

LUDGVAN PARISH COUNCIL

This is to notify you that an Extraordinary Meeting of Ludgvan Parish Council will be held on Wednesday 18th October, 2017 in the Oasis Childcare Centre, Lower Quarter, Ludgvan commencing immediately following the Roads Committee meeting.

S. P. Hudson

S P Hudson
Parish Clerk
13/10/2017

AGENDA:

	Page No.
Public Participation Period (if required)	
1. <u>Apologies for absence</u>	
2. <u>Declarations of interest in Items on the Agenda</u>	
3. <u>Dispensations</u>	
4. <u>Cornwall Council – Planning Applications - For decision</u>	
(a) PA16/09690 - Tregarthen Barn - Proposed extension, alterations including a balcony and juliet balconies and associated works (Previously approved PA15/04591)	2
5. <u>Marazion Dune Management - Final Report</u>	3-80

**LUDGVAN PARISH COUNCIL - EXTRAORDINARY MEETING 18TH OCTOBER
2017
PA16/09690 - Tregarthen Barn**

1. *Background:*

1.1 Members will recall the above planning application which it has previously considered in March 2017.

1.2 Minute LPC 588(c) raised an objection on the following grounds:

i. the proposal is overbearing in its size;

ii. overlooks the neighbouring property;

iii. the materials used are out of keeping.

1.3 Cornwall Councillor, Simon Elliott requested that the application be determined by Committee which it was on 25th September 2017 but was deferred for further clarification until 23rd October 2017.

2. *Update:*

2.1 Following the Cornwall Council Planning Committee meeting the Clerk was contacted by the applicant asking whether it was acceptable to provide information to the Parish Council prior to the application being further considered by Cornwall Council Members.

2.2 The information received has been distributed under separate cover.

3. *Conclusion*

Members are asked to consider the information provided and decide whether they wish to amend their views in any way.

REPORT (DRAFT)

Cornwall Beach & Dune Management Plans – Marazion

Prepared for

Cornwall Council

October 2017



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Appendix A Sand Dune Management Techniques & Preliminary Decision Support Tool v2.0

Appendix B An Overview of Coastal Sand Dunes

Appendix C Baseline Report

Appendix D Options Appraisal

Appendix E Site Actions Summary Map

Appendix F Summary Leaflet

Document history

This document has been issued and amended as follows:

Version	Date	Description	Created by	Verified by	Approved by
0.1	02-10-2017	Draft for comment	AF, SH, EH	AF	

Executive Summary

This Beach & Dune Management Plan (BDMP) for Marazion has been produced as part of the Cornwall Beach & Sand Dune Management Project commissioned by Cornwall Council in 2015. The BDMP has two purposes:

1. Identify the best management approach; in terms of monitoring and intervention (when trigger levels are reached) requirements for the beach and dune system at Marazion; based upon the best practice framework developed as part of the Cornwall Sand Dune and Beach Management Strategy produced by Halcrow in 2009, and updated as part of developing the new BDMPs by CH2M in 2015 (see Appendix A).
2. Provide a long-term (50 year) approach to beach and dune management at Marazion that is based upon an up-to-date understanding of the beach-dune system and coastal processes at the site, as well as predictions of future coastal evolution. For background information, Appendix B provides an overview of how beach-dune systems work.

This BDMP report provides:

- An introduction to the project and BDMP (Section 1);
- A summary of the characteristics (Section 2) and coastal process drivers at Marazion (Section 3); and
- Discussion and definition of suitable management techniques to apply at Marazion, including a plan of action and the recommended monitoring and response programme (Section 4).

The key issues to be addressed by beach and dune management activities include:

- Erosion of the dunes due to natural processes, including limited sediment in the system, increasing erosion risk to paths and backshore assets including highway.
- Uncontrolled public access within the dunes resulting in dune further erosion and littering.
- Outflanking of hard defence adjacent western end of sand dunes due to erosion.
- Wind-blown sand on highway.
- Constraints posed on dune system by backshore assets including highway and SPA prevent natural rollback.
- Potentially unfavourable BAP habitats and control of non-native invasive species within dune vegetation.
- Consideration of environmental impacts on designated features.
- Lack of information / data relating to beach and dune levels to inform management.
- Limited funding to undertake management activities.

Key recommendations in this BDMP focus on managing the erosion pressures and access issues by a combination of dune stabilisation and access management measures.

Introduction

1.1 Project Background

Many of the sand dunes and beaches around Cornwall's coast are currently experiencing erosion and sediment loss. This is a pressing concern as these sand dunes and their associated sandy beaches are one of the most important resources in Cornwall due to:

1. Their role in providing protection against the risk of coastal flooding due to the dynamic nature of beach-dune interactions and their sheer size preventing the sea from impacting upon the hinterland behind the dune systems.
2. Their role in providing important biologically diverse habitats that cannot be easily recreated elsewhere if it were to be lost to coastal erosion or inappropriate development.
3. Their role in providing access to the sea for residents and visitors alike, which is vital to the holiday industry upon which a significant proportion of Cornwall's economy depends.

It is vital therefore that the sand dunes and beaches around Cornwall's coast, that represent some 15% of the total sand dune habitat in Britain, are managed in a holistic, sustainable way over the long-term that balances the needs of each of the three distinct functions of sand dunes and beaches that combined make up the beach-dune system.

To ensure that these vital resources are managed in such a way, in 2009 the Cornwall Sand Dune and Beach Management Strategy was developed by Halcrow (now CH2M) for the Cornwall & Isles of Scilly Coastal Group. The main focus of the strategy is the management of flood and coastal erosion, although the habitat and tourism value of the dunes will also be considered. This project delivered an Inventory of Beaches and Dunes; a Best Practice Management Guide and two pilot Beach and Dune Management Plans (BDMPs) for Fistral Beach and Harvey's Towans (Hayle).

To build on this previous work, Cornwall Council commissioned CH2M to work with them and local communities to (a) produce seven new BDMPs for locations at Constantine Bay, Porthcothan, Porthtowan, Par Sands, Praa Sands, Summerleaze and Widemouth Bay; and (b) review and update the two pilot BDMPs for Harvey's Towans and Fistral Beach produced in 2009. Figure 1.1 shows each of these locations.

This document is the BDMP for Marazion and sets out sustainable management practices for the sand dunes and beach in this area. It should be reviewed every 5-10 years unless significant, rapid changes occur that warrant an earlier review.

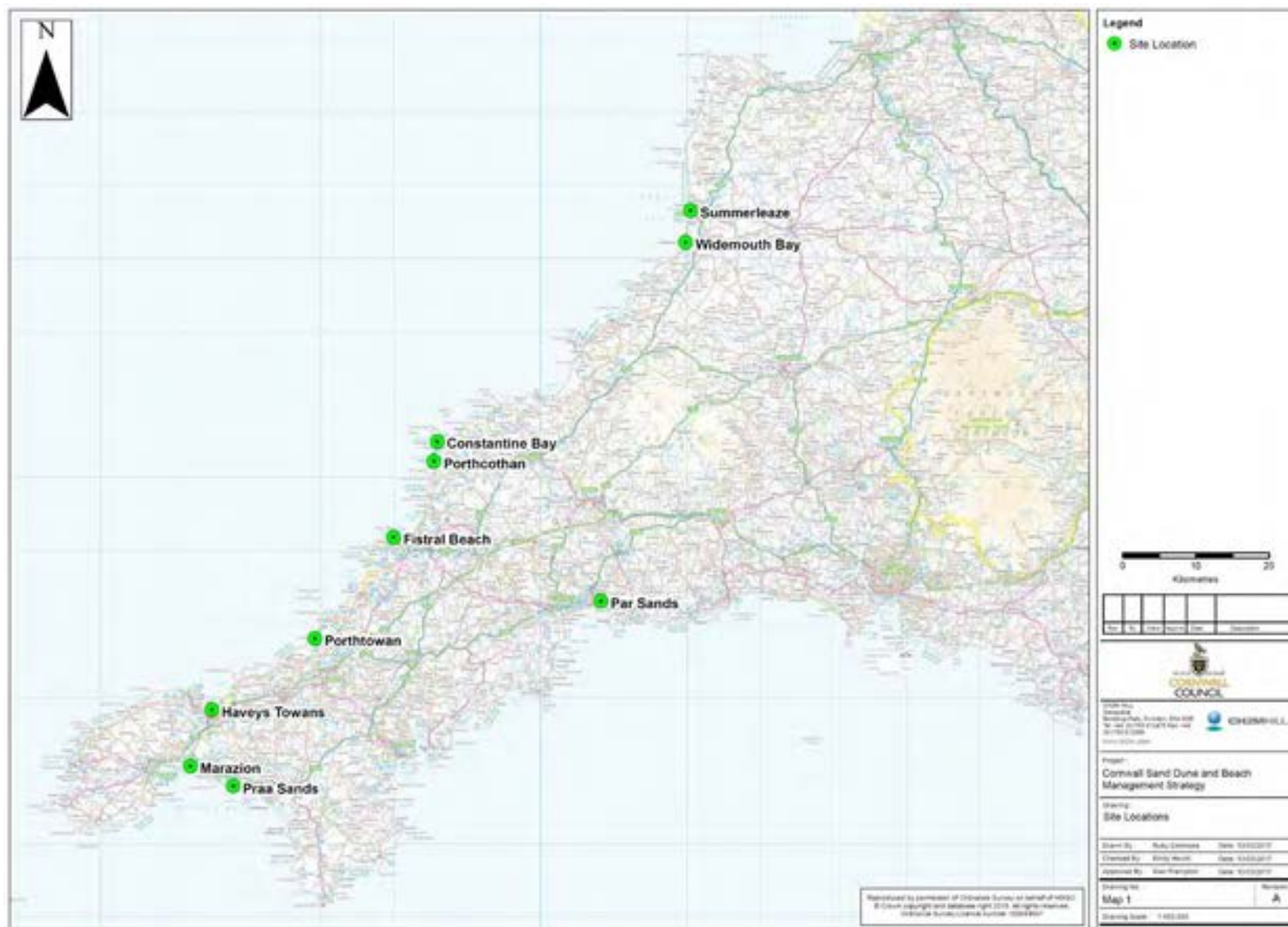


Figure 1.1 BDMP locations around Cornwall

1.2 Project Aims

Beaches and Sand Dunes have many uses and functions. These include amenity, recreation, commercial and community uses, and coast defence, habitat and earth science functions; all of which have social, environmental and economic value. In this case, the main focus of the BDMP is the management of the dunes and beach to ensure they fulfil their flood and coastal defence function to help protect communities around the coast of Cornwall from coastal flooding and erosion by the sea; whilst also considering the needs for management of habitat and amenity use in the area.

