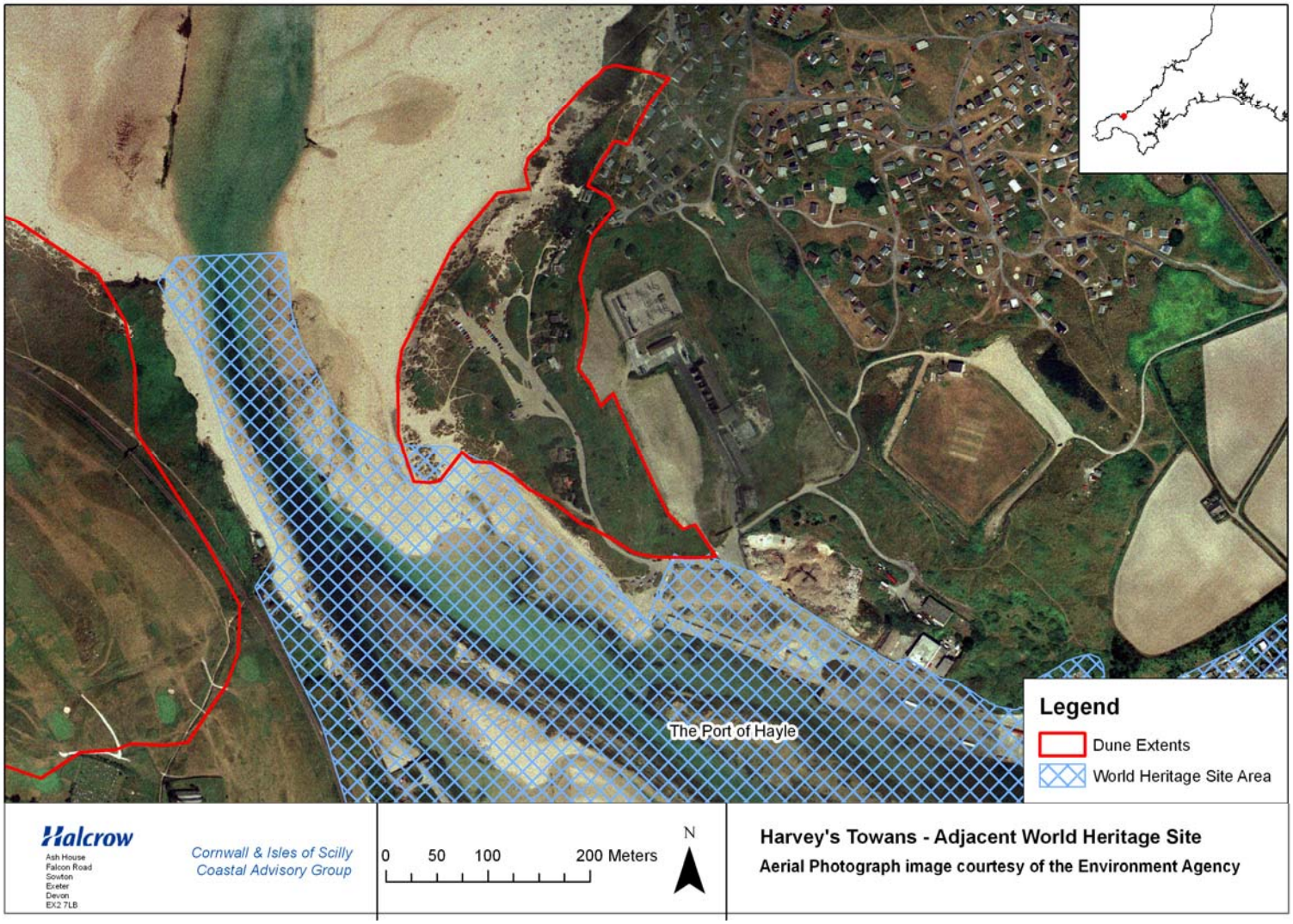


Figure 5 – Cornwall and West Devon World Heritage Site adjacent to Harvey's Towans

2.6 *Value of the dunes*

The management of the dunes needs to acknowledge the benefit of the sand dunes for their aesthetic value, and thus attractiveness to local residents and visitors, as well as acknowledging the coastal defence function of the dunes. The specific values of the dunes at Harvey's Towans include:

- Coastal erosion buffer for properties within and behind the sand dunes;
- Soft approach to managing blown sand into urban areas behind the beach and dunes;
- Providing a store of sand that can naturally feed the beach to compensate for seasonal erosion;
- To form an aesthetically attractive backdrop to the beach, providing sheltered areas and viewing points for beach users;
- Significant environmental habitat value.

The influence of the dune management on the wider St Ives Bay sediment transport should be considered as the tourism/ recreational value of Hayle surfing beach relies on banks which influence the wave conditions and make the area attractive for surfing.

2.7 *Key Problems Experienced*

The key pressures impacting on the dunes which are to be considered in the Dune Management Plan include:

- High foot traffic leading to erosion and bare sand areas;
- Uncontrolled access leading to numerous pathways;
- Trampling erosion at dune toe preventing formation of new dunes;
- Uncontrolled fires and barbeques within the dunes;

- Wind blown sand affecting properties;
- Storm wave erosion at dune toe.

2.8 Other Studies

2.8.1 *Shoreline Management Plan (SMP) Policy*

The current Shoreline Management Plan (SMP1) for Lands End to Hartland Point was completed in 1999 (Halcrow 1999). The SMP1 policy recommended Hold the Line for Harvey's Towans. It should, however, be noted that these policies are currently being reviewed as part of the Cornwall and Isles of Scilly SMP2, which is due to be completed by March 2010 (http://www.ciscag.org/SMP2CIS.html).

The SMP1 identified that dune management would be necessary to stabilise and maintain the current position of the dunes and Hold the Line. The location of tourist developments makes dune retreat difficult, but it was identified that the landward relocation of the most seaward chalets may be necessary to allow a more natural dune to form in the longer term. Hard defence intervention was not recommended along this frontage.

2.8.2 *Habitat Study*

As part of the EU funded project 'Integrated Coastal Zone Management: Towards an Atlantic Vision', coastal habitat surveys were carried out for eight sites in Cornwall in 2005 on behalf of the Natural Environment Service of Cornwall County Council. The aim of the project was to demonstrate best practice and at the Cornwall sites focused on the management of beaches, associated dunes and coastal habitats. The project reports were completed in 2005.

Hayle was one of the survey sites identified for this study. The survey aimed to collate and analyse existing ecological data and combine this with updated information to make recommendations for improving the quality and extent of habitats and species. The report (Spalding Associates (Environmental) Ltd, 2005) assessed the condition of the open dune and dune grassland as unfavourable due to damage and the presence of non native species. For nature conservation purposes management should aim to maintain the dunes in favourable condition and the report recommends that the site should be restored to reach the target as effectively as possible. The reasons for failure and targets for the dune system habitat are provided in Table 1.

Table 1 - Reasons for failure in quality assessment of dune areas and recommended targets (from Spalding Associates (Environmental) Ltd, 2005)

Interest Feature	Reason for failure	Management Target
Open Dune	Unfavourable due to damage and presence of non-native species.	Retain extent of existing open dune and increase where possible. Control trampling erosion of foredune and yellow dune. Eliminate invasive non-native species, reduce other non-native species. Control ruderal species. Reclaim dune habitat wherever possible.
Dune Grassland	Unfavourable due to damage, presence of non-native species and restricted zonation.	Retain existing dune extent. Re-instate grey dune and dune grassland wherever possible. Maintain areas of bare sand on grey dune habitat. Eliminate invasive non-native species and reduce other non-native species.

This Pilot Dune Management Plan focuses on sand dune management for flood and coastal defence purposes rather than habitat management. Some consideration is given in the development of management measures of the dune habitat, however, the separate coastal habitat report summarised above (Spalding Associates (Environmental) Ltd, 2005) should be referred to for habitat management information.

2.9 Sources of Information

The key sources of information are the Cornwall Sand Dune and Beach Management Strategy Reports:

- Site Visit Report (Halcrow, 2006);

- Post Storm Site Visit Report (Halcrow, 2007);
- Sand Dune Inventory and Guidance (Halcrow, 2009a);
- Sediment Budget Report (Halcrow, 2009b);
- Sand Dune Management techniques (Halcrow, 2009c);

The South West Regional Coastal Monitoring Programme (SWRCMP) provided the monitoring data used in this study (www.channelcoast.org).

3 Factors Affecting the Beach Dune System

3.1 Wind and Wave Climate

Appendix A provides wind, wave and water level data taken from the Lands End to Hartland Point SMP1 (Halcrow, 1999). The data are for the nearby sites of Mawgan (wind) and Gwithian (wave and water levels). These sites are likely to be representative of the conditions at Harvey's Towans.

For prevailing conditions, the largest proportion of wind originates from the south-westerly sector and for storm conditions from the westerly sector, but it is fairly well distributed amongst all directions for both. Nearshore wave conditions are dominated by waves from the 285°N -345°N sector, and can be significant in both height and period due to exposure to the large Atlantic fetch.

3.2 Sediment Budget and Linkages

3.2.1 St Ives Bay

St Ives Bay forms one of two key sediment sinks on the North Cornish Coast with material stored in the beaches and dunes along the coast and within the Hayle Estuary. The bay, however, can be considered to be a closed embayment as sediment inputs from the River Hayle and offshore sources are limited. Freshwater flows are thought to be generally low except during fluvial flood events, and offshore sediments are thin and patchy. Previous studies including the SMP1 and Hayle Wavehub studies (Halcrow 1999 and Halcrow 2006) indicate a cyclic movement of sediment within the bay. Sand is thought to be moved on the seabed by longshore drift, forming a clockwise subtidal rotation of sediment on the periphery of the St Ives Bay. Beach material is thought to be transported by wave action with longshore drift of beach sand occurring towards the mouth of the estuary from both Black Cliff to the east and Porth Kidney Sands to the west.

This possible recycling of material around St Ives Bay indicates that sediment eroded from within the bay, such as that released from the sand dunes, is likely to remain within the embayment and is not lost from the bay system.

Rapid accretion of sediment is thought to occur within Hale Harbour and the approach channel and there is a long history of dredging within the estuary.

Maintenance dredging of Hayle Harbour Channel is currently carried out by Hayle Harbour Commission. The dredging licence states that 53,000 tonnes of material can be dredged each year, with 20% of this dredged material having to be reinstated back into the sediment cell. 80% of the dredged material can therefore be removed from the system. In April 2008 to May 2009 25,000 tonnes of material was dredged, and of this 7,000 tonnes were reinstated back into the sediment cell (28% of the dredged volume). The Harbour Commission currently do not have a licence to dump the material at sea within the sediment cell and so it was placed on the sand dunes and beach at Harvey's Towans in December 2008. The placement of the material at this location is not a permanent arrangement, with future dredged material likely to be dumped at sea once licences have been obtained.

3.2.2 Sediment Budget

Analysis of the Sediment Budget was carried out based upon a review of available literature, analysis of historical mapping, analysis of monitoring data and site visits (Halcrow 2009b).

Potential sediment sources include:

- Nearshore Sources;
- Offshore Sources;
- Aeolian transport (from the beach to the dunes).

The beach material has a high carbonate content indicating that the main sediment source has been from offshore. The SMP (Halcrow, 1999) speculated that the supply of sediment from this source may no longer be significant. This could result in problems in the future if supply decreases but sediment loss from the system continues. There are limited amounts of sandy sediments offshore within St Ives Bay, but these are not thought to interact with the shoreline sediments. Recycling of material within St Ives Bay is therefore likely to be the main contemporary sediment pathway.

The main losses of sediment are believed to have been:

- Wave erosion of the dune toe releasing sediment into the beach system where it may be moved offshore by storm waves;
- Sediment transport into the estuary.

Some sediment loss will also occur through maintenance dredging of Hayle Harbour Channel (Section 3.2.1) however, further information and study of sediment transport is required to fully assess the impacts of this sediment loss, as any sediment transport studies carried out for the dredging licence were not available for this work.

It is thought that at this site new sediment supply is limited or absent under contemporary conditions. Further studies would be needed to clarify the extent of this erosion and investigate in more detail the sediment transport pathways of eroded material.

The Hayle Harbour Hydrodynamic Modelling Report identified signs of erosion and retreat of the dunes at Harvey's Towans and notes that they were believed to have been eroding for the last 50 years (Babtie, 2002). Wave focussing along the river channel is thought to be impacting on the dune system as it erodes the dune toe and erodes sediment from the dune system. This erosion is corroborated by the analysis of the aerial photography which shows an area of considerable retreat of the foredune at the south-western extreme of the dunes. Interestingly the beach profile analysis over the period from 2006 to 2009 does not support this, with accretion in the area where erosion was recorded over the longer period by the aerial photography analysis. This difference may represent a short-term reversal in the long-term trend; however, further monitoring is required to determine the true trends.

3.2.3 Human Activity

The Harbour Commission have the authority to manage the site, but they do not actively manage the sand dunes. Discussion with the Harbour Master indicates that the council are involved in management of the dunes, although, they have no responsibility to do this.

The following management systems are currently in place:

- An information board is located at the main access point from the Holiday Park providing information on dune habit and asking people to help protect it (Figure 6);

- Fencing is present within the dunes, however, much of this has been damaged and is likely to be remaining from previous management schemes, which are no longer maintained;

- Signage indicating access to the beach and the coast path route are present but damaged, with some signs lying on the ground/ propped up in the vegetation (Figure 7).

These management practices require updating and maintenance as they are not currently effective in managing the dune system.

Figure 6 - Signage at access point to beach

Figure 7 – Damaged signage to beach/ coast path

Harvey's Towans is a popular tourist beach, attracting large numbers of visitors. There are also holiday chalets within the dune system and a public car park has been constructed within the inactive dunes. The dunes are therefore subject to pressures resulting from these human influences, with the key issues at this site as follows:

- High foot traffic along access routes and unmaintained management measures lead to erosion of the dunes at access points, with significant steep bare sand areas present on the dune front;
- Numerous eroded pathways through the dunes resulting in fragmentation of the dune system in terms of the habitats;
- Erosion due to trampling at the dune toe, which prevents embryo dunes from establishing;
- Fires and barbeques within the beach and dune system which produce litter and damage the dune vegetation;
- Holiday chalets have been constructed within the dunes, which have resulted in removal of vegetation, likely compaction of the dune

beneath and also increased pressure through trampling. They may also inhibit the evolution the dune system in the future;

- The industrial and tourism land development directly behind the dunes restrict the active dune area and the ability of the dune system to react to future pressures (Figure 8).

Figure 8 – Properties and car park within the dune system

Maintenance dredging of the harbour channel could also influence the beach-dune system. A more detailed study would be required on the sediment transport within the sediment cell to assess the pressures on the beach and dunes resulting from the removal of sediment from the system. A number of studies have been carried out previously in order for the dredging licence to be agreed but these were not available for this work.

ING Real Estate are currently seeking planning permission for a new development at Hayle harbour including retail, office and industrial space as well as a large number of residential properties. If this development is approved, visitor numbers at Harvey's Towans could also increase.

3.3 Future Changes

Future Climate change could impact on the sediment budget at this site in a number of ways:

- Increased sea level and wave energy leading to increased wave action at the toe of dunes;
- Increased storm waves leading to increased beach erosion;
- Increased wind action and aeolian transport between the beach and dunes;
- Increased pressure on dunes due to widening of estuary mouth in response to an increased tidal prism resulting from sea level rise.

As the dunes at Harvey's Towans are primarily climbing and cliff top dunes they will be less sensitive to sea level rise than other frontal dune sites around Cornwall. They will however be more sensitive to changes in wind strength and direction.

The dunes at Harvey's Towans show some accretion with the progradation of the small spit into the estuary. It is possible that this will continue to infill if sediment movement into the estuary continues, offsetting some effects of climate change.

3.3.1 *UKCP 09*

UKCP (United Kingdom Climate Projections) released updated information on future climate change in 2009 (http://ukclimateprojections.defra.gov.uk/).

This update indicates that the south west of Britain would be subject to an increase in sea levels, wind, precipitation and wave height. The increases in these drivers, however, are predicted to be smaller than that estimated by previous UKCIP 02 information. This would mean that future changes in the dune system resulting from climate change would be smaller than previous climate change predictions suggest.

3.3.2 *Sea Level Rise*

Future sea level rise and increased storminess could lead to erosion of the beach dune system. With higher sea levels and increased storms, erosion of the dune system may occur, releasing sediment from the dunes to the beach system. Increased wave energy and more frequent storms may also result in

beach erosion leading to a steepening of the beach. This may lead to a loss of sediment from the beach to offshore sinks, where it may be lost from the beach-dune sediment budget.

Future sea level rise could also result in an increase in the tidal prism of Hayle Estuary, with more water entering the estuary. This could lead to widening of the estuary mouth. Due to the location of the dunes at the entrance to Hayle Estuary, a widening of the channel could lead to increased erosion pressures on the beach and dune front.

3.3.3 Climate Change

Aeolian transport is thought to be important within St Ives Bay and can contribute notable volumes of sand to the dunes. The impacts of future climate changes are uncertain but periods of increased wind speed could increase aeolian transport if associated with dry conditions. This would enable sediment from the beach system to be transported to the dunes and stored for release during storm periods.

If increased sea level rise and increased precipitation occur, however, this could reduce aeolian transport. With MLW being closer to the dune toe, less sand would be exposed to the wind. Increased precipitation could lead to wetter, consolidated sand which is less likely to be moved by wind action.

3.3.4 Site Influences

The geomorphology of St Ives Bay is thought to be fairly stable and unlikely to be subject to significant geomorphological changes in the future. Changes in management of the Black Cliffs and Gwithian Towans area could however impact upon the dune at Harvey's Towans. With net sediment transport towards the estuary mouth, changes to this section of coast to the west could impact upon the sediment feeding Harvey's Towans. Changes proposed to the coast within St Ives Bay should therefore consider the impacts upon Harvey's Towans.

As a result of the location of Harvey's Towans at the entrance to Hayle Estuary the dunes are likely to be affected by changes in the management of Hayle Estuary. If management within the estuary changes this could impact upon the sediment budget at Harvey's Towans. Also, if changes in estuary management impact upon the morphology of the estuary mouth, this could significantly impact on the dune system. Changes to estuary management should therefore consider impacts on the dunes at Harvey's Towans.

Future pressures upon the dunes from human activity are likely to continue into the future. If the proposed redevelopment of Hayle Harbour is implemented, visitor numbers at Harvey's Towans may increase. Dune management is then likely to become more important as tourism pressures will become greater and will require careful management.

4 Historical Changes

4.1 General Description

St Ives Bay is a small estuary formed from the infilled valleys of the rivers Hayle and Angarrack. The nature of the terrain in the bay and prevailing wind direction has enabled a build of sand to develop into climbing dunes to the east of the Estuary and much of the slate cliffs are now covered with wind blown sand. Harvey's Towans developed as wind blown sand collected immediately to the east of the estuary mouth and currently consists of climbing, fringing and cliff top dunes.

4.2 Long-term evolution

Historic Ordnance Survey (OS) mapping analysis, using a series of OS maps ranging from 1888 to 2000 (presented in Halcrow, 2009b), indicates that the aspect of the beach has changed over the last 120 years (Figure 9). The Mean High Water (MHW) mark roughly describes the location of the base of the dune and its migration over time. There is a protrusion in the HWM at the edge of the estuary mouth; the analysis shows that this protrusion remained in the same location between 1888 and 1970, with some variation in its exact position. At some point between 1970 and 1987 the base moved significantly landward and further into the mouth of the estuary. The Mean Low Water (MLW) mark shows that the position of the river channel has varied over time; this change in position seems to occur periodically, with long periods of stability in between – the LWM has been in its current position for the past four decades according to the OS maps.

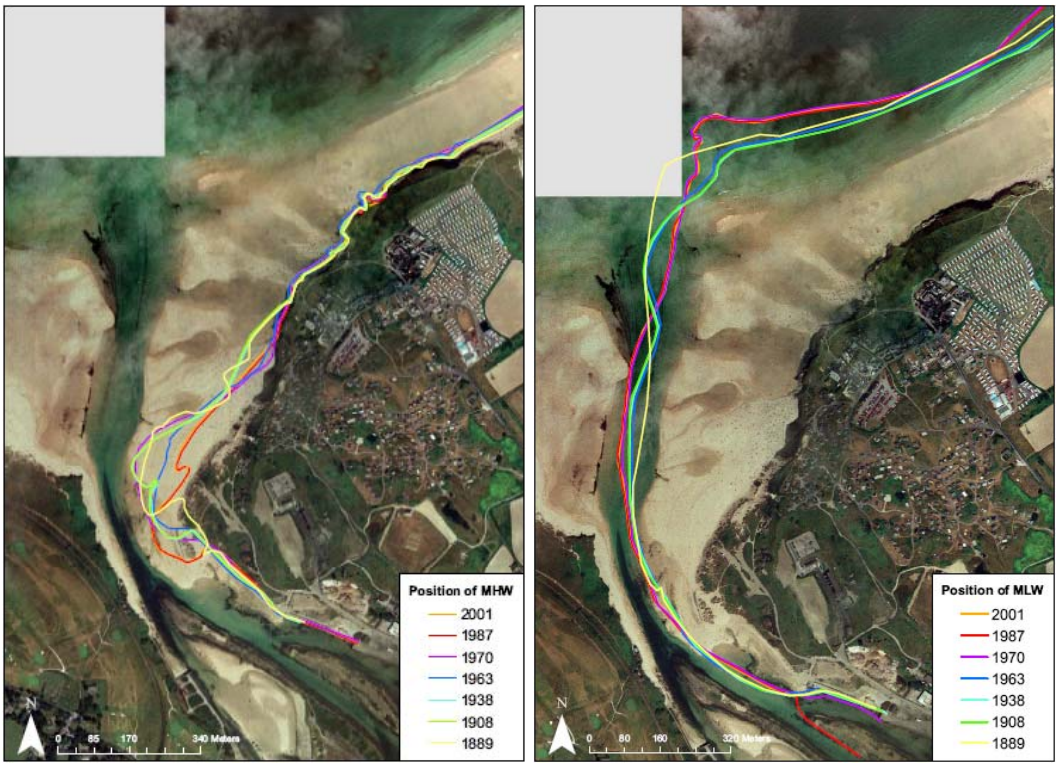


Figure 9 – Comparison of MHW and MLW, respectively, using historical OS Mapping (Aerial photographs courtesy of Plymouth Coastal Observatory)

The analysis of 2001 and 2007 aerial photography indicates little change in the position of the dune toe and foredunes for the majority of the site (Figure 10). There is, however, an area at the most westerly extreme where the foredunes have retreated by about 14m. Directly south of this, another area of foredune near to the river channel has also been eroded.

The photographs also appeared to show an area of considerable dune-toe recession at the northern extent of the dunes. Further analysis, however, showed that this is an erroneous feature caused by the two aerial photographs having been taken at different angles.

Figure 10 – Comparison of dune toe position digitised from 2001 and 2007 aerial photographs (courtesy of Environment Agency and Plymouth Coastal Observatory respectively)

4.2.1 Contemporary Behaviour

Six profiles have been surveyed at Harvey's Towans as part of the SWRCMP and three of these cover accessible areas of dune (Figure 11). The beach profile charts (Appendix C) show that the dunes in the estuary mouth (Profiles 7a00805 and 7a00807 Figure 11) have accreted over the monitoring period, with growth of the crest of a small foredune in front of the main dune system.

The beach in the estuary mouth has also accreted over the analysis period, up to February 2008. The recent profile, however, September 2008, shows a drop in beach levels along the majority of the profiles measured. This is associated with an increase in level immediately in front of the dune system. As this is only observed in one data set, further monitoring will be required to identify whether this is a short term response, which may be followed by a recovery period.

Figure 11 - Location of beach profiles currently measured by the South West Regional Monitoring Programme(Aerial photograph courtesy of Plymouth Coastal Observatory)

The profiles outside of the estuary mouth show the beach to experience regular fluctuations in the position of the MLWS contour, indicating that the position of the low water channel is not stable and varies over short periods.

To the east of the estuary mouth, the beach profiles show variability in both beach height and cross-sectional area, but there is no discernible trend. The observed changes will relate to different exposure conditions: as wave energy varies from season to season and year to year, the morphology also varies. This is shown by observed evidence of relatively large scale beach changes at Hayle Harbour entrance (HR Wallingford, 2007). Further monitoring data is therefore needed to identify long term or recurrent trends.

4.2.2 Storm Response

There is currently no post storm monitoring data available for Harvey's Towans. The wave data set collected by the SWRCMP is currently too short for data to be usefully analysed to derive post storm survey trigger conditions. Post storm surveys are therefore triggered based on a subjective assessment of the wind and wave conditions by coastal scientists working on the SWRCMP. The storm threshold is currently set to a significant wave height of

5.5m by SWRCMP. If the wave height exceeds this, additional parameters are assessed such as wave period and tidal state and the local authority engineer is contacted to identify any specific concerns at the site. If the need for a survey is identified based on this assessment the survey is completed within 24 hours. It is recommended that Cornwall Council liaise with the SWRCMP to contribute local knowledge as to the conditions which should trigger a post storm survey.

A post storm inspection was carried out by Halcrow in January 2007, prior to the implementation of the SWRCMP. A full report is provided in Appendix B. It was difficult to carry out any specific measurements at Harvey's Towans as there were few fixed structures present to use for photographic comparisons. Erosion of the dune face was, however, evident following the storm conditions and also accretion of sand at the back of the beach due to aeolian transport. Small sized rocks at the base of the sand dunes had been buried with dune material and the toe of the dune eroded by waves. Erosion and slumping of the dune face had occurred. Sand levels in front of much of the dune system appeared to have increased due to sediment transfer from the dunes.

5 Dune Management Plan

This section covers the development of the Dune Management Plan and is divided into four sections:

1. Key Issues to be Addressed
2. Generic Management Techniques;
3. Discussion of suitable techniques at Harvey's Towans;
4. Plan of Action.

5.1 Key Issues to be Addressed

The key issues to be addressed include:

- High foot traffic leading to erosion and bare sand areas;
- Uncontrolled access leading to numerous pathways;
- Erosion at dune toe preventing formation of new dunes;
- Fires and barbeques within the dunes.

5.2 Available Management Techniques

The possible generic management techniques that could be applied are listed below:

- Adapt backshore management/ uses - allow natural processes to continue and adapt backshore management accordingly. May involve moving, replacing or demolishing backshore assets which are at risk;
- Access management; for example control fencing;
- Zoning of dune system; for example barbeque areas;

- Public awareness signs and display boards, guided walks, public talks, interpretative leaflets, wardens and visitor centres;
- Planting;
- Thatching;
- Mulching/ matting/ sand binders;
- Hard protection methods; for example gabion revetments, groynes and artificial headlands;
- Morphological modification; for example dune fencing, planting bulldozing / contouring and beach drainage;
- Sediment modification; for example beach recycling, reprofiling and nourishment;
- Removal of defences;
- Monitoring.

For a full description of all the management techniques available, please refer to the Sand Dune Management Techniques Report (Halcrow 2009c).

5.3 Appropriate Management Techniques at Harvey's Towans

Management at Harvey's Towans must encompass the management of both the natural pressures of wind and wave erosion and the pressures caused by human activity.