BDMPs are a non-statutory method of providing a coastal defence plan for managing a beach and dune system at a local level that takes into account and, where possible, promotes or enhances the other uses and functions of a beach. BDMPs provide a framework for more cohesive management of a beach and dune system that may be regulated and used by different parties, all with their own agendas. They establish a means to control the physical form of beaches and sand dunes and the general beach and dune environment, and to promote good practice within the environment.

BDMP production is often led by Local Authorities with support from the Environment Agency and is usually done in collaboration with relevant stakeholders, as will be the case here. Assistance is available to the authorities to undertake appropriate management and to maintain the coastal defence function provided by the beach and dune system and any associated hard defence structures, as well as other requirements both now and in the future.

Given this, **the aim of this BDMP is to provide a new long-term strategic BDMP for Marazion.** This will be achieved by delivering the following objectives:

1. Identify the best management approach; in terms of monitoring and intervention (when trigger levels are reached) requirements for the beach and dune system at Marazion; based upon the best practice framework developed as part of the Cornwall Sand Dune and Beach Management Strategy produced by Halcrow in 2009, and updated as part of developing the new BDMPs by CH2M in 2015 (see Appendix A).
2. Provide a long-term (50 year) approach to beach and dune management at Marazion that is based upon an up-to-date understanding of the beach-dune system and coastal processes at the site, as well as predictions of future coastal evolution. For background information, Appendix B provides an overview of how beach-dune systems work.

1.3 Dune Management Plan

To achieve the aim and objectives defined in Section 1.2, the BDMP for Marazion is structured as follows:

- Section 1 – Introduction (this section).
- Section 2 – Site Description.
- Section 3 – Factors Affecting the Beach Dune System.
- Section 4 – Beach & Dune Management Plan.

1.4 Key Contacts

The BDMP and its implementation is led by Cornwall Council. The key contact for this work is:

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Telephone: 01209 614383

Email: martin.clemo@cornwall.gov.uk

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Site Description

2.1 Location

Marazion is located on the south-west coast of Cornwall. The site is situated within the wider embayment of Mount's Bay which includes Penzance and Newlyn to the west and the Lizard Peninsula and Porthleven to the east (refer to Figure 2.1).

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Figure 2.1 Map showing the Marazion BDMP location and extent (red outline).

2.2 Setting

Marazion is located on the south coast of Cornwall and is a popular area with tourists for a wide range of activities. The site is exposed to south-west Atlantic swell waves; however, it is afforded some protection from direct wave action by St Michael's Mount and partially submerged rock platforms. The coastline is unique in that there is a small section of semi-natural dunes constrained by formal hard defences at either end; it is also constrained by a road and freshwater Special Protection Area (SPA) site behind so the dunes are not able to naturally regrade and retreat back as they might do otherwise during storm periods (or in the longer term with sea level rise). Situated within the wider Mounts Bay there is minimal longshore transport at Marazion, instead the majority of material is transported cross-shore, with wind-blown sand supporting the dunes. In addition to natural processes, dune erosion at Marazion is also caused by human impacts (e.g. trampling). Limited dune management has taken place in the past to address these issues (mostly human impacts). St Aubyn Estates own beach and dunes down to MHW. Duchy of Cornwall own land below MHW.

2.3 Key Characteristics

2.3.1 Present Site

With reference to Figure 2.2, the principal characteristics of the present beach and dune system within the wider Mounts Bay context are as follows:

- At the western end of Mounts Bay is the Penzance frontage including Ponsandane and Chayandour (where the train line from London to Penzance runs along the coastline) and Eastern Green.
- In the eastern central part of the Mounts Bay is 'The Long Rock' – a more resistant rocky felsite outcrop which acts as a submerged breakwater (between 0 to -1mODN) helping to dissipate wave energy and intercept sediment transport. At The Long Rock coastal defences have been in place for many years to help protect the road and railway (and Marazion Marsh SPA freshwater site) behind from coastal erosion and flooding. The defences consist of concrete banks and rock armour. The beach is sandy, although there are some cobbles and boulders. An outfall discharges to the east of The Long Rock.
- From the end of the seawall at Marazion eastward to the town of Marazion there are no formal hard defences, only a semi-natural dune system backed by a road (West End Road) and the Marazion Marsh freshwater SPA. Marazion Marsh and the fronting dune system is described as providing a 'buffer' between The Long Rock and Marazion town itself (Royal Haskoning, 2011). The defences between the dunes and the road and between the town and the dunes to the east are starting to be outflanked.
- The eastern section of the dunes is intercepted by the Red River which drains across the beach.
- To the east of the Red River the dune is much lower and transitions into a heavily engineered frontage with reflective vertical seawall, sloped revetment and rock armour. These defences protect the town of Marazion including car parks along the frontage but also shops, restaurants, hotels and residential properties behind. Marazion itself is built on harder rock similar to St Michael's Mount.
- Marazion provides the access point to St Michael's Mount which is an important physical control on the coastline to the east of Marazion. St Michael's Mount consists of slate beds on the northern flank and a granite extrusion on the southern flank. Marazion has various rock types underlying it. The Mount itself acts to trap sediment on its western side (particularly influenced by the causeway) and provides some shelter from the wave climate to the Marazion frontage from storm events from the south west but also more locally generated waves from the south east. Shallow rocky platforms to the north west of St Michael's Mount (e.g. Great Hogus has a

maximum level of 1mODN) also locally influence wave transmission to the foreshore. The Great (and Little) Hogus are fundamental in maintaining beach width along the West End Road frontage.

- Marazion East is an area of undefended exposed steep cliff which is eroding and is an important source of new sediment to the Mount's Bay.
- Venton Cove (which lies east of St Michael's Mount) is also part of the wider Marazion frontage in terms of coastal processes but also the area of the town which lies behind it.

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Figure 2.2 Map showing location of Marazion relative to wider Mounts Bay features.

2.4 Natural and Historic Environment

The Study Area contains (or is within close proximity to) the following nature conservation designations. These are central in the consideration of options for the beach and dune management plan:

Within the Marazion BDMP study area:

- Mounts Bay Marine Conservation Zone
- The Cornwall Area of Outstanding Natural Beauty
- Marazion Bridge listed structure
- Marazion Marsh County Wildlife Site.

Within close proximity (2km) of the Marazion BDMP study area:

- Marazion Marsh SPA/SSSI/RSPB reserve
- Cornwall and West Devon Mining Landscape (UNESCO) World Heritage Site
- Designated Archaeology and Cultural Heritage (scheduled monuments, listed structures and buildings)
- St Michael's Mount geological SSSI.

These features are shown on Figure 2.3 and discussed in further detail below.



Figure 2.3 Environmental designation features in the vicinity of the Marazion BDMP area.

2.4.1 Ecology

2.4.1.1 Designated Nature Conservation Sites

There are nature conservation designations that are within or lie in close proximity to the Study Area and require consideration when planning and implementing beach and dune management measures (Figure 2.2).

Internationally and Nationally Designated Sites

- **Mounts Bay Marine Conservation Zone**

The BDMP study area is within the Mounts Bay Marine Conservation Zone (MCZ) and protected habitat and features are present within close proximity (see Figure 2.4a and 2.4b).

The Mounts Bay MCZ covers the BDMP study area seaward from mean high water, which includes the Red River channel up to the entrance of the Marazion Bridge. The area forms part of the wider MCZ that spans an area of almost 12km² within Mounts Bay.

The MCZ has been designated to protect and conserve the following broad-scale habitat features and associated features of conservation importance. The distribution of which are presented within Figure 2.3a and 2.3b:

- *MCZ protected broad-scale habitat:*

Moderate energy intertidal rock, High energy intertidal rock, Intertidal coarse sediment, Intertidal sand and muddy sand, Moderate energy infralittoral rock High energy infralittoral rock, Subtidal sand.

- *MCZ features of Conservation Importance:*

Seagrass beds, Giant goby (*Gobius cobitis*), Stalked jellyfish (*Halicystus spp*), Stalked jellyfish (*Lucernariopsis campanulata*), Stalked jellyfish (*Lucernariopsis cruxmelitensis*).