One of the principle factors of damage to Harvey's Towans is the result of human use of the dunes, for example trampling, barbeques etc. (see Section 3.2.3). Visitors to the dunes need to be encouraged, as tourism forms the main basis of the local economy, but visitors must be managed to minimise the damage to the dunes which attract them. The proposed ING development at Hayle Harbour could increase pressure on the dunes as the area becomes more attractive to tourists and the local residential population increases.

5.3.1 Access Management

Access to the dunes is mainly via the car park at the back of the dune system or from holiday chalets within the dunes. This has resulted in significant erosion along the principle access routes, leading to steep, bare sand areas at the front of the dunes (Figure 12).There is also an extensive network of paths through the dunes due to unrestricted access from the public car park. Both local people and holiday makers visit the beach and dunes at Harvey's Towans and so visitor numbers are significant all year round, although they are higher in summer. This results in the dunes being under pressure year round with no seasonal recovery period in which dune building and vegetation growth can take place without trampling pressures.

The construction of boardwalks with steps on the steeper sections is recommended to minimise trampling impacts along the main access route from the holiday chalets. This will help prevent high foot traffic from eroding the dune face further and could allow vegetation to establish either side of the board walk, if handrails are used for safety and to keep people to the paths. There are a number of different designs of boardwalk and sloping stepped structures which can be investigated (BCTV, 2005). The design of the boardwalks would need to consider factors such as wind direction, dune mobility and the characteristics of beach users. Boardwalks will need to be constructed at appropriate positions and using appropriate designs to minimise problems including burial of the boardwalk with blown sand or undermining of the boardwalk during storms. The design should also minimise the impact on natural dune processes. The increased focus of visitors around the entrances to board walks would require detailed design and monitoring to ensure this did not result in increased erosion.

There are numerous eroded tracks through the dunes, principally resulting from uncontrolled access from the car park. These access tracks develop as visitors will travel the shortest route to the beach from wherever they are parked, leading to the development of a network of paths through the dunes. Access to the dunes and beach from the car park could be managed to reduce the area of dune affected by trampling. Access fencing and signage could be implemented to provide designated access points from the car park to the dunes. By directing visitors along designated paths vulnerable areas can be protected from trampling and erosion. As erosion along these routes will be concentrated, management measures such as board walks or rotation of which footpaths are open may be required to reduce erosion along the paths. The

designated access routes should be obvious to visitors as they park, and therefore signage needs to be clear to ensure the routes are followed. The presence of dune wardens to ensure designated routes are followed would also be beneficial. Regular maintenance of signage would be required.

5.3.2 Bare Sand Areas

The climbing dunes at Harvey's Towans are high, steep dunes. Where access is gained to the beach from the car park and beach users travel down the steep dune face to the beach, there are wide steep sections of eroding bare sand where new vegetation is not establishing (Figure 12). As visitors trample the dune system, vegetation is destroyed and the sand becomes more mobile, with the dune then becoming more vulnerable to wind erosion. Continued trampling destroys any marram grass which attempts to re-establish on the bare dune face, thus preventing the dune from recovering. Although there may be conservational benefits to some bare sand areas, without management they can lead to issues of wind blown sand in developed areas behind the dunes and loss of dune habitat. Over stabilisation of the dunes however would not be desirable as the dunes would become undynamic and unable to react to pressures. Management through stabilisation therefore needs to be applied only to appropriate sections of the dune system and these sections should be identified by a dune manager with an understanding of the local dune system.

Figure 12- Erosion of steep dune face through trampling along many access routes

To manage the steep bare sand areas sand stabilisation measures are recommended. The eroding areas should be fenced off to enable vegetation to establish without the threat of trampling. If fencing is not successful, sand stabilisation measures such as planting, mulching, thatching or sand binding could also be implemented to stabilise the dune face and reduce wind erosion. Planting may be most appropriate, with native species such as marram grass and sea couch used where possible to avoid damaging the dune habitat. Matting, mulching or sand binding compounds could be used alongside planting to further stabilise the sand surface if this is required. Thatching may not be appropriate in amenity areas such as Harvey's Towans, as it can provide an attractive barbeque fuel to visitors. The dune manager should assess which areas of bare sand are vulnerable and require stabilising, as it can be beneficial to have some areas of bare sand exposed to encourage habitat diversity. For the stabilisation measures to be effective a supply of wind blown sand would be required.

The formation of embryo dunes on the sand feature extending into the estuary shows that embryo dune formation is possible at this site (Figure 13). At the dune toe embryo dune formation may not succeed as high trampling pressure means that vegetation and sand build up do not survive long enough to fully establish into dunes. To encourage embryo dune formation fencing could be constructed to prevent access to the dune toe where embryo dunes could form. The presence of a dune warden would help ensure restricted access zones are adhered to. Preventing access will give establishing sand trapping vegetation a greater chance of survival, encouraging sand build up and embryo dune formation. Sand trapping fencing could also be constructed to further encourage dune formation. These measures to encourage vegetation growth and embryo dune development along the dune front can also increase the dunes ability to respond to and recover from seasonal wave erosion. If the dune front is subject to regular wave action the embryo dunes will not be able to fully establish. Further investigation and monitoring is recommended before implementing these measures to ensure conditions are suitable for embryo dune formation at the proposed location on the dune site.

Figure 13– Embryo dunes forming on sand feature extending into estuary

5.3.3 *Development*

The dunes at Harvey's Towans are restricted by industrial development and numerous chalets which have been developed both within and behind the dunes. This development restricts the ability of the dune to react to both natural and anthropogenic pressures and interrupts the natural processes of the dynamic dune system. The dunes act to trap sand which would otherwise collect in developed areas where it would be a nuisance. In order to prevent further restriction of the natural dune processes, it is recommended that no further development is allowed within the dune system. If erosion of the dune system continues or increases with sea level rise, it may be beneficial in the longer term to remove chalets located towards the front of the dune system to allow the dunes to remobilise.

5.3.4 *Education of Beach and Dune Users*

To increase the success of the management measures implemented, a series of educational signage and leaflets should be developed. Education of beach users explaining why the management measures are in place can discourage damaging behaviour and encourage visitors to adhere to measures such as controlled access. Educational signs should be attractive and clear to gain attention and include information such as:

- The importance of the dunes at Harvey Towans;
- The pressures on the dunes, such as high visitor numbers and wave erosion;
- The impacts of the actions of beach users on the dune system;
- Dune management techniques in place and how they help the dune system; and,
- How the beach users can contribute to protecting and enhancing the dune system.

Large informative signage should be placed at key locations such as at access points and near to pay and display machines in the car park. Smaller repeater signs should be located throughout the dunes reinforcing the request to stay outside of the enclosed areas and allow dunes to recover. Signs indicating access routes should be clear and easily visible to make following the designated routes the 'easy option' for visitors. All signage and associated management measures will require regular maintenance to be effective. This can be carried out by a dune warden.

It would be beneficial for dune managers to liaise with the owners of the holiday chalets and regular beach users to inform them of dune management measures in place. Through liaison they can encourage beach users to understand the dune system and the benefits they can gain from it. This will encourage them to consider the impacts of their actions and how they can work towards improving the dune environment. Educational leaflets can be produced, showing similar information to the signage. These can be provided to chalet owners to be left in the chalets for holiday makers to read on arrival. A small visitor centre would also be an effective way of educating visitors about the dunes, with a designated warden located here during the day. This could simply be a small wooden hut which the warden would use as a base. Information posters and leaflets could be positioned on the outside the hut under a shelter. A dune warden would be able to provide information while also being present to ensure management signs are adhered to. The warden and visitors centre could be linked in with the management of the adjoining Mexico to Gwithian Towans dune complex and could also provide activities such as guided walks and education days for local schools.

5.3.5 *Dune Front Erosion*

Erosion of the dune face by wave action causes cut back of the dunes during the winter. Babtie (2002) reported that lowering beach levels accentuate this as wave action is able to reach further up the beach and so the volume of aeolian sediment reaching the dunes to aid recovery is reduced as the beach is submerged for longer. As the dunes are eroded they will, however, add sediment to the beach, increasing the beach levels and forming a positive feedback mechanism. The short term monitoring conducted as part of this study will need to be continued in order to determine whether beach levels are lowering over the longer term. Recession of the dune front due to wave action is difficult to prevent. Stabilisation of eroded areas of the dune face may help to reduce this, but the waves will continue to reach the face and cause erosion leading to dune cliffing and block failure of the dune face. Wave erosion can be reduced using hard defence structures, but these would decouple the dunes from the beach and such structures are not therefore recommended for dune management at this site. Significant economic justification would also be required for such engineering works.

Beach nourishment could be an option at this site in future years if erosion becomes a threat to properties, but such a scheme can be very costly. To develop beach nourishment scheme would require detailed investigation of coastal and estuarine processes including waves, currents and sediment transport and an assessment of the impacts of any proposed schemes on these processes. Hydrodynamic modelling carried out by Babtie Group in 2002 (Babtie, 2002) for Penwith District Council indicates that the principle sediment transport route is from Hayle Beach towards the estuary. The impacts of an increase in sediment upon the estuary would therefore require further investigation. Permits and consents will also be required and information on this can be found at the Marine and Fisheries Agency website (http://www.mfa.gov.uk/environment/index.htm). An Environmental Impact Assessment and Health and Safety Assessment would also be required.

5.3.6 *Monitoring*

A monitoring scheme is recommended for this site to record changes in the dune front and beach levels at regular intervals throughout the year, taking account of seasonal changes. This could be linked in with the SWRCMP survey data, with liaison to ensure sufficient frequency and spacing of profiles. Post-

storm monitoring should also be carried out. This will provide information on the storm response and recovery of the beach and dunes to assess whether further management is needed (see Section 6).

5.4 Plan of Action

Table 2 provides a summary of the recommended actions at Harvey's Towans.

In addition to the action plan the following recommendations should be considered:

- A study of carrying capacity of the dunes could be carried out to assess sustainable visitor numbers and methods of controlling visitor numbers;

- Development of a working group to manage the dunes which includes specialists in dune habitat, tourism and coastal defence functions. This will ensure a holistic approach to dune management. The working group will need to consider the Habitat Study (Section 2.8.2) this Dune Management Plan and any appropriate tourism plans.

Table 2 - Recommended Actions for Harvey's Towans

Issue	Recommended Management Action	Timing	Who Should Action	Risk Identification		Priority	Reference
				Risk	Mitigation	High/ Medium/ Low	
Erosion at dune toe	• Planting and fencing of areas in which embryo dunes are forming to enable dune to establish and become more robust to erosion • If becomes very severe (emergency) rock can be placed at dune toe, but careful design is needed to prevent decoupling of the beach dune system. Economic justification would be required for these works to be implemented	• Spring/ summer months to enable due toe to establish prior to winter season	Dune Manager	• Planting and fencing does not trap significant sand to develop a more robust toe due to trampling or other issues	• Ensure good access control fencing is constructed to prevent trampling. • Plant when conditions are most favourable (early Spring) • Use plant species with high sand trapping ability	L	PLANTING - http://handbooks.btcv.org.uk/handbooks/content/chapter/751 http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.2.shtml FENCING - http://handbooks.btcv.org.uk/handbooks/content/section/3948 http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.4.shtml ARIFICIAL HEADLANDS – http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.9.shtml SAND BAGS – http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.6.shtml RECYLING AND REPROFILING - http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.5.shtml
Erosion at access points which lead to steep bare sand areas on the face of the climbing dunes	• Steps or boardwalks to reduce dune trampling and erosion	• Spring – to be constructed prior to peak tourist season	Dune Manager	• Steps/ boardwalks may become buried with sand when accretion takes place. • Visitors do not use designated route and continue to use other eroded pathways	• Careful design of the steepness, location and angle of the steps • Clear signage to direct visitors and control fencing of eroded areas	H	BOARDWALKS - http://handbooks.btcv.org.uk/handbooks/content/section/3947
Steep bare sand areas	• Fencing of vulnerable bare sand areas • If dune face does not recover following fencing, stabilisation measures such as planting can be implemented • Sand trap fencing and reprofiling can be implemented if dune face is too steep and does not stabilise	• Spring – prior to peak tourist season. In general planting tends to be most successful in early March	Dune Manager	• Planting does not establish successfully and erosion continues	• Select robust species • Plant when conditions are most favourable (early Spring) • Exclude beach user from the area with control fencing and signage • If sand surface continues to erode consider using sand binders or mulching to stabilise sand surface and aid plant establishment	M	FENCING - http://handbooks.btcv.org.uk/handbooks/content/section/3948 http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.4.shtml PLANTING - http://handbooks.btcv.org.uk/handbooks/content/chapter/751 http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.2.shtml STABILISING http://handbooks.btcv.org.uk/handbooks/content/chapter/749
Litter and barbeque debris throughout the dunes	• Signage to encourage visitors to leave with their rubbish or place in bins • Inform users of the damage the litter/ debris can cause • Provide a visitors information centre and dune warden	• Design signs and boards and display prior to peak tourist season. Maintenance of signage to be carried out annually or as appropriate	Dune Manager	• Beach visitors ignore signage and continue to hold barbeques and drop litter	• Use attractive signage to explain the damage caused • Strategic positioning of signs at key locations • Wardens to patrol site interacting with beach users to provide education and not just enforcement	M	SIGNAGE - http://handbooks.btcv.org.uk/handbooks/content/section/3949

Issue	Recommended Management Action	Timing	Who Should Action	Risk Identification		Priority	Reference
				Risk	Mitigation	High/ Medium/ Low	
Numerous eroded tracks through the dunes	• Plan pathways and add signage. • Use fencing to protect eroding areas. If fencing is not exposed to wave attack, temporary fencing could be used to vary pathways once vulnerable areas have recovered.	• Plan at end of peak tourist season to implement prior to next peak season	Dune Manager	• Visitors do not use designated routes and continue to use other eroded pathways	• Clear signage to direct visitors • Educational signage to explain damage caused through not using designated routes • Control fencing of eroded areas to prevent access	M	SIGNAGE - http://handbooks.btcv.org.uk/handbooks/content/section/3949 ACCESS MANAGEMENT– http://handbooks.btcv.org.uk/handbooks/content/section/3942 FENCING - http://handbooks.btcv.org.uk/handbooks/content/section/3948 http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.4.shtml
Vandalism of management techniques	• Employ dune warden and develop visitors centre (could be combined with Gwithian to Mexico Towans) with educational activities such as nature walks • Educational Signage • Liaise with regular beach users, outdoor instructors and chalet owners	• Liaise with beach users prior to peak season and throughout if appropriate • Design educational boards and display prior to peak tourist season. Dune warden can be present at peak tourist times	Dune Manager	• Regular beach users, outdoor instructors and chalet owners are not interested in dune management and do not pass information on to others • The wrong people are identified for liaison • Signage is ignored • Visitor centre is not used • Warden not able to attend to all issues	• Identify the relevant persons for liaison through good public communications • Ensure signage is attractive to visitors and displayed at strategic locations • Advertise the development of the new visitor centre and make educational activities attractive to adults and children • Plan warden activities and adjust to respond to immediate issues as appropriate. Try to identify problems as early as possible to minimise work involved in addressing them. Prioritise key issues	H	SIGNAGE - http://handbooks.btcv.org.uk/handbooks/content/section/3949 Warden scheme has successfully been implemented at Perranporth. Nature walks are implemented at Perranporth and Gwithian
Management techniques ignored	• Employ dune warden and develop visitors centre (could be combined with Gwithian to Mexico Towans) with educational activities such as guided nature walks, open days and school trips • Educational Signage • Liaise with regular beach users, outdoor instructors and chalet owners • Dune Management leaflet distributed and can be left in holiday chalet when new holiday makers arrive. Liaison with owners of chalets/ holiday park	• Liaise with beach users prior to peak season and throughout if appropriate • Design educational boards and display prior to peak tourist season. Dune warden can be present for peak tourist times	Dune Manager	• Regular beach users, outdoor instructors and chalet owners are not interested in dune management and do not pass on information to others • The wrong people are identified for liaison • Signage is ignored • Visitor centre is not used • Warden not able to attend to all issues	• Identify the relevant persons for liaison through good public communications • Ensure signage and leaflets are attractive and displayed at strategic locations • Advertise the development of the new visitor centre and make educational activities attractive to adults and children • Plan warden's activities and adjust to respond to key issues as appropriate. Try to identify problems before they arise to minimise work involved in addressing them	H	SIGNAGE - http://handbooks.btcv.org.uk/handbooks/content/section/3949

Issue	Recommended Management Action	Timing	Who Should Action	Risk Identification		Priority	Reference
				Risk	Mitigation	High/ Medium/ Low	
Monitoring	• Regular monitoring to continue as part of SWRCMP. Photos to monitor bare sand areas (fixed aspect). Post Storm surveys to be carried out to assess storm response	• Interim profiles and bi-annually • Post storm following significant storm conditions • Photographs seasonally and at key times such as before and after tourist season. Photos can be more frequent if dune warden is employed on site	Dune Manager / SWRCMP / Cornwall Council	• Storm conditions not severe enough to trigger post storm survey • Topographic surveys do not extend far enough into sand dunes	• Assess storm trigger conditions to ensure they are appropriate • Liaise with SWRCMP at Plymouth Coastal Observatory	H	South West Regional Coastal Monitoring Scheme - http://www.channelcoast.org MONITORING INFORMATION - http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_2.shtml#a5

6 Monitoring and Response

6.1 Survey Requirements

6.1.1 Beach surveys

Six profiles are currently surveyed at Harvey's Towans and are undertaken on a twice yearly basis with additional post storm surveys following major storm events. Figure 14 shows the location of the beach profiles measured. Beach profiles from 2006 to present are contained within Appendix C. No post storm surveys have been triggered at this site since the start of the programme in 2006.

Figure 14 - Location of beach profiles currently measured by the South West Regional Coastal Monitoring Programme (Aerial photographs courtesy of the Plymouth Coastal Observatory)

Cornwall Council should liaise with the SWRCMP team to ensure survey data provides the information required at Harvey's Towans. The current beach surveys should be extended at their landward end to incorporate the dune

face and at least the first dune ridge. A photograph should be taken of the dune face at the time of each profile. The photograph will provide information on vegetation cover and dune face characteristics such as slumping or cliffing. These monitoring data will provide ongoing data on aspects including the beach level, position of the dune front and the dune shape.

In addition to the SWRCMP data, the dune manager can carry out other monitoring of key issues. Fixed aspect photography could be carried out of eroded areas to monitor aspects such as the size and development of blow outs, and the establishment of planting. This entails digital photographs being taken from the same point, pointing in a set direction, at regular intervals, to enable the changes in the dune to be compared between photographs.

Regular walk over surveys should also be carried out by a dune manager to monitor the issues identified in this report, and the success of any management measures implemented. This can include a visual assessment of aspects such as:

- Barbeque debris and litter;
- Damage to information signs;
- Number of and size of bare sand areas;
- Erosion along access routes;
- Any structures which need repair such as boardwalks or fencing;
- Growth and spread of vegetation in planted areas;
- Embryo dune formation at the dune toe.

6.2 Trigger Conditions

Trigger conditions enable operating authorities to quickly assess whether intervention is required to maintain the existing dune system. The actions required when the trigger conditions are reached should be considered in light of the conditions immediately prior to, during and predicted to follow the assessment. The beach and dunes will be inspected following a storm event. However, the dune system will typically experience erosion during a storm event and usually recover to near the pre-storm level following a period of

calmer conditions. It is therefore recommended that unless further storm conditions are predicted, the dunes should be allowed a period to recover after a storm event before remedial action is taken. Similarly, erosion will be significant in summer when visitor numbers are high, but vegetation may show some recovery during the quieter seasons if conditions allow.

Beach profile data was available from November 2006 to present, but not all of the profiles measured extended into the dune system. Due to the short time period involved, this dataset does not provide enough information for specific measured trigger levels to be defined. Action and Emergency trigger states have been developed for the dunes based on assessment of the data available, the dune characteristics and engineering judgement. When applied by the dune manager the trigger states should be assessed giving consideration to local knowledge of the site.

6.2.1 Action conditions

The Action State is defined as the beach/dune level at which intervention is required. At Harvey's Towans this is defined as the point at which erosion of the dune system reaches a stage at which it is unable to recover to pre-erosion condition without further management. The dune system at Harvey's Towans was considered to be at an Action State in 2008. Table 3 outlines the key indicators for action conditions and the criteria for assessing whether action conditions have been reached.

The dune manager will have the greatest knowledge of the dune site and will be best placed to assess the condition of the dunes against the criteria to decide when intervention is required.

Table 3– Action condition indicators and criteria*

Indicator	Criteria			
	Extent*	**Persistence**	**Trend**	**Anticipated Evolution**
Recession and/or cliffing of dune front	Cliffing of the dune front as a result of wave action has removed vegetation and embryo dunes along much of the dune frontage (e.g. along more than 50% of the dune frontage). Noticeable recession of the dune front (e.g. >2m) along much of the frontage (e.g. along more than 50% of the dune frontage). Properties within the dunes may be threatened in the near future	Cliffing or recession of the dune front has been present for two or more years and hence is not a temporary response which will be followed by recovery during calmer conditions	Cliffing is becoming steeper and higher, or recession is increasing as erosion continues with no sign of recovery	Further storm conditions predicted which are likely to cause further erosion of the dune front and increased cliffing and/ or dune recession
Unacceptable area of bare sand (assessed by dune manager with knowledge of site – note some bare sand can be beneficial so this should be carefully assessed)	The area of bare sand is of significant size and/ or depth to cause concern and is unlikely to recover without management	Area of bare sand has been present for more than one year without recovering	Area of bare sand is increasing is size	Area of bare sand is present at the start of the peak season and is likely to increase through the tourist season as a result of trampling erosion
Access Points eroded leading to erosion of dune system	Access points eroded to form a steep and wide bare sand pathway (e.g. >4m wide and on steepest part of dune face)	Access point has been eroded to form a steep and wide bare sand pathway for more than one year	Erosion is continuing and access path is becoming wider or deeper	Access is eroded at start of the peak season and is likely to be worsened by high foot traffic throughout the peak season
Large number of access routes through the dunes preventing dune recovery	In addition to the strategic access routes a large number of other pathways are eroding through the dune system (e.g. >4 other pathways)	Additional routes have been present two or more seasons and are affecting dune recovery	Erosion along the additional routes is increasing and/ or more routes are being developed through the dunes due to trampling	Additional access routes are present at start of the peak season and are likely to be further eroded, or more routes are likely to be developed during the peak season
Missing or Damaged Management Infrastructure	Infrastructure removed or damaged by beach users e.g. Signage removed or vandalised, planks taken from board walks, fencing removed, rocks taken from gabions	Beach management measures are impaired due to missing infrastructure	Trend is continuing with more infrastructures being removed or damaged by visitors	Missing infrastructure noted immediately prior to or during the peak season, and more is likely to be stolen/ damaged until the end of the season
Evidence of barbeques and fires within the dunes	Debris indicates numerous barbeques and/or camp fires are being held on the dunes (e.g. more than 2)	Evidence of barbeques over a period of three months	Number of barbeques and campfires being held is consistent or increasing	Barbeques and campfires anticipated to increase over future months

*Note: the dune manager is best placed to assess when issues are significant enough to require actions based on local knowledge and site characteristics.

6.2.2 Emergency conditions

The Emergency State is defined as the beach/dune state at which emergency remedial action should be undertaken as soon as practicable. At Harvey's Towans emergency state may be reached following a very severe storm event, or as a result of a significant health and safety risk forming during the peak tourist season when visitor numbers are high. (Table 4) outlines the key indicators for emergency conditions and the criteria for assessing whether emergency conditions have been reached.

Table 4- Emergency Condition Indicators and Criteria*

Indicator	Criteria		
	Magnitude	**Timing**	**Consequence**
Recession and/or cliffing of dune front	Recession of the dune front immediately threatens the safety of holiday chalets and other developments within the dunes	Further severe storms are forecast and are likely to cause further erosion	Undermining and potential loss of property
Access Points eroded leading to erosion of dune system	Access points eroded to form a very steep path or significantly cliffed path which causes significant health and safety risk to beach users such as the elderly or children	Access point has eroded to the magnitude stated when beach visitor numbers are significant	Beach users could fall and be injured in the immediate future
Missing or Damaged Management Infrastructure	Infrastructure removed or damaged by beach users resulting in management techniques being ineffective such as; • signage removed or vandalised • planks taken from board walks • fencing removed	Infrastructure lost or damaged during peak season when high visitor numbers are present	Dune management techniques are ineffective e.g. • fencing is removed allowing access to planted areas, trampling establishing vegetation and preventing sand stabilisation • wooden planks missing from boardwalks cause significant health and safety hazard

*Note: the dune manager is best placed to assess when issues are significant enough to require actions based on local knowledge and site characteristics.

6.3 Response

6.3.1 Action conditions

When action conditions are observed, the specific problem should first be assessed to identify the appropriate response. Responses to Action Condition indicators are suggested in Table 5.

Table 5 - Actions Condition Indicators and potential responses*

Indicator	Action
Recession and/or cliffing of dune front	Apply adaptive management, allowing the dunes to erode and moving assets which are at risk
	If fencing of dunes does not enable dune to recover, apply stabilisation measures such as planting to encourage embryo dune formation, making the dunes more resilient against erosion. Most appropriate if significant storm conditions are not predicted in the immediate future and dune front is not exposed to constant wave action
	If erosion of beach and dunes is a consistent issue, liaise with Hayle Harbour Commission and commission study to assess whether dune replenishment with dredged material from channel maintenance would be an appropriate regular management measure
Unacceptable area of bare sand in vulnerable location (assessed by dune manager with knowledge if site)	Fence off bare sand areas to prevent access and enable dune to recover
	If vegetation is unable to establish following fencing of the area, implement stabilisation planting
Access Points eroded leading to erosion of dune system	Construct boardwalks or steps along access paths
	Consider moving access routes away from eroding area. Fence off and stabilise existing access with methods such as planting to stabilise and allow recovery
Large number of access routes through the dunes causing fragmentation of the dune system and prevent dune recovery	Improve direction signs and educational signage to encourage visitors along designated foot paths
	Improve fencing to control access and ensure visitors use designated footpaths
Missing or Damaged Management Infrastructure	Replace missing infrastructure to enable management measures to be effective
	Assess why management has been damaged/ removed and whether an alternative form of management would be more successful
	Increase educational signage leaflets and liaison with beach users to encourage visitors to consider the need for dune management and the implications of damaging/ removing management techniques
	Increase presence of dune warden and educational activities
Evidence of barbeques and fires within the dunes	Increase educational signage, leaflets and liaison with beach users to encourage visitors to consider the need for dune management and the implications of damaging/ removing management techniques
	Increase presence of dune warden

* Note: the dune manager is best placed to assess when issues are significant enough to require actions based on local knowledge and site characteristics

6.3.2 Emergency conditions

If emergency conditions are reached, reprofiling of the beach and dunes may be considered to build the dunes if there is sediment available on the beach. Further studies should then be carried out into long term solutions such as reactivation of the inactive dune area. Responses to Emergency Condition Indicators are suggested in Table 6.