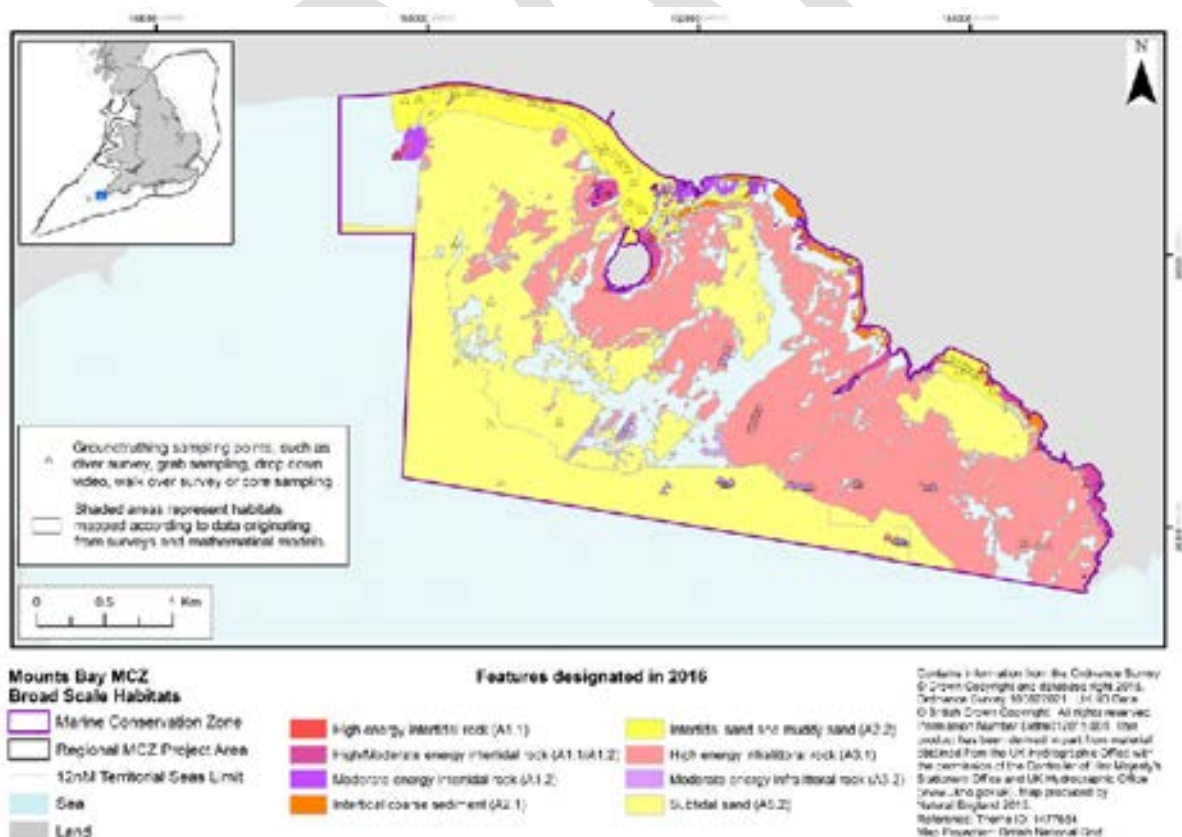


Figure 2.4a Marazion BDMP: Mounts Bay MCZ showing distribution of MCZ protected broadscale habitat (Natural England, 2016a).

an influence on the proposed scheme, have been described. The associated targets are quoted under them:

Priority habitat within the BDMP study area (Spalding Associates Ltd, 2005):

- Coastal Sand Dunes
 - Open dune (Quality assessment Unfavourable (marginal) due to damage).
 - Retain existing dune extent and increase where possible.
 - Control trampling erosion of foredune and yellow dune.
 - Control ruderal species.
- Dune grassland
 - Unfavourable, damage and lack of zonation.
 - Retain existing dune extent.
 - Re-instate dune habitat near Marazion wherever possible.
 - Reduce fragmentation wherever possible.
 - Maintain areas of bare sand on grey dune habitat.
 - Eliminate invasive non-natives.
- Vegetated shingle
 - Favourable.
 - Retain and restore open shingle habitat wherever possible.
- Littoral and infralittoral rock
 - Probably favourable (but non-natives present and no baseline on which to make assessment). Further information regarding this habitat type has been documented by the recent 2016 Mounts Bay MCZ designation.
 - Retain extent and quality, particularly rockpools Monitor non-natives.

Priority within close proximity to the BDMP study area (magic.gov.uk):

- Saline Lagoons (present within Marazion Marsh SPA/SSSI designated area behind the main public carpark for the beach).
- Lowland Fens (present immediately adjacent north of the BDMP study area with the SPA/SSSI).
- Reedbeds (Surround the Red River channel, part of the SPA/SSSI).
- Deciduous Woodland (north and north west of the BDMP study area within Marazion Marsh SPA/SSSI).
- Maritime Cliffs and Slopes (Marazion East and St Michael's Mount).

2.4.1.3 Invasive non-native plant species

Japanese Rose (*Rosa rugosa*) and Montbretia (*Crocsmia x crocosmiiflora Montbretia*) are invasive non-native plant species listed under Schedule 9 of the Wildlife and Countryside Act (1981) as amended. The Wildlife and Countryside Act (1981) as amended lists invasive non-native species that are likely to have a significant impact on habitats, native species or have economic or social impacts within Schedule 9. These species have been identified within the dune habitat of the Marazion Marsh County Wildlife Site within the BDMP study area (Thomson Ecology, 2016. See Figure 2.5 below).



Figure 2.5 Distribution of non-native plant species at Marazion (Thomson Ecology, 2016)

The extent of Japanese rose consists of three small patches with a total area around 300 m² located close to the car park. The extent of montbretia shown is indicative only (Thomson Ecology, 2016). The encroachment of Schedule 9 invasive non-native species Japanese Rose and Montbretia is concerning for the following reasons:

- They could cause crowding out of native species;
- They could cause modification of habitat structure and type through changes to the species structure and compositions; and
- They could cause physical modification of habitats through changes in sedimentation, erosion, pH and nutrient dynamics.

Though there is no legal obligation to control these species it may be considered best to undertake some form of control in order to minimise some of the potential impacts on either the physical environment, priority dune habitat or designated sites. There is a legal obligation to prevent spreading. Measures to achieve this are described in Section 4.2.4.

Native species out of keeping with the dune habitat, i.e. brambles and ivy, may also be considered to cause similar concerns e.g. crowd out natural dune species.

2.4.2 Designated Geological Conservation Sites

2.4.2.1 Geological SSSI

St Michael's Mount SSSI, fringes the south west coastal section of on St Michael's Mount (see Figure 2.2 above). The SSSI is designated for its geological cliff and foreshore exposures which is described by the following citation:

'The megacrystic granite of St. Michael's Mount is a fractured granite cusp of the Cornubian batholith. The granite contains disseminated tin mineralisation and has been invaded by a swarm of

sub-parallel, greisen-bordered, mineral veins which are excellently exposed over a wide area on the wave-cut platform.

The extent of the exposure permits the opportunity to study variation in the mineralogy and chemistry of the veins both laterally and along the strike, as well as the nature of the alteration produced by the greisenization. The interest compliments that observed at Cligga Head but can be observed in plan on St. Michael's Mount rather than in vertical exposure.' (Cornwall Rigs Group, 2007)

2.4.2.2 County Geology Site (CGS)

During the storms in January and February 2014, a well-documented fossil forest was uncovered between The Long Rock and Wherry Town at Marazion. Reported by a coastal heritage risk document to Historic England, Professor Robin McInnes (2016) noted that the forest, and natural heritage feature, was thought to be well persevered but at risk due to increased scour and beach lowering to potential exposure and loss. It is unknown if this site has been declared a CGS since the Criteria for Cornwall and the Isles of Scilly' (ERCCIS and Cornwall Wildlife Trust, 2010) which list all of the CGS sites has not recently been updated.

Venton cove is a County Geology Site (CGS) located west of the BDMP study area is considered to be of regional scientific importance for its geology and educational value. Its main features are described as 'Pneumatolytic Breccia Intrusion, intersected by an elvan dyke and a cross-cutting epithermal quartz vein, intruded into Killas. Raised beach and 'head' deposits in the cliff' (Cornwall RIGS Group, 2007).

2.4.3 Landscape Setting

The importance of high quality landscape, seascape, and visual amenity to the Marazion area is recognised by the following important designations (see Figure 2.3 above) and require consideration when undertaking beach and dune management measures:

Within the BDMP study area:

- **The Cornwall Area of Outstanding Natural Beauty (Area 08 South Coast Western)** is characterised by granite outcrops, steep rugged cliffs, a freshwater habitat held back from the sea by a shingle bar and sandy beaches (Cornwall AONB, 2017).

Located within close proximity:

- The internationally designated **Cornwall and West Devon Mining Landscape (UNESCO World Heritage Site)** is located on the north-western side of Marazion town at its closest point.

2.4.4 Archaeology and Cultural Heritage

The importance of historic and cultural heritage to the Marazion and surrounding area is recognised by the following national designations, which will need to be considered when undertaking taking beach and dune management activities at Marazion (see Figure 2.3 above).

2.4.4.1 Designated Archaeology and Cultural Heritage

There are a number of listed structures and listed buildings are present in close proximity of the BDMP study area (see Figure 2.3 above), including:

- **The Marazion Bridge** that carries the coastal road over the Red River channel is a grade II **listed structure** and located on the landward edge of the BDMP study area.
- **The Old Marazion Bridge** and accompanying boundary stone, carries Green Lane West over the Red River channel from the coastal road, north of the study area, are also grade II **listed structures**.
- There are **scheduled Monuments (Four crosses on St Michael's Mount)** and other **listed buildings and structures** present within Marazion Town and on St Michael's Mount.

2.4.4.2 Non-designated archaeology

The remains of two non-listed WWII concrete infantry box are present on the beach. The two boxes were originally present on the dunes, but the dunes have now been lost and the boxes degraded. As such, after some storms, metal work from the boxes (and other WW2 defences) become exposed and have now created a health and safety issue and require removal.

2.5 Land Use

The land immediately behind the dunes is occupied by a key local access road that connects Marazion and Penzance, car parking (that forms part of the overall traffic management system for the town of Marazion) and development of various kinds including residential and commercial properties, and amenities. Landwards of the road is a freshwater SPA.

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 and habitat function of the dunes. The specific values of the dunes at Marazion include:

- Coastal erosion buffer for the road (and freshwater SPA) behind the sand dunes.
- Local recreational value.
- To form an aesthetically attractive backdrop to the beach, providing sheltered areas and viewing points for beach users.
- Significant environmental habitat value.

2.7 Key Problems Experienced

The key issue at Marazion is that the dunes and beach are eroding, putting the road, Marazion Marshes SPA and Marazion town at risk. There are no current formal defences in place to protect against this erosion, however as stated in SMP1 and SMP2 the focus should be on active management of the dunes to prevent breaching rather than provision of hard defences. The Mount's Bay Adaptive Management Strategy (Royal Haskoning, 2015) recommends do minimum in the short term whilst preparing a full Mounts Bay FCERM Strategy in consultation with a stakeholder group in the coming years.

In addition, the following observations made by Spalding Associates Ltd (2005) are still relevant following the site visit in March 2015 (refer to Appendix C):

- The extensive coastal defence structures.
- Localised trampling erosion on the dune and intertidal rocky shore habitats.
- Fragmentation and restriction of the dune system.
- Recreational use of the beach.
- Presence of invasive non-native plant species.
- Localised pollution.
- Bait digging (polychaete worms associated with the mud and fine sand).

Also, further observations made during site visit in February 2017 that reinforce the Spalding observations in 2005 include (refer Appendix C):

- Uncontrolled access over the dune with several paths cutting through the dune face where vegetation had been trampled and foot traffic has led to erosion.

- Erosion of main footpath over the top of the dunes, particularly at eastern and western end of the dunes.
- Species out of keeping with the dune habitat (i.e. brambles and ivy) within large parts of the dune system, particularly towards the top and landward sides of the dunes. Non-native species are also present (i.e. Japanese Rose and Monbretia).
- Narrowing of the dunes at the western end where meets hard coastal defences appears to be an obvious weak point.
- A retaining wall is present at the back of the dunes to prevent rollover onto the road behind. This wall is of variable height and condition.
- Cliffling of dunes evident along much of the dunes (both to east and west of Red River channel), with tide line evident along toe of dunes for much of length. This creates a static line and inability for dunes to be dynamic in response to coastal forcing.
- Limited sediment supply in the area to build/maintain dunes.
- The Marazion urban frontage are afforded some protection from wave activity by offshore reefs (Great Hogus and Little Hogus) and presence of St Michaels Mount and causeway. However, the western extent of the dunes and beach is less sheltered in comparison.
- Areas either side of Red River channel have been flattened and dune vegetation largely removed (though evidence of it trying to re-establish, particularly on Folly Field on the eastern side of the channel); these areas could potentially provide space to create new dune habitat. Potential issues of visitors walking over area from carpark to eastern side of Red River – no evidence of controlled footpath/signage.
- Evidence of litter and dog waste within the dune.

2.8 Other Studies and Plans

The following summarises key studies and plans that have a direct bearing on the approach to beach and dune management at Marazion.

2.8.1 Shoreline Management Plan (SMP) Policy

Marazion lies within two Policy Units defined by the Cornwall & Isles of Scilly Shoreline Management Plan Review (SMP2), adopted in 2011 (Royal Haskoning, 2011b). These Policy Units are:

- 19.5 (Marazion west (Chapel Rock to Marazion Bridge)), and
- 19.6 (Marazion Marsh).

The short, medium and long-term policy in both Policy Units is to “Hold the Line”. The stated intent of this policy approach is “...to provide a transition area between Marazion town frontage and Marazion Marsh which maintains the defensive line. In order to adhere to legislation and maintain the integrity of this internationally important freshwater wetland site, a hold the line policy is preferred through all three epochs. A more detailed strategy is required to consider the options for this area in more detail at the earliest opportunity.”

2.8.2 Marazion Marsh SPA Site Improvement Plan

The Marazion Marsh Site SPA Site Improvement Plan (SIP) was produced by Natural England in 2014. The plans provides a high level overview of the issues affecting the condition of the site and outline priority measures to improve the condition of the sites features. The proposed actions as described within the SIP have potential for direct impact on beach and dune management activity, most notably the following:

- **Remove accumulation of silt from Longrock Pool (SIP Action 1B)**

There are proposals to undertake a desilting operation of the Longrock Pool within the boundary of Marazion Marsh Special Protection Area (SPA). Funding is yet to be granted and is subject to further investigations and permitting that includes a Habitats Regulations Assessment. This action is proposed for undertaking between 2017 and 2020.

Proposed plans as part of the action include the potential to create dunes landward of the road utilising the dredged material.

2.8.3 Marazion Cycle Way

There are future plans to make an official Mounts Bay cycle way along the coastal frontage. Cornwall Council (2012) have considered five options, which have undergone a range of assessments to date.

It is understood that no final preferred option has yet been selected, but it is likely that future beach and dune management activities will need to consider the implications for, and interactions with, any such cycleway in this location. Further details are provided in Appendix C.

2.8.4 Penzance Harbour Arm Extension

There is potential that a future Penzance Harbour Arm extension project may alter Mounts Bay processes, which would potentially impact beach and dune processes in the BDMP area.

2.8.5 Landscaping Project

A potential longer-term management of coastal flood and erosion risk as set-out in the Mounts Bay Strategic Assessment of Adaptive Frontages is currently leaning towards a “landscaping” solution in about 20 years or so time to enhance the dunes. The project is subject to further investigations in the coming years as part of the planned full Mounts Bay Strategy.

DRAFT

Factors Affecting the Beach Dune System

3.1 Wind, Wave Climate and Tides

3.1.1 Wave Climate

The coastline at Marazion is orientated north-west to south-east, with the beach and dunes facing approximately 230 degrees (south-west). The predominant wave direction (Figure 3.1) along the south coast of Cornwall is reported to be from the south-west (approaching from 180°) and the coastline is exposed to open Atlantic swell waves (Royal Haskoning, 2011b). However as noted in the SMP the coastline is relatively sheltered by the Penwith Peninsula. During storm periods the frontage from Longrock to Penzance receives large amounts of wave energy which originate from due south and the south east.

The Penzance Directional Waverider Buoy, operated as part of the South West Regional Coastal Monitoring Programme (SWRCMP) is the nearest wave buoy to Marazion, and has been reviewed for this study (refer to Figure 3.2 for the wave data point).

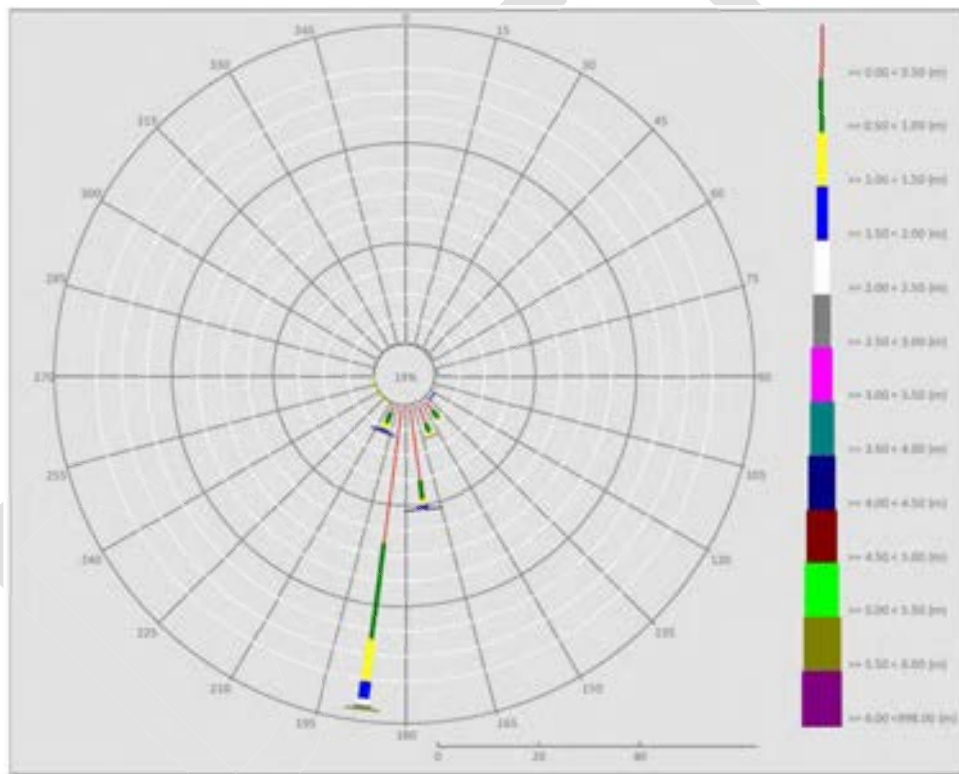


Figure 3.1 Offshore wave height recorded by the Penzance Directional Waverider Buoy between 6th April 2007 and 31st December 2015 (PCO, 2015a).



Figure 3.2 Map showing the location of the wave data collection points at Penzance relative to the coastline.

3.1.2 Storm Waves

Storm analysis undertaken by PCO (2014c) provides an overview of the storm conditions recorded by the Penzance Directional Waverider Buoys since 2007. Further analysis since 2014 has been provided by PCO (2015a).

For each wave buoy in the SWRCMP, an individual storm threshold is set. A storm event is defined when significant wave heights equivalent to the 0.25 year return period (i.e. the threshold wave height (H_s) for 2 to 4 storms in an average year) occurs for set period of time (i.e. 16 hours). The significant wave height is calculated when a 5 year time series of data becomes available for the wave buoy and is then reset each year. Prior to that, the height is based on an educated conservative guess from looking at the wave data available. The reason that the 0.25 year return period is used is because the SWRCMP have found that in general there are 3 to 4 storms in any one year that result in the movement significant amounts of sediment.

For their reporting, PCO produce a storm calendar. The calendar includes a graph, where each dot represents a storm (i.e. where the H_s exceeds the storm threshold) and shows the H_s for that particular storm. PCO plot the significant wave height for the 1 year return period for that particular buoy on the graph (calculated in the same way as significant wave height for the 0.25 year return period) as a red line. Where storms plot above the red line they are considered to be more severe/extreme and are listed in a separate table. The table and storm calendar for the Penzance Directional Waverider Buoy are presented in Table 3.1 and Figure 3.3 and respectively.