Table 6 - Emergency Condition Indicators and potential responses

Indicator	Action
Recession and/or cliffing of dune front	Reprofiling of the beach and/or dunes. Bulldozers can be used to move sand from lower down the beach to eroded areas. This will enable dangerous steps which have formed to be levelled out. The requirement for this should be carefully assessed to ensure economic justification
	Adapt backshore management such as moving or removing chalets which are severely affected by erosion to manage health and safety risk (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/appendix_1.1.shtml)
Access Points eroded leading to erosion of dune system	Reroute access pathways to avoid eroded areas using fencing and signage. Fence of eroded areas to enable recovery with planting and sand stabilisation methods applied as necessary
Missing or Damaged Management Infrastructure	Replace or repair management infrastructure as soon as possible to ensure effective management can continue
	Increase presence of dune warden

* Note: the dune manager is best placed to assess when issues are significant enough to require emergency actions based on local knowledge and site characteristics

7 References

BCTV (2005) 'Sand Dunes – a practical handbook' Complied Brooks, A. Revised Agate, E. BCTV, Doncaster, 109pp (http://handbooks.btcv.org.uk/handbooks/index)

Babtie (2005) 'Hayle Harbour Hydrodynamic Modelling Report' on behalf of Penwith District Council

Defra (May 2007) 'Guidance for Local Authorities on Implementing the Biodiversity Duty' (http://www.defra.gov.uk/wildlife-countryside/pdf/biodiversity/la-guid-english.pdf)

Halcrow (1999) 'Land's End to Hartland Point Shoreline Management Plan', Report produced by Halcrow Group Ltd , Swindon for Cornwall & Isles of Scilly Coastal Group ,Volumes 1 - 4.

- Volume 1 – Strategy Document
- Volume 2 – Studies and Reports
- Volume 3 – Maps and Supporting Information
- Volume 4 – Updates to the SMP

Halcrow (2002). Futurecoast CD. Produced by Halcrow Group Ltd, Swindon, UK, as part of the Futurecoast study for DEFRA 2002.

Halcrow (2006) Wave Hub Development and Design Phase Coastal Process Study Report on behalf of South West of England Development Agency

Halcrow (2007). Cornwall Sand Dune and Beach Management Strategy. Sand Dune Inventory and Draft Interim Report

Halcrow (2009a). Cornwall Sand Dune and Beach Management Strategy. Sediment Budget Report.

Halcrow (2009a). Cornwall Sand Dune and Beach Management Strategy. Sand Dune Management Techniques and Management Tool

Herring, P. (1998) 'Historic Landscape Assessment, Presenting a Method'

HR Wallingford (August 2007) 'Hayle Harbour Development, Hydraulic Studies Phase 2' Report EX5569, Appendix 13, Technical Annex 13F, for Planning Application. Downloaded June 2009 http://www.hayle.net/harbourdownloads.htm

Pye, K (2007) 'Sand Dune Processes and Management for Flood and Coastal Defence Defra Project FD 1302 (www.defra.gov.uk)

Scottish National Heritage (2000) 'A Guide to Managing Coastal Erosion in Beach/Dune Systems' SNH, Scotland, 128pp. (http://www.snh.org.uk/publications/on-line/heritagemanagement/erosion/sitemap.shtml)

Spalding Associates (Environmental) Ltd (2005) 'Ecological Assessment of Coastal Zone Management Issues at Hayle, Cornwall', for Cornwall County Council.

Website References

Channel Coastal Observatory website containing South West Regional Coastal Monitoring Programme Data (Accessed July 2009): www.channelcoast.org

Cornwall and Isles of Scilly SMP Review on Cornwall and Isles of Scilly Coastal Advisory Group Website (Accessed August 2009): http://www.ciscag.org/SMP2CIS.html)

Marine and Fisheries Agency (Accessed May 2009) http://www.mfa.gov.uk/environment/index.htm

United Kingdom Climate Projections 2009 (UKCP 09) (Accessed July 2009): http://ukclimateprojections.defra.gov.uk/

Appendix A – Wind, wave and water level data

Offshore wave conditions at 50.5°N 5.66°W predicted by the Met Office Wave Model were used in the computer modelling of the inshore wave conditions for the Lands End to Hartland Point SMP1 (Halcrow 1999). This Appendix presents the wind and wave data extracted from the SMP1 which is most appropriate to Harvey's Towans.

Table A1 – Nearshore Hydrodynamics for Gwithian (Part 1)

7A–2-3 Gwithian	nearshore hydrodynamics sheet no 1 / 2
national Grid co-ordinates	156457 E 40749 N
OD to CD conversion	-3.40
seabed elevation at prediction point	-5.7
beach azimuth	335 °N

water levels

tidal state	water level (mOD)	Return period (years)	water level (mOD)
MHWS	3.21	1:200	3.85
		1:100	3.84
MHWN	1.51	1:50	3.82
		1:20	3.78
MLWN	-1.01	1:10	3.75
		1:5	3.72
MLWS	-2.63	1:2	3.64

Note: an allowance of 0.31 m is appropriate for sea level rise over the next 50 years

extreme wave conditions

return period	conditions	offshore wave direction °N							
years	m (s) °N	225 - 255	255 - 285	285 - 315	315 - 345	345 - 15	15 - 45	45 - 75	75 - 105
1:200	H_s (T_m) *Dir*	4.0 (8.7) *309*	6.3 (9.6) *313*	8.5 (10.3) *317*	4.4 (7.9) *321*	3.8 (7.6) *327*	2.7 (7.1) *333*		
1:100	H_s (T_m) *Dir*	3.8 (8.5) *309*	6.0 (9.4) *313*	7.7 (10.0) *317*	4.2 (7.7) *321*	3.7 (7.5) *327*	2.6 (7.0) *333*		
1:50	H_s (T_m) *Dir*	3.6 (8.4) *308*	5.6 (9.2) *313*	7.3 (9.8) *317*	4.0 (7.5) *321*	3.5 (7.3) *330*	2.4 (6.8) *334*		
1:20	H_s (T_m) *Dir*	3.4 (8.1) *308*	5.3 (9.0) *313*	7.1 (9.7) *317*	3.8 (7.4) *321*	3.3 (7.1) *328*	2.2 (6.6) *334*		
1:10	H_s (T_m) *Dir*	3.2 (8.0) *308*	5.0 (8.8) *313*	6.4 (9.4) *317*	3.6 (7.2) *321*	3.1 (7.0) *328*	2.0 (6.3) *335*		
1:5	H_s (T_m) *Dir*	3.0 (7.8) *308*	4.8 (8.6) *313*	5.7 (9.0) *317*	3.4 (7.0) *321*	2.9 (6.8) *328*	1.9 (6.2) *335*		
1:2	H_s (T_m) *Dir*	2.7 (7.5) *308*	4.1 (8.1) *312*	4.6 (8.1) *317*	2.9 (6.6) *321*	2.5 (6.4) *329*	1.6 (5.7) *336*		

Table A2 – Nearshore Hydrodynamics for Gwithian (Part 2)

7A–2-3 Gwithian — **nearshore hydrodynamics sheet no 2 / 2**

wave climate frequency distributions

frequency of occurrence by wave height and wave period

wave height (m)	wave period (s) 1.0 - 2.0	2.0 - 3.0	3.0 - 4.0	4.0 - 5.0	5.0 - 6.0	6.0 - 7.0	7.0 - 8.0	8.0 - 9.0	9.0 - 10.0	10.0 - 11.0	11.0 - 12.0	12.0 - 13.0
5.50 – 6.00	0	0	0	0	0	0	0	0	0	0	0	0
5.00 – 5.50	0	0	0	0	0	0		0	0	0	0	0
4.50 – 5.00	0	0	0	0	0	2	2	0	0	0	0	0
4.00 – 4.50	0	0	0	0	0	21	2	0	0	0	0	0
3.50 – 4.00	0	0	0	0	0	76	2	0	0	0	0	0
3.00 – 3.50	0	0	0	0	60	132	1	0	0	0	0	0
2.50 – 3.00	0	0	0	0	304	82	0	0	0	0	0	0
2.00 – 2.50	0	0	0	108	490	35	1	0	0	0	0	0
1.50 – 2.00	0	0	22	713	394	38	1	0	0	0	0	0
1.00 – 1.50	0	5	767	1398	308	26	0	0	0	0	0	0
0.50 – 1.00	0	1366	2892	703	0	0	0	0	0	0	0	0
0.00 – 0.50	2249	1189	293	509	255	53	35	4	0	0	0	0

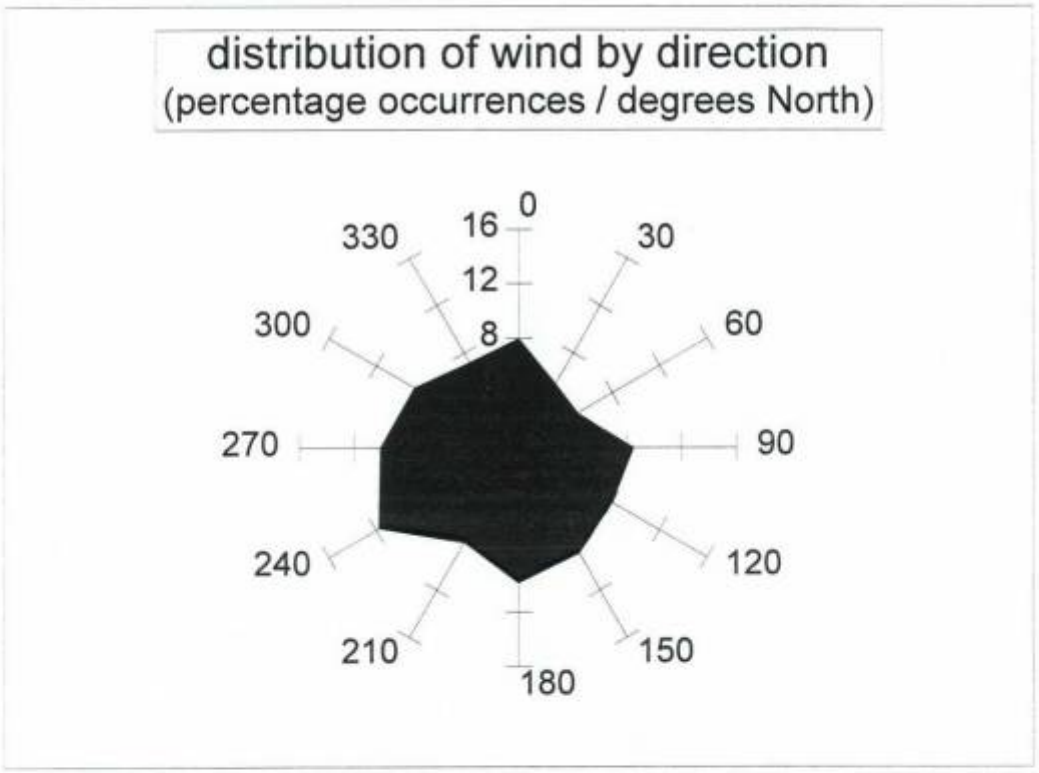
frequency of occurrence by wave height and wave direction

wave height (m)	wave direction (Deg) 345 - 015	015 - 045	045 - 075	075 - 105	105 - 135	135 - 165	165 - 195	195 - 225	225 - 255	255 - 285	285 - 315	315 - 345
5.50 – 6.00	0	0	0	0	0	0	0	0	0	0	0	0
5.00 – 5.50	0	0	0	0	0	0	0	0	0	0	2	0
4.50 – 5.00	0	0	0	0	0	0	0	0	0	0	3	1
4.00 – 4.50	0	0	0	0	0	0	0	0	0	0	21	2
3.50 – 4.00	0	0	0	0	0	0	0	0	0	0	73	5
3.00 – 3.50	0	0	0	0	0	0	0	0	0	0	180	13
2.50 – 3.00	0	0	0	0	0	0	0	0	0	0	359	27
2.00 – 2.50	0	0	0	0	0	0	0	0	0	0	562	72
1.50 – 2.00	0	0	0	0	0	0	0	0	0	0	979	189
1.00 – 1.50	0	0	0	0	0	0	0	0	0	0	2038	466
0.50 – 1.00	163	0	0	0	0	0	0	0	0	0	4354	444
0.00 – 0.50	362	0	30	208	146	160	145	227	206	27	2998	78

annual wave energy

	total energy (kJ/m/s)	onshore energy (kJ/m/s)	longshore energy (kJ/m/s)
total energy	9917	8039	3672
above mean sea level	11031	6880	4117
below mean sea level	8677	7981	3176