The storm calendar for the Penzance Directional Waverider Buoy shows that seven individual storms have exceeded the 1 year Return Period since 2007. Three of those storms (43 %) occurred between October 2013 and February 2014. Overall the SW coast of England experienced 22 extreme storms from October 2013 to April 2014 (Masselink et al, 2015). The impact of these storms on beach change is described in Section 3.3.2.3.

Table 3.1 Storms exceeding 1 year Return Period at Penzance since deployment in 2007. Those occurring during the storm season October 2013 to February 2014 are shaded pink (source: PCO, 2014b).

Date	Wave Height (m)	Return Period
04/02/2014	6.06	Greater
16/01/2010	4.7	> 1 in 3 years
13/11/2009	4.64	> 1 in 3 years
13/01/2008	4.54	> 1 in 2 years
22/11/2012	4.27	> 1 in 1 year
03/02/2008	4.24	> 1 in 1 year
23/12/2013	4.24	> 1 in 1 year
24/12/2013	4.24	> 1 in 1 year
03/02/2014	4.19	> 1 in 1 year

Figure 3.3 presents the storm events from 2008 to 2015 to understand the frequency and magnitude of events. In addition, more recent data (PCO, 2015a) indicates there were two significant storm events in January 2015 and December 2015. Details of these events are recorded in Figure 3.4 and Table 3.2. It is likely that with sea level rise increased water levels and hence wave energy will lead overall to increased impacts on the shoreline (erosion and overtopping). Figure 3.3 above shows storms (significantly above the $H_s=3.25\text{m}$ threshold) with several storms occurring in Jan 2010 and Jan 2014. There has been only 2 storm events above the threshold in 2015 (see Figure 3.4) but there may have been additional storm events in 2016 which would exceed the threshold.

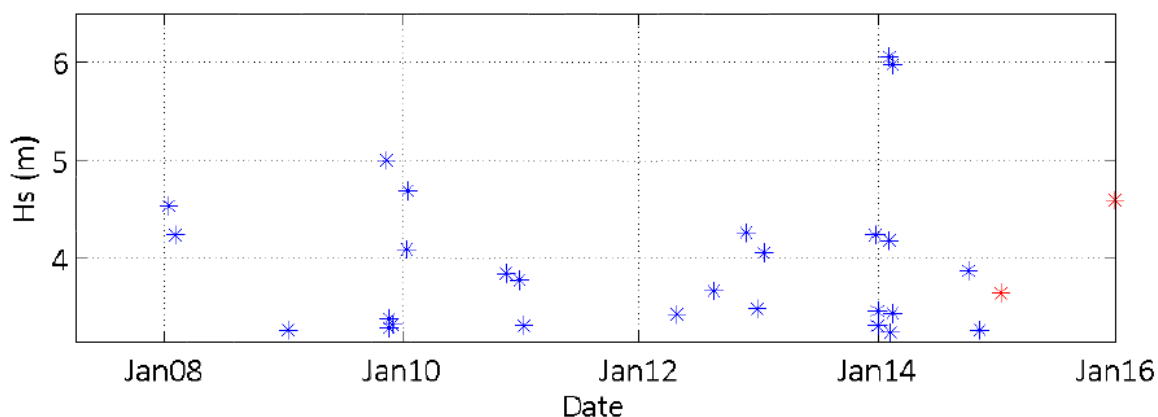


Figure 3.3 Storm calendar for Penzance 2008-2015 (PCO, 2015a)

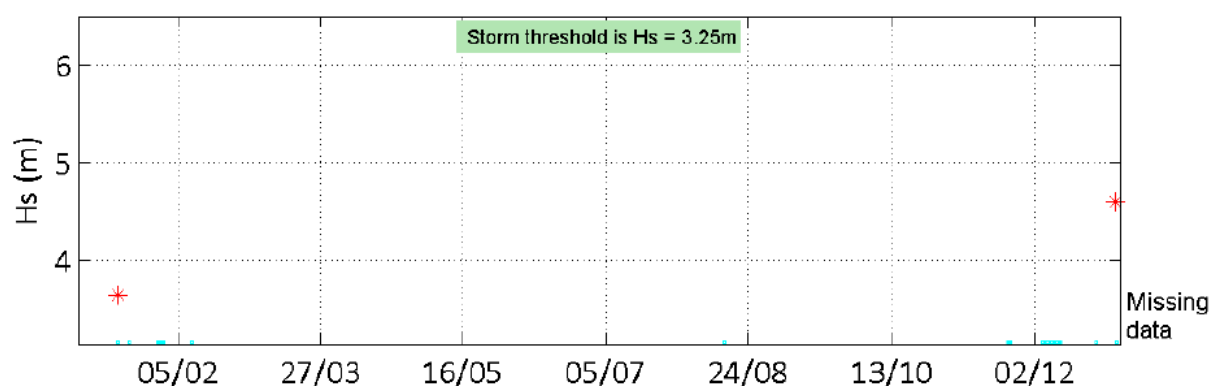


Figure 3.4 Storm calendar for Penzance during 2015 (PCO, 2015a)

Table 3.2 Details of 2 storm events which occurred in 2015.

Date/Time	H _s (m)	T _p (s)	T _z (s)	Dir. (°)	Water level elevation* (OD)	Tidal stage (hours re. HW)	Tidal range (m)	Tidal surge* (m)	Max. surge* (m)
30-Dec-2015 08:30	4.60	10.0	7.5	186	2.42	HW +1	4.1	0.44	0.55
15-Jan-2015 00:00	3.65	10.5	6.9	196	1.69	HW +1	2.3	0.56	0.56

3.1.3 Tides

Tidal levels have been extracted from the current Admiralty Tide Tables (UKHO, 2016) for the closest location with the best available data, in this case Penzance, and converted to Ordnance Datum (mOD). The tide levels for Penzance are presented in Table 3.3. Overall the tidal range in this area is around 4.2m. Residual tidal currents are typically less than 1 m/s (and around 0.5m/s in Mounts Bay) with net eastward sediment transport attributed to the residual tidal flow pattern (Royal Haskoning, 2009).

Table 3.3 Tide levels (in mOD) for Penzance, adjusted from standard port Plymouth (Devonport).

Tidal Condition	Tide Level (mOD)
Highest Astronomical Tide (HAT)	3.05
Mean High Water Spring (MHWS)	2.45
Mean High Water Neap (MHWN)	1.25
Mean Sea Level (MSL)	0.15
Mean Low Water Neap (MLWN)	-1.05
Mean Low Water Spring (MLWS)	-2.25
Lowest Astronomical Tide (HAT)	Data not available

Figure 3.4 presents a cross-section of a typical dune profile (extracted from Royal Haskoning, 2015) against regular and extreme tidal levels. Generally, the toe of the dunes (up to 1mODN) are exposed to regular tidal impacts (i.e. wetted area). It's only under extreme conditions that the dune is impacted (up to 4mODN). However, this excludes potential wave impacts.

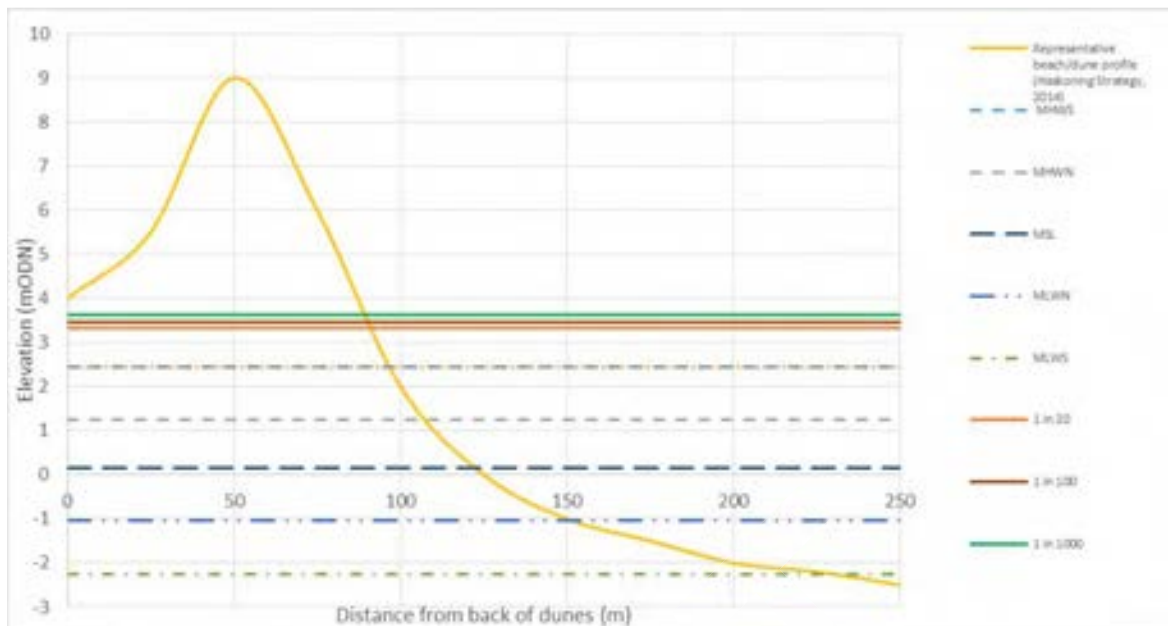


Figure 3.4 Cross section of a typical dune profile. Note the key wetting and dry areas of the beach and dunes under different conditions.

3.1.4 Wind climate

South-west England is one of the more exposed areas of the UK and the strongest winds are associated with the passage of deep depressions. As Atlantic depressions pass by the UK the wind typically starts to blow from the south or south-west, but later comes from the west or north-west as the depression moves away. Overall the wind blows predominantly from a SW direction. This is confirmed by data from Cudrose, Portleven Airport (www.windfinder.com) – see Figure 3.5.

The frequency and strength of depressions and therefore mean wind speeds (and gusts) is greatest in the half of the year between autumn to spring (winter). Wind data has been sourced from the Met Office and worldweatheronline.com. The graph (Figure 3.6) shows a typical yearly variation of the monthly mean speed and highest gust at St. Mawgan (near Newquay). From November to March the highest mean wind speeds occur and the lowest are between June to August. The peak gust follows a similar pattern and in the past 30 years both December and January the maximum gust have reached almost 90knots. Figure 3.7 shows average and maximum wind gusts for Penzance. The maximum gust (40mph) is approximately 35knots which is less than for St Mawgan.

Wind direction distribution in (%)
Year

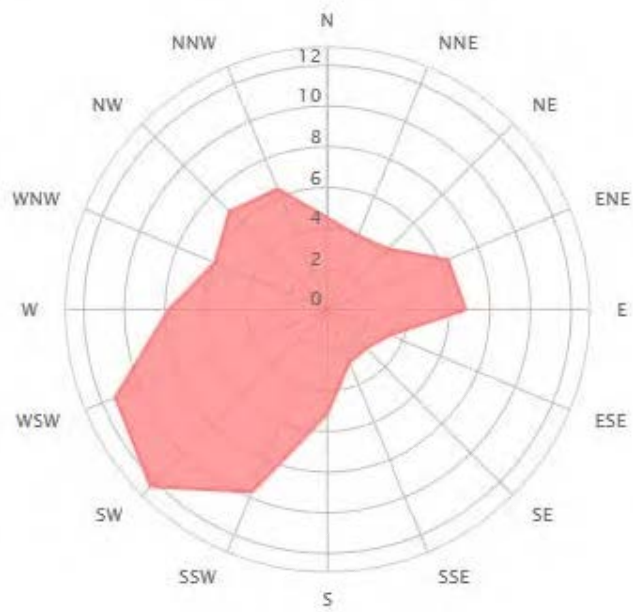


Figure 3.5 Observations taken between 11/2000 - 03/2017 from Porthleven/Culdrose Airport. Source :windfinder.com.

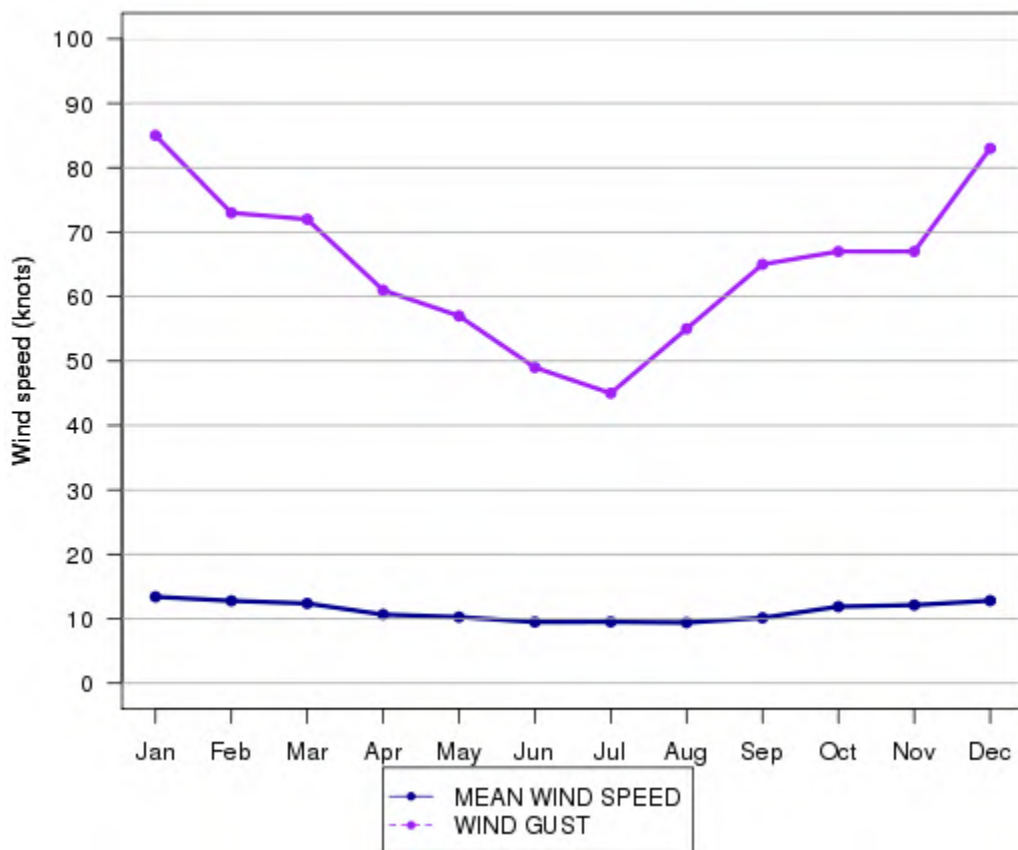


Figure 3.6 Monthly average mean wind speed (1981-2010) and maximum gust i.e. 'instantaneous' speed averaged over 3 seconds (1956-2007) at St Mawgan (near Newquay). Source: Met Office.

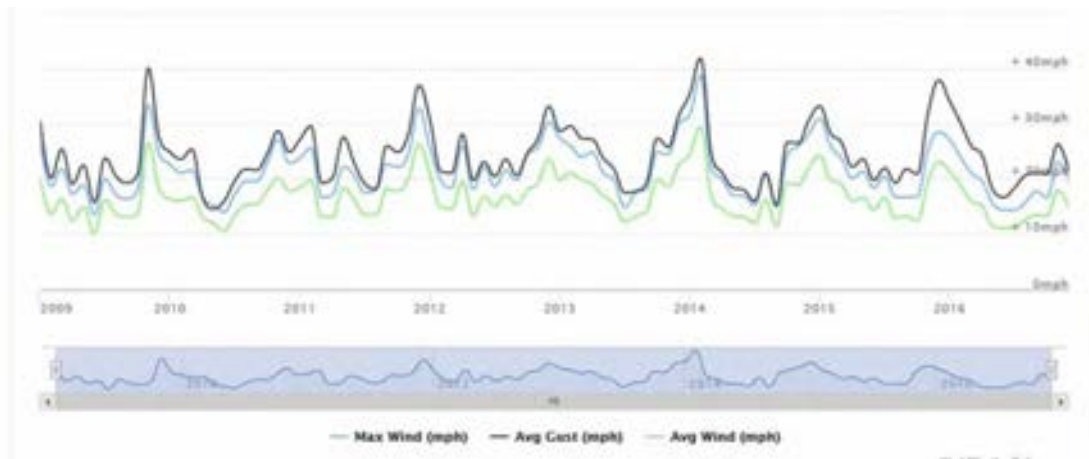


Figure 3.7 Average and maximum wind speeds and gusts (mph) for Penzance (2009-2016). NB 1mph= approx. 0.87knots and 0.45m/s. Source: WorldWeatherOnline.com.

Average wind speed gusts were highest in 2010 and 2014 (40mph and 42mph respectively) which may have contributed to increased windblown sand transportation. Average gusts were also high in 2012, 2013 and 2015 in the early first few months of the year. However, it should be noted that these speeds are recorded at 10m elevation (the dunes are less than 10m crest height) and therefore actual wind speeds across the beach and at the base of the dunes are likely to be significantly lower. Arens (1994 in Van Rijn, 1998) states that when the onshore wind speed is less than 10m/s sand is likely to be only transported as far as the base of the dunes; when wind speeds are greater than 10m/s sands are able to enter the vegetation zone. Overall the wind speeds measured at Penzance (and as a proxy for Marazion) have potential to transport sand across the beach for building at the base of the dune and occasionally gusts could cause sand transport to reach further into the dunes and even overtopping them (as shown from the sand accumulating on the road behind the dune). In terms of future changes, increased frequency and severity of Atlantic depressions could increase wind speeds and potentially windblown transport.

3.1.5 River Dynamics

The Red River discharges from Marazion Marshes under a bridge across the road and across Marazion beach. It was originally named as the 'Red River' because of discolouration from mining spoil. The river is unlikely to be contributing significant sediment into the system at this point (Halcrow, 1999). The river flows are more likely to have a greater influence on the dunes due to migration (anecdotal evidence from local stakeholders). As noted in Halcrow (2009) changes in position and size of the river channel across the beach can influence erosion and accretion patterns, particularly where the river bed cuts landward eroding dune sediment. This is reviewed further in Section 3.3.2.

3.1.6 Climate Change and Sea Level Rise

Information on the impacts of climate change is available from 'Advice for Flood and Coastal Erosion Risk Management Authorities' (Environment Agency, 2011). This guidance highlights that the main risk of climate change in relation to beach management is from sea level rise.

The guidance (Environment Agency, 2011) suggests that predictions of the future rate of sea level rise for the UK coastline should be taken from UKCP09. Data downloaded from UKCP09 provides sea level rise from 1990. Anticipated rates of relative sea level rise and surge estimates over three time periods are presented in Table 3.4. The following estimates are presented in the table:

- Lower End Estimate: this is the low emissions scenario, 50% frequency, taken from the UKCP09 User Interface.
- Change Factor: this is the medium emissions scenario, 95% frequency, taken from the UKCP09 User Interface.