Table A3 – Wind Distribution at St Mawgans



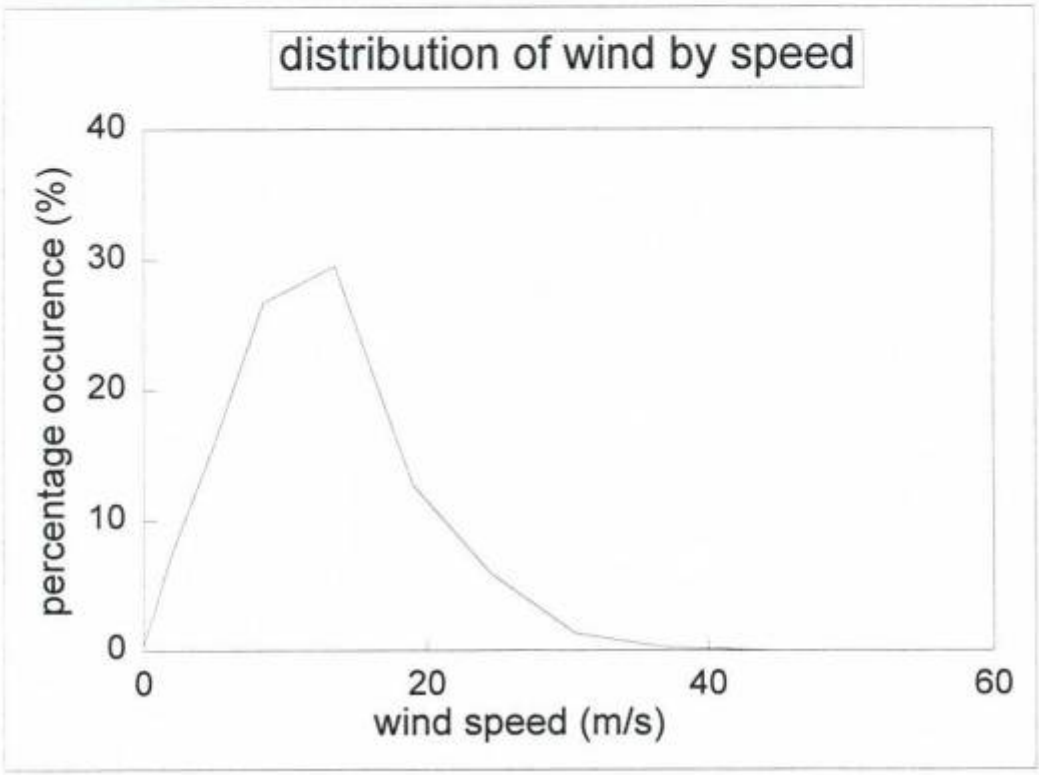
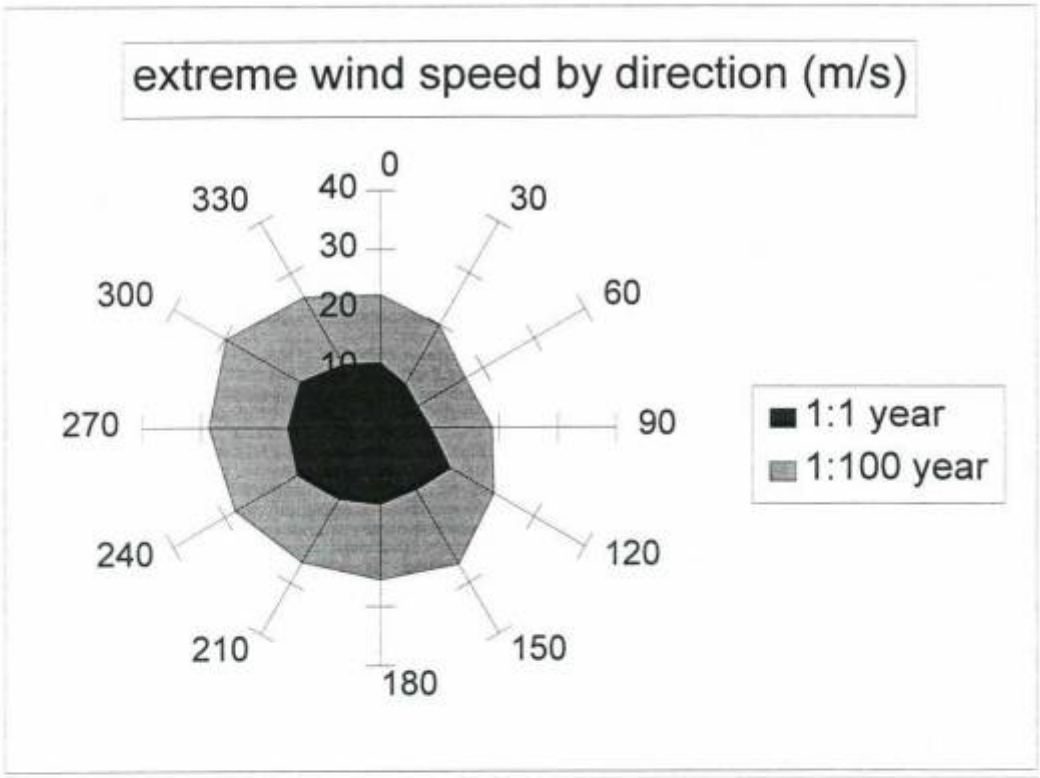


Figure 4.1 Wind distribution - St Mawgans

Table A4 – Extreme Wind Distribution at St Mawgans



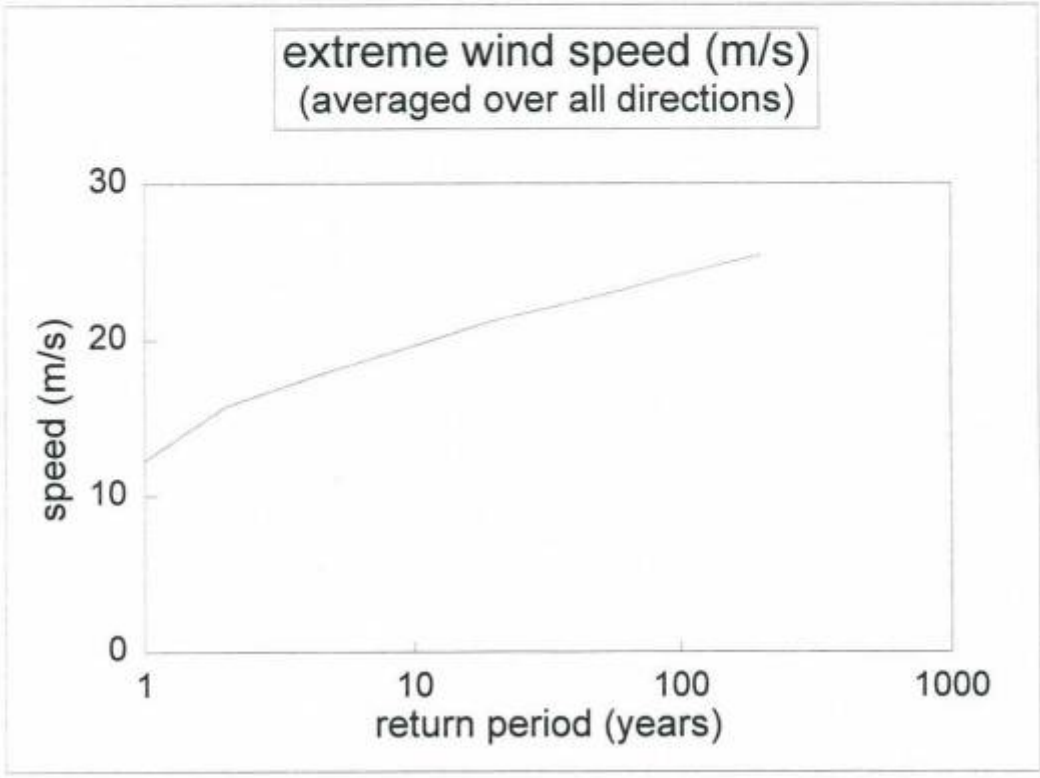


Figure 4.2 Extreme winds distribution - St Mawgans

Appendix B – Post Storm Inspection

Storm Conditions

The site was visited between October 2006 and December 2006 and again in January 2007. Wave and wind data for January 2007 indicated that the peak storm occurred from January 18th to January 19th and the data from this storm have been used to provide the storm conditions for this analysis. It is likely that other storms over this winter period have contributed to the storm response observed, however the January 18th to January 19th storm was the most recent and severe storm at the time of the post storm site inspection, and provides representative storm conditions.

An assessment of the January storm conditions was made based upon:

- Measured offshore wind and wave data - Sevenstones Lightship at 50.1°N 6.1°W (Met Office, 2007);
- Modelled wave data - at Met. Office point 50.1°N 6.1°W (Met Office, 2007);
- Measured Onshore wind data – St Mawgans 50.08°N 5.26°W (Met Office, 2007);
- Measured Inshore Wave Data – Perranporth Wave Buoy at 50.35°N 5.17°W (PCO, 2007);
- Measured Water Level Data – Newlyn 50.1030°N 5.5428°W (supplied by the British Oceanographic Data Centre as part of the function of the National Tidal & Sea Level Facility, hosted by the Proudman Oceanographic Laboratory and funded by the Environment Agency and the Natural Environment Research Council) (POL, 2007).

Figure B1 shows the location of the data points in relation to the 9 detailed study sites.

SANDS (Halcrow's Shoreline and Nearshore Data System) was used to carry out analysis of the storm conditions. The data sets all indicate that the largest storm occurred between 18th and 19th January when a low pressure system tracked east across the country. A summary of this storm from the SANDS analysis at the two wave buoy sites is provided in Table 1.

Table 1 SANDS Storm Analysis Results

Site	Start	End	Dur (hrs)	Peak Time	Peak Hs (m)	Peak Tp (s)	Peak Dir	Mean Energy	Total Energy	PrePeak	PostPeak
Seven Stones	18/01/2007 04:00	19/01/2007 07:00	27	18/01/2007 22:00	7.7	8.39	-	4.164814815	6747	5805	942
Perranporth	18/01/2007 03:30	19/01/2007 05:30	26	18/01/2007 12:00	5.5	11.1587	288	3.509615385	5475	2181	3294

Assessment of the inshore wave data at Perranporth indicates that a significant wave height (Hs) of 4m can be used as the threshold to select the storm period. The hydrodynamic data in the Dune Inventory (Halcrow, 2007) shows a frequency of occurrence of just 5 for waves of 4m with a direction of 285°N-315°N. This indicates that it can be considered as storm conditions. A plot of the

measured wave heights against time also indicated that this was an appropriate storm wave threshold. Using a wave height threshold of 4m the storm duration on 18th – 19th January was 26hrs, with a peak Hs of 5.5m, Tp of 11s. Modelled data from the Met Office indicates a wave direction of 288°N at this time.

A threshold wave height of 5.5m was applied for the Seven Stones measured wave data. A plot of this measured wave data against time indicated that this was the start of the peak in wave heights which formed the storm period. Based upon a threshold wave height of 5.5m for the offshore wave data at Seven Stones, the storm duration was 27hrs, with a peak significant wave height of 7.7m and period of 8s. The modelled data at this time gives a wave direction of 254°N.

The wind speeds at the Seven Stones, St Mawgan and Culdrose reached gale force strength. St Mawgans recorded a maximum wind speed of 41kn in a direction of 230°N. The Seven Stones site (offshore) recorded wind speeds of 47kn with a direction of 250°N.

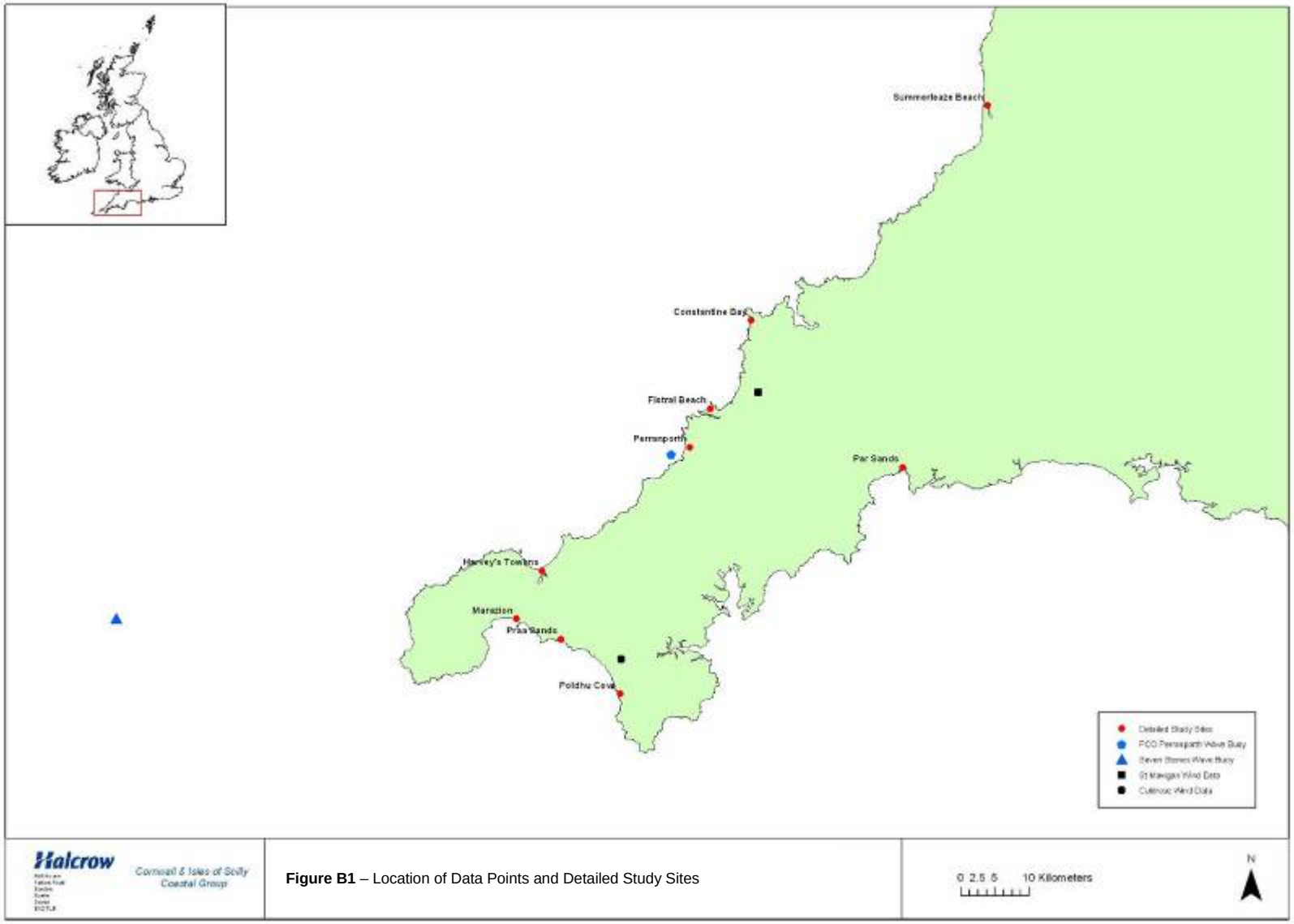


Figure B1 – Location of Data Points and Detailed Study Sites

Site Response

Harvey's Towans is a north-west facing site with a small spit extension located at the entrance to Hayle Estuary within St Ives Bay. In the January 2007 Storms the tide level and large westerly wave heights measured offshore indicate that waves could have reached the dune face, causing erosion.