- Upper End Estimate: these are generic values of sea level rise provided in the climate change guidance; they are 4mm (up to 2025), 7mm (2026 to 2050), 11mm (2051 to 2080), and 15mm (2081 to 2115).
- H++ Scenario: these are generic values of sea level rise provided in the climate change guidance; they are 6mm (up to 2025), 12.5mm (2026 to 2050), 24mm (2051 to 2080), and 33mm (2081 to 2115).
- Upper End Estimate + Surge Estimate: This is the upper end estimate plus the upper end surge estimate. The surge estimate are generic values provided in the climate change guidance; they are 20cm (up to the year 2020's), 35cm (up to the year 2050's), and 70cm (up to the year 2080's). With regard to the surge increase, the uncertainty with surge increase is even greater than for sea level rise.

The climate change guidance (Environment Agency, 2011) recommends that in planning future coastal management options, the Change Factor (medium 95% frequency scenario) be used as the preferred scenario. All other scenarios are included to demonstrate the sensitivity of decision making through time, and can be used to refine the options to prepare for a wider range of future change.

Table 3.4 Relative sea level rise estimates for Marazion (see text above for explanation of terms used in this table).

Time period	Various estimates of relative sea level rise and surge (mm/year)				
	Lower End Estimate	Change Factor	Upper End Estimate	H++ Scenario	Upper End Estimate + Surge Estimate
2015 to 2025	0.04	0.06	0.04	0.24	0.06
2015 to 2055	0.15	0.26	0.27	0.62	0.49
2015 to 2115	0.44	0.77	0.92	1.62	1.92

3.2 Sediment Budget and Linkages

The alignment of the coast at Marazion to the incident wave direction results in the potential for both longshore and cross shore transport (Halcrow, 2009). There are weak sediment links along this frontage, due to a weak net eastward tidal residual drift (accumulation of sediment on the western side of St Michael's Mount and its causeway supports this view). Sediment transport is primarily sand grade material which is wave driven particularly under storm conditions (Royal Haskoning, 2011). Most transport is cross-shore from the beach and onto the dunes by wind-blown transport, however the supply of sand is weak and unlikely to be sufficient in the long term for stabilisation and accretion of the dunes.

Due to the bounding rock headlands, little sediment is lost or gained outside of Mounts Bay through longshore transport. Sediment is supplied to the beach via dune face erosion and potentially via the discharge of sediment from the freshwater Red River, although it is unlikely to supply significant volume of sediment to the beach/dune system. From the beach, sediment can be transported offshore to the nearshore zone or further afield, for example to sediment sinks within Mounts Bay, and returned to the dune system during calmer periods. This has been evidenced in the 2013/14 storm recovery assessment (PCO, 2014) where in some areas (e.g. Harlyn Bay) the volume of sediment recovered by summer 2014 (post storms in January 2014) increased by up to 500%. However, for Marazion the beach volume only appeared to increase by 3% suggesting that recovery here was less strong than other sites. It would be interesting to see how this has changed since 2014 and further study on this would be recommended.

Some sediment is released from cliff erosion at East Marazion and through erosion of rock outcrops but is unlikely to significantly influence the frontage at Marazion due to the St Michael's Mount causeway and the fact that alongshore movement of sediment is generally in an eastern direction. The Mounts Bay Strategic Assessment of Adaptive Frontages states that currently '*longshore sediment movement, apart from locally within the influence of natural shore features, the frontage as whole is seen as being in good equilibrium*' (Royal Haskoning, 2015).

Marazion dunes is a well visited area by dogwalkers and general visitors; there is easy access from the main car park to the east of Red River. Footpaths have been created through the dunes which has caused vegetation trampling and die-back and potential for sand compaction in some areas. This could impact the potential for saltation to occur through the dunes or in some areas increase likelihood of dune blow outs.

3.3 Historical Changes

3.3.1 General Description

Marazion is located on the south-west coast of Cornwall. The site is situated within the wider embayment of Mount's Bay which includes Penzance and Newlyn to the west and the Lizard Peninsula and Porthleven to the east (refer also to Figure 2.1 above). The whole of Mount's Bay coastline is formed of Devonian rocks including mudstones, volcanic lava and tuffs (Royal Haskoning, 2015) with rocky outcrops, typical for this part of the UK coastline along Devon and Cornwall. Marazion is bounded by The Long Rock in the west and St Michael's Mount in the east. Between the two outcrops, is a wide, shallow plan shape bay with sandy beach backed by sand dunes.

The Mount's Bay frontage (in which Marazion is situated) can be divided into several defended and undefended sections as follows:

- At the western end of Mounts Bay is the Penzance frontage including Ponsandane and Chayandour (where the train line from London to Penzance runs along the coastline) and Eastern Green.
- In the eastern central part of the Mounts Bay is 'The Long Rock' – a more resistant rocky felsite outcrop which acts as a submerged breakwater (between 0 to -1mODN) helping to dissipate wave energy and intercept sediment transport. At The Long Rock coastal defences have been in place for many years to help protect the road and railway (and Marazion Marsh SPA freshwater site) behind from coastal erosion and flooding. The defences consist of concrete banks and rock armour. The beach is sandy, although there are some cobbles and boulders. An outfall discharges to the east of The Long Rock.
- From the end of the seawall at Marazion eastward to the town of Marazion there are no formal hard defences, only a semi-natural dune system backed by a road (West End Road) and the Marazion Marsh freshwater SPA. Marazion Marsh and the fronting dune system is described as providing a 'buffer' between The Long Rock and Marazion town itself (Royal Haskoning, 2011). The defences between the dunes and the road and between the town and the dunes to the east are starting to be outflanked.
- The eastern section of the dunes is intercepted by the Red River which drains across the beach.
- To the east of the Red River the dune is much lower and transitions into a heavily engineered frontage with reflective vertical seawall, sloped revetment and rock armour. These defences protect the town of Marazion including car parks along the frontage but also shops, restaurants, hotels and residential properties behind. Marazion itself is built on harder rock similar to St Michael's Mount.
- Marazion provides the access point to St Michael's Mount which is an important physical control on the coastline to the east of Marazion. St Michael's Mount consists of slate beds on the northern flank and a granite extrusion on the southern flank. Marazion has various rock types

underlying it. The Mount itself acts to trap sediment on its western side (particularly influenced by the causeway) and provides some shelter from the wave climate to the Marazion frontage from storm events from the south west but also more locally generated waves from the south east. Shallow rocky platforms to the north west of St Michael's Mount (e.g. Great Hogus has a maximum level of 1mODN) also locally influence wave transmission to the foreshore. The Great (and Little) Hogus are fundamental in maintaining beach width along the West End Road frontage.

- Marazion East is an area of undefended exposed steep cliff which is eroding and is an important source of new sediment to the Mount's Bay.
- Venton Cove (which lies east of St Michael's Mount) is also part of the wider Marazion frontage in terms of coastal processes but also the area of the town which lies behind it.

In January 2007, several storm events occurred which caused dune fencing to be dislodged or displaced and a drop in sand levels was observed (Halcrow, 2007). Wave attack had disturbed the sand dune management techniques put in place by Natural England. Measurements taken at a sturdy post near to the middle of the dune front, indicated a drop in sand levels in the region of 35cm since October 2006. The pathway immediately behind the front row of fencing was sloping where it was previously a flat pathway, due to the decrease in beach levels at base of the dunes. The vegetation along the front of the dunes had been eroded by the waves. In October 2006, marram grass extended in front of the fencing in a number of sections. Following the storm in 2007 there was no vegetation in front of the fencing and the vegetation behind the fencing had been cut back in places

Following the recent unusual and prolonged 2013/2014 storms, significant erosion also occurred along the coast at Marazion. PCO prepared a report assessing the impact of the storms for a number of sites across Cornwall but only with focus on the beach not the dunes specifically. Figure 4.2 shows changes in beach sediment volume during the 2013/14 storms. Mount's Bay experienced loss across all beaches except some beaches to the east of the Bay near Goldsithney. Anecdotal evidence from local residents and stakeholders suggests significant erosion was experienced during this period.

Behaviour of the beach and dunes has been adversely affected by human interventions, both historically and current. Today, the dunes are also subject to erosion as a result of beach users climbing, sliding down and digging into the sand on the dune face. To the west of the dunes (where the transition to the hard defences meets the dunes), beach users have eroded the path to the road behind, exposing the dunes and potentially creating a weak point in the defence line in the longer term. To the east, there is evidence of erosion by cliffing of the sand dunes and grassed vegetated top of the dunes. Erosion has also occurred where visitors have walked from the car park directly onto the dunes rather than taking the signed footpath. This is likely to be a significant contributor for erosion in this particular area.

Appendix C provides further information.

3.3.2 Long Term Evolution

3.3.2.1 Comparison of Ordnance Survey Mapping

A comparison of the 1939 Ordnance Survey Mapping with current day aerial photography (2012) and also the 2014 MHWS mark estimate from LIDAR shows:

- The 1939 High Water Mark is very similar to the MHWS mark in 2014 (MHWS is slightly inland which would be expected for a spring tide level) with the exception of the area around the Red River channel.
- The dune extent is significantly different on the west of the red River channel; the 1939 map suggests that the sand dunes closest to the Red River used to extend much further seawards and south eastwards. However, the line of the dune is very straight suddenly changes direction at the interface with the Red River channel so the accuracy of this level is uncertain. Looking at a

1964 map available to view online (at www.oldmaps.co.uk) the extent of the dunes is much more similar to the 2012 extent than the 1939 map. However, the dune extent to the west towards The Long Rock is much more similar for 2012, 1939 and 1964.

- The dune extent to the east of the Red River on the 1939 map is smaller than the current day aerial photograph extent giving further confidence that the 1939 dune extent map should be considered carefully. This is again represented better on a 1964 map viewed online.

Further details of this analysis are provided in Appendix C.