At this site it was difficult to carry out any specific measurements due to the lack of fixed objects present on the beach-dune area impacted upon by the storm waves. An inspection of the site using a visual comparison with the October 2006 site visit and November 2006 baseline photographs indicates erosion of the dune face during the storm conditions, but accretion of sand at the back of the beach due to aeolian transport. The offshore wave conditions and recorded high westerly wind speeds support this.

During the October 2006 site visit there was a build up of small sized rocks at the base of the sand dunes where the beach tapers into the estuary (Plate 1). These were not present at the time of the post- storm survey (Plate 2). A comparison of the pre and post-storm photographs at a number of locations indicated that the sand levels had not dropped in front of the dunes (although this is subjective due to the lack of measurements available). At the location in Plates 1 and 2 it is likely that the storm waves removed the rocks from the toe of the dune front and began to erode the dune toe. There was evidence of some erosion and slumping of the dune front as a result of this, and hence the release of sediment into the beach system. This is a typical storm response with the dunes acting as a sediment store which can be released into the beach in winter and be returned to the dunes for storage in summer when the summer beach profile forms. Further survey data will be required to confirm whether or not the sediment will be returned to the dune during summer periods.

During the site visit in January 2007 it was noted that the sand levels in front of much of the dune system appeared to have increased. This sand appeared to have built up through wind action carrying the sand to the back of the beach. With wind speeds of up to 41kn recorded at Culdrose, aeolian transport at low water would have contributed to the build up of sand in front of the dunes. The release of sediment into the beach from the dune front that has not yet been reworked by wave action could also be a contributing to this sand build up.

It was noted that the embryo dune present on the spit feature (Plate 3) had maintained much of the vegetation which had established in October 2006. The embryo dunes appeared slightly smaller in size as a result of the storm; however, a topographic survey would be needed to confirm this. The location of these embryo dunes a greater distance from the estuary mouth could result in the dunes being protected from wave action. Much of the wave energy would be dissipated by the flat sand at the estuary entrance before it reached the spit feature.

Plate 1: Small rocks had built up at the base of the sand dunes in October

Plate 2: In January the rocks had been removed and the dune face eroded by wave action

Plate 3: Embryo dunes on the spit feature survived the storm conditions

References

CEFAS (2007) Data from Centre for Environment Fisheries and Aquaculture Science website http://www.cefas.co.uk/data/wavenet.aspx. Wavenet provides real time wave data for U.K. Used to locate appropriate measured wave data.

Halcrow (2002) Futurecoast CD. Produced by Halcrow Group Ltd, Swindon, UK, as part of the Futurecoast study for DEFRA 2002.

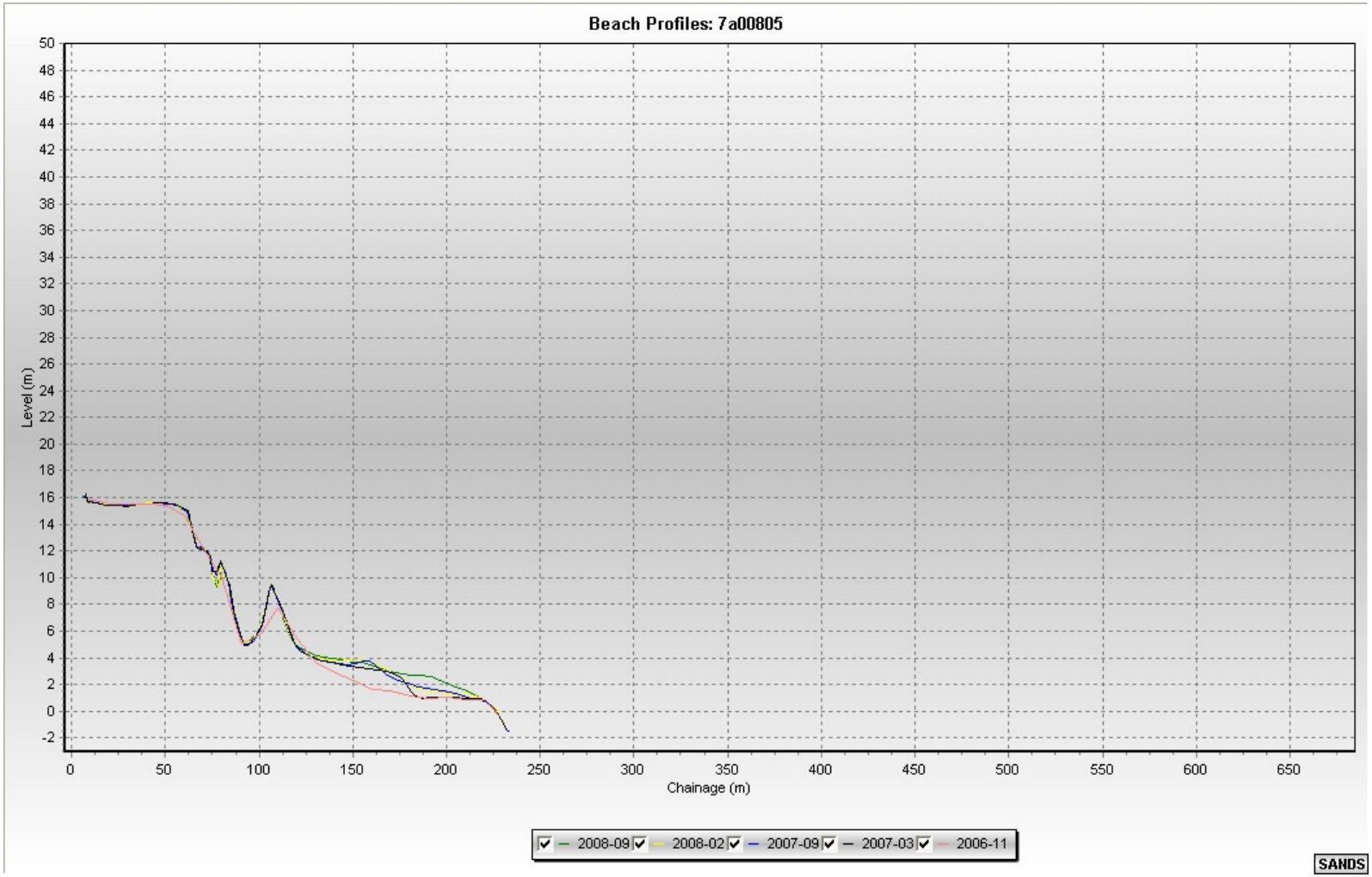
Halcrow (2009) Dune Inventory produced as part of Cornwall Sand Dune and Beach Management Strategy, PDF file/ word file for each of the 25 dune sites

Met Office (2007) Data from Met Office website http://www.metoffice.gov.uk/: For purchase of Seven Stones wave data, Modelled Wave Data and Culdrose and St Mawgan Wind Data.

PCO (2007) Data from Plymouth Coastal Observatory via Channel Coastal Observatory website www.channelcoast.org Real time wave data updated every 30 minutes. Wave data downloaded February 2007.

POL (2007) Data from Proudman Oceanographic Laboratory website: http://www.pol.ac.uk/ntslf/ Quality checked data loaded to archive with 3 month delay. Water level data downloaded April 2007 from archive.

Appendix C - South West Regional Coastal Monitoring Programme Beach Profiles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Level (m)
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16
14
12
10
8
6
4
2
0
-2
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50
100
150
200
250
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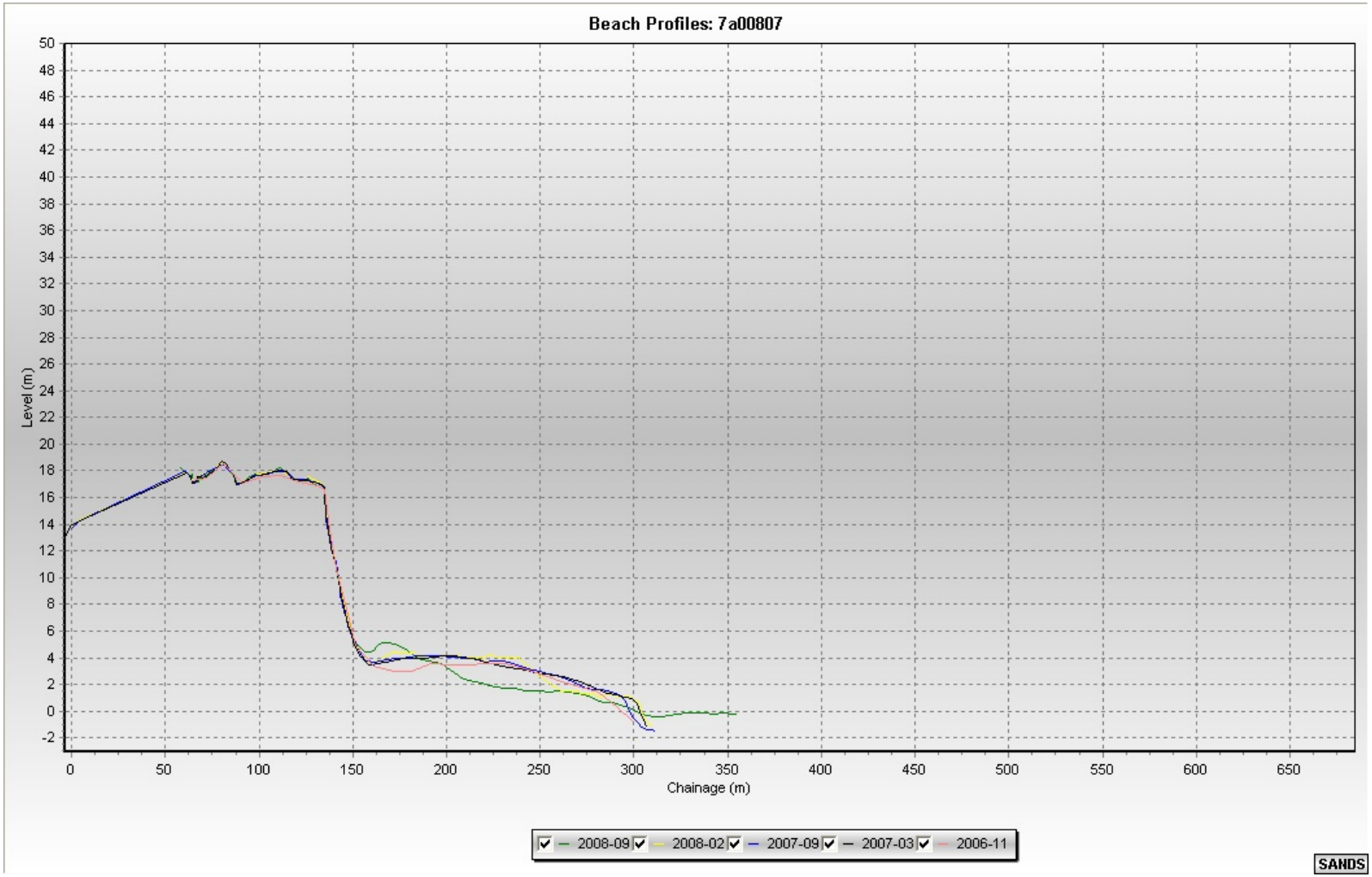
2008-02
2007-09
2007-03
2006-11
SANDS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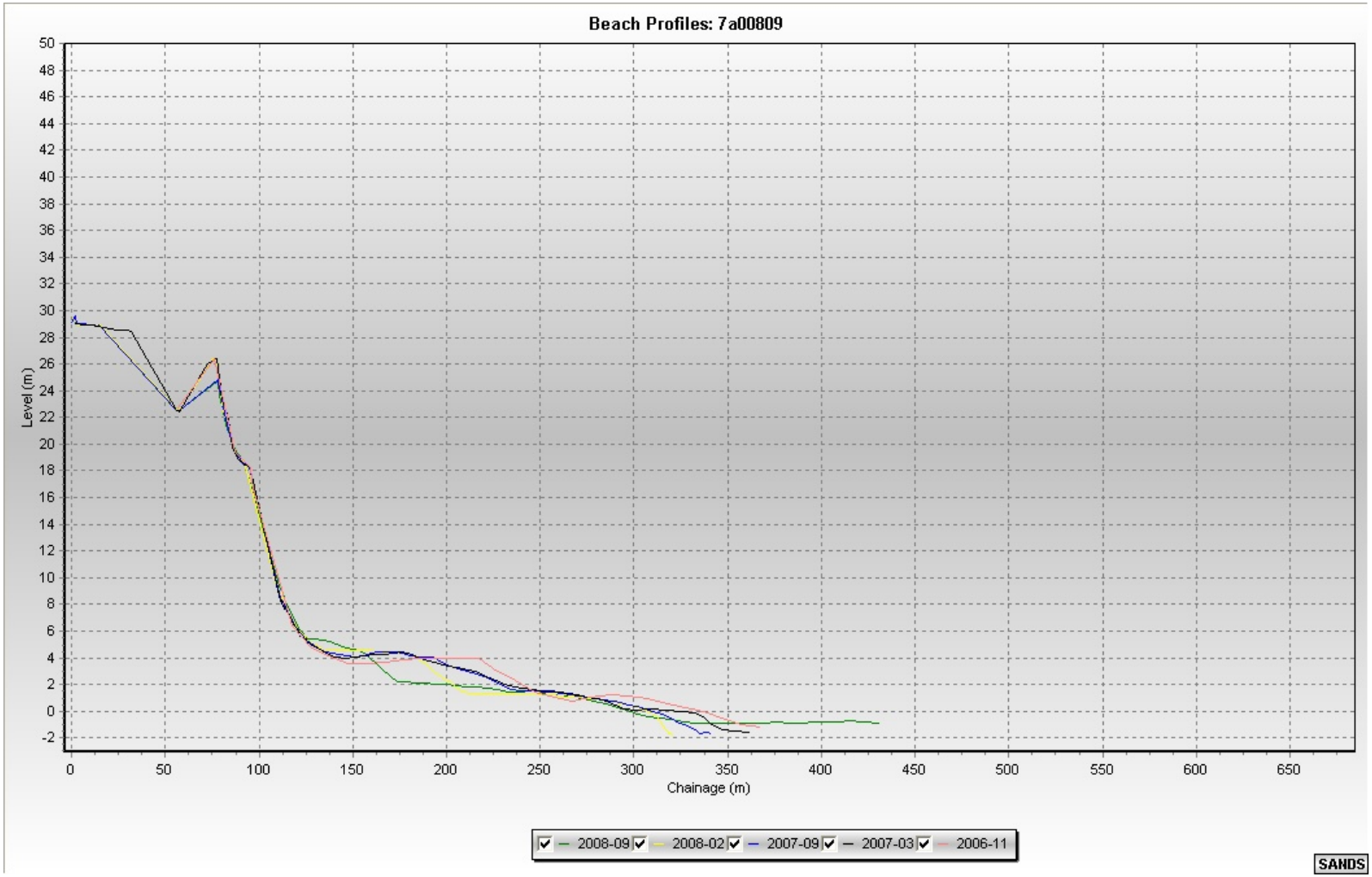
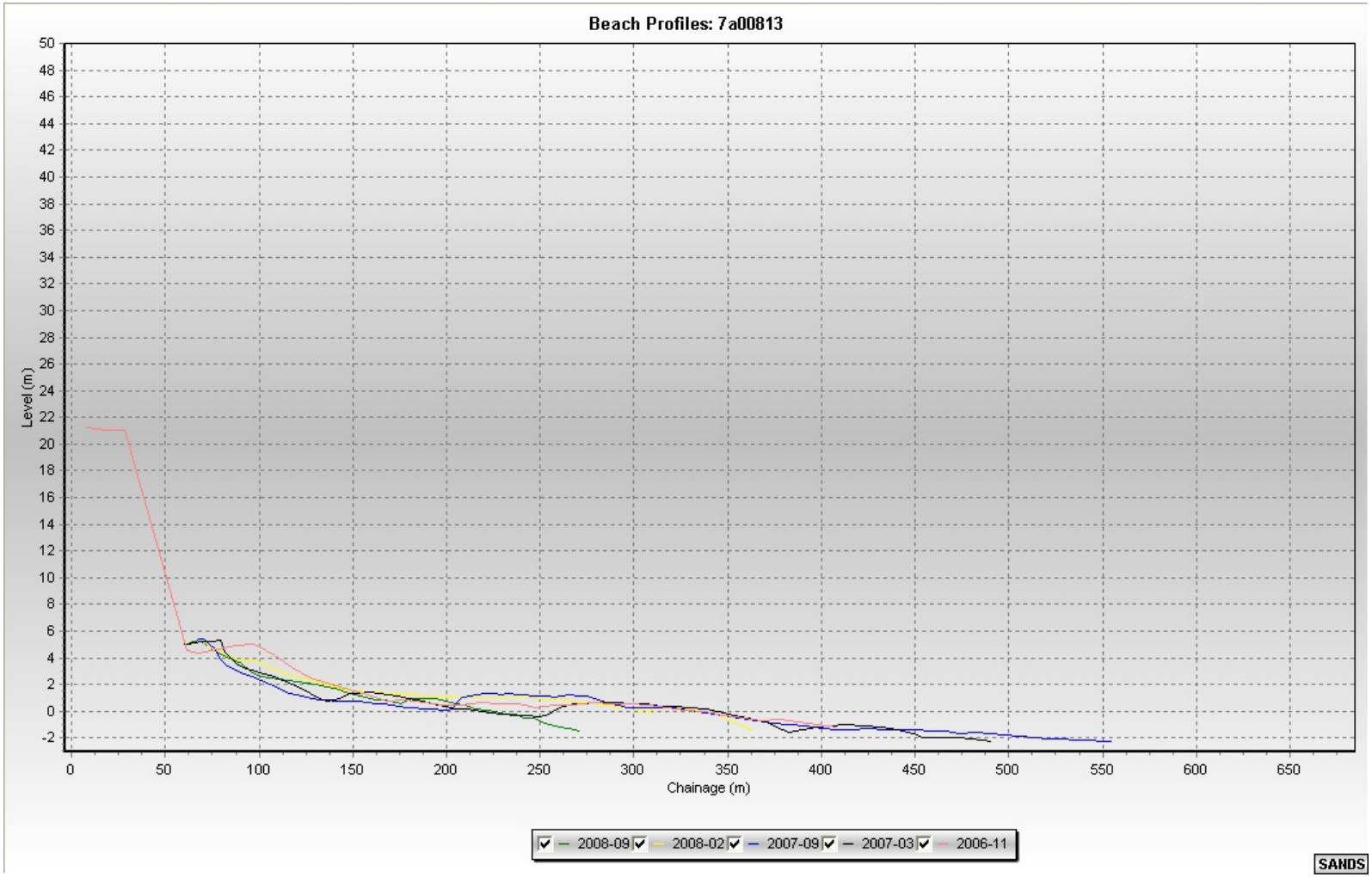
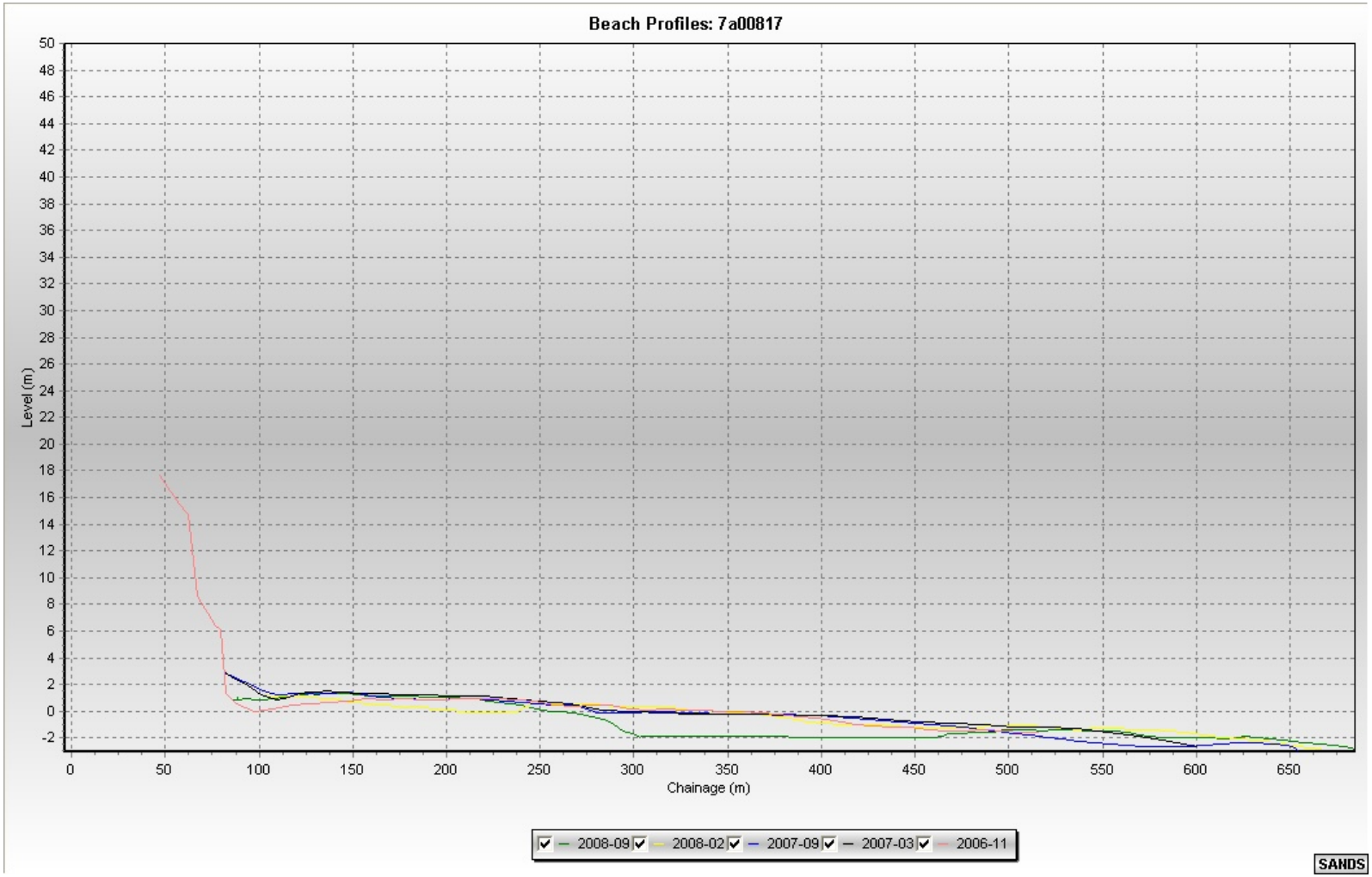
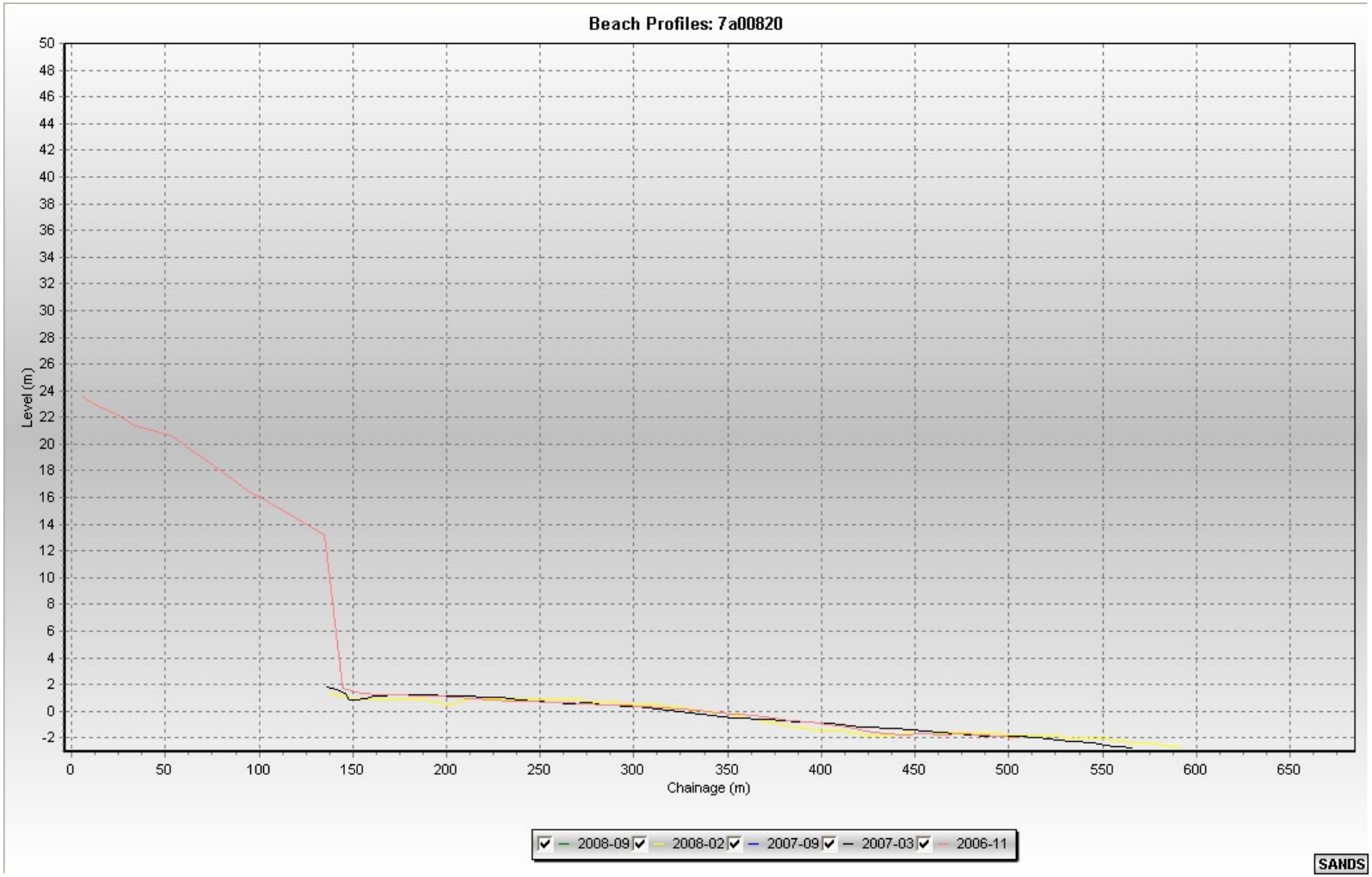
Chainage (m)
2008-09
2008-02
2007-09
2007-03
2006-11
SANDS


Beach Profiles: 7a00809
Level (m)
Chainage (m)
2008-09
2008-02
2007-09
2007-03
2006-11
SANDS


Beach Profiles: 7a00813
Level (m)
Chainage (m)
2008-09
2008-02
2007-09
2007-03
2006-11
SANDS


Beach Profiles: 7a00817
Level (m)
Chainage (m)
2008-09
2008-02
2007-09
2007-03
2006-11
SANDS


Beach Profiles: 7a00820
Level (m)
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
0
50
100
150
200
250
300
350
400
450
500
550
600
650
Chainage (m)
2008-09
2008-02
2007-09
2007-03
2006-11
SANDS