3.3.2.2 Analysis of Aerial Photographs

Using historical aerial photographs, the dune toe was digitised and compared (refer to Figure 3.8). The analysis shows that the between 2007, 2010 and 2012:

- There was no significant change in the position of the dune toe between 2007 and 2010 other than a small amount of movement near the river channel. NB: there are some areas on the dunes to the west of the Red River channel where the dunes appear to have advanced (<1m) – this could be due to differences in vegetation cover or small digitisation errors.
- Between 2010 and 2012 significant retreat appears to have occurred along the dunes in front of the car park at Marazion (approximately 4m retreat i.e. 2m/year erosion rate). Change is particularly noticeable closest to the footpath from the car park to the dunes where up to 14m of erosion has occurred in 2 years (i.e. average of 7m/year). This is likely to be due to unrestricted access to the dunes and beach via the car park at Marazion with the public walking on the toe of the dunes. There is also evidence of where access from the car park to the beach has had a significant impact on the dune extent. Most visitors are present in the summer months so this is when impacts are likely to be more significant.
- Increased wave action is unlikely to have been the cause of erosion in this area. The eastern part of the frontage gains slightly more shelter from the nearshore rocky outcrops but has experienced erosion. If wave action was the main cause observed retreat would be mirrored on the western side of the Red River, where the sheltering effect is less. This is not the case however and results show some accretion. This is also the case for wind impacts – if increases in wind activity (e.g. during winter of 2010) were a fundamental impact on dune dynamics then they would be expected to be consistent across the area (i.e. both east and west of the Red River); this is not the case and further supports the influence of localised pressures.

Further details of this analysis are provided in Appendix C.

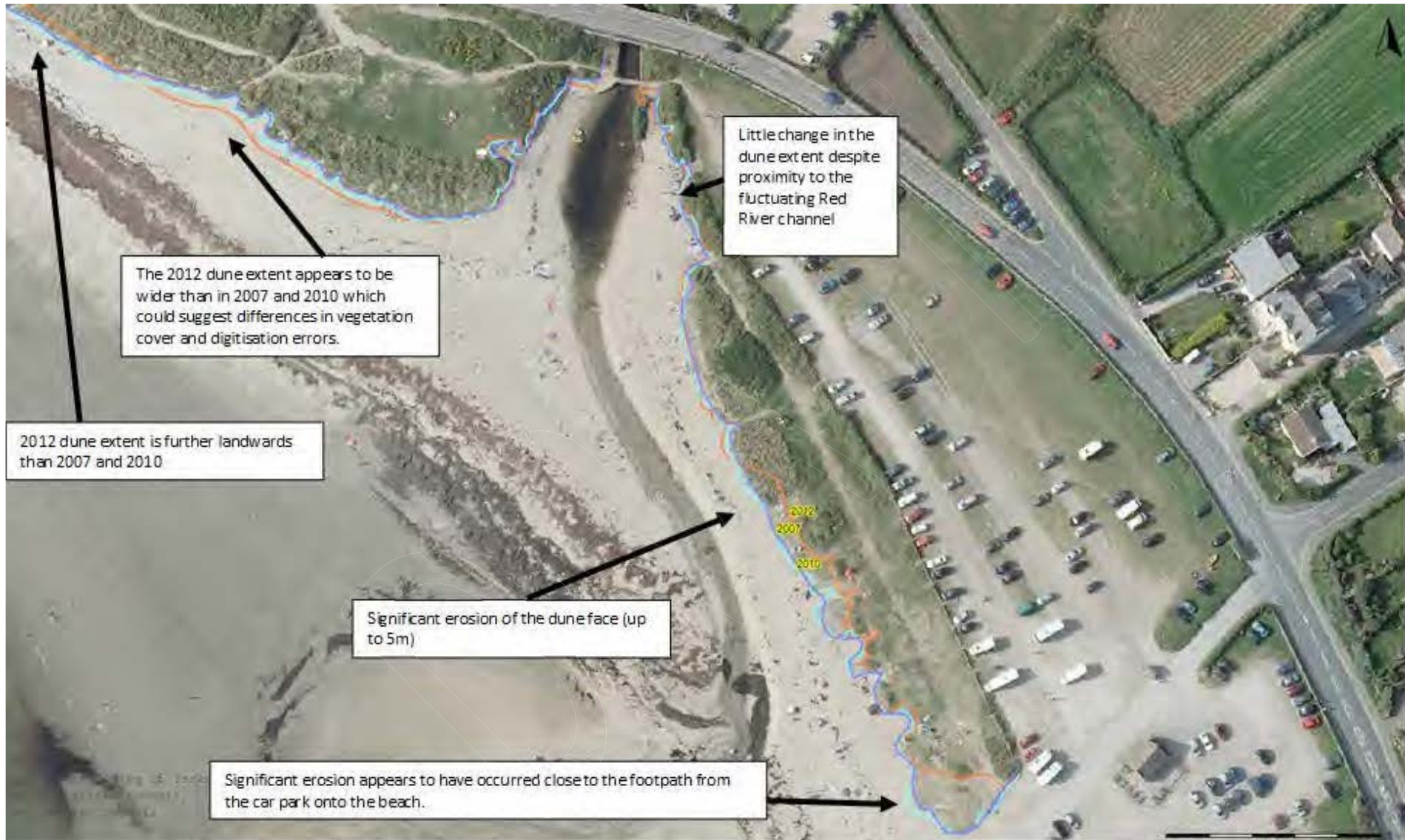


Figure 3.8 Dune toe position at Marazion in 2007, 2010 and 2012 (refer to Appendix C).

3.3.2.3 Beach Profile Analysis

Beach profile monitoring undertaken by the Plymouth Coastal Observatory (PCO) for the South-West Regional Coastal Monitoring Programme (SWRCMP) provides recent data and analysis for the beach at Marazion. A summary of the findings from the latest annual survey report (PCO, 2014a, 2015b, 2016) are presented in this section and provide an overview of beach profile change between Spring 2014 and Spring 2015 and 2016, and over the longer-term from the baseline survey in 2007 to the most recent survey in Spring 2015/6. **It should be noted that the calculations of cross sectional area cover the beach and do not include the dunes.** In addition to this topographic difference models have been prepared using available LiDAR data and changes in the MHW level assessed.

Short term (2014-2016)

- Between Spring 2014 and Spring 2015 (refer to Figure 3.9), all the profiles in this survey unit have lost material, with the exception of the most westerly profile 6e00747, which increased in cross-sectional area by 8%. All three other profiles displaying erosion have lost 4% of their cross-sectional area equating to a loss of between 13-22m² for each profile. However, between 2015 and 2016 there is a different trend where all profiles are accreting (range between 1% and 9%- the most being directly in front of the car park (6e00743) at Marazion). This trend could be due to a slow recovery of material following the storms of 2013/14.
- Mounts Bay to the west of Marazion (Figure 3.10) shows a general accretion trend between spring 2014 and 2015 with the exception of 2 profiles (6e00792 and 6e007788) either side of the train station at Penzance. The profile with the most increase over this period was at The Long Rock (profile 6e00780) which increased by 21% in CSA in just one year. Between 2015-2016 there are wide variabilities in profiles at Mounts Bay – some profiles are accreting and some eroding. Most erosion is occurring at The Long Rock (profile 6e00776) which could be the system re-equilibrating after significant sediment accretion in the same area in 2014/15.
- Considering the profiles results together it appears that in the short term, sediment has been lost from Marazion in 2014/15 and either moved west towards Mounts Bay frontage during 2014-15 or sediment was lost offshore and following this (during storm recovery between 2015-2016) the sediment has moved back from Mounts Bay towards Marazion.

Short term (2013/14 winter storms)

- As part of the SWRCMP, PCO have also prepared a report (PCO, 2014b), which examines the change to a selection of the beaches along the south-west coast, with a view to identify how beach change occurring as a result of the 2013/2014 winter storms compares to the longer-term behaviour of the beach. The frequency of the storms over the winter of 2013/2014 allowed for little, if any beach recovery and consequently each storm was impacting on a progressively weaker beach. Significant wind blown (aeolian) transport is likely during this time which would contribute to changes in the dune face.
- Analysis of beach profile data to assess beach volume change over the longer term (typically between 2003 and 2013), the 2013/2014 winter storm period (typically between October/September 2013 and February 2014), and over a post-storm period between winter 2013/2014 and summer 2014 is described below:
 - Beach volume changes at Marazion (1km stretch surveyed) indicate 18,100m³ of material was lost between 2013/14 during the storm period; conversely during the period from 2007-13 results indicate an increase of volume by 5,100m³.
 - These results are consistent with the general trend observed across the south-west where the overall trend prior to the 2013/14 winter storms had been for beach accretion at most beaches and the majority of beaches lost material during the 2013/14 winter storms.
 - Beach recovery by summer 2014 was only 3% (significantly less than other beaches). Unfortunately, there is no longer term analysis of recovery between 2014/15/16.

Longer term (2007-2015/16)

- Over the longer term, between 2007 and spring 2015 (refer to Figure 3.11), the two central profiles in the survey unit at Marazion have eroded since 2007 (-1% and -6% respectively). However, the profiles to west (1% at the red river) and east (4%) at St Michael's Mount) have accreted. Between 2007 and spring 2016 (Figure 3.12) all profiles except one have been accreting – particularly the profile (6e00743) directly in front of the car park.
- In Mount's Bay between Spring 2007-Spring 2015 (Figure 3.13) generally there is accretion between Marazion dunes and The Long Rock outcrop and at Penzance but the area in between Penzance and The Long Rock outcrop there is general erosion. Comparison between Spring 2007 and Spring 2016 (Figure 3.14) also shows a similar trend.

Changes in the Mean High Water Springs (MHWS) contour (refer to Figure 3.15) shows variation on the position of the contour. The MHWS level is heavily influenced by the presence of the Red River channel which meanders and fluctuates its position from west to east across the beach. However, generally to the east of the Red River channel, the MHWS has migrated seawards from 2007 to 2014, supporting the results that the beach has been accreting. To the far west of the Red River channel in front of the dunes the MHWS level has not significantly changed between 2007 and 2011 but in 2014 the MHWS level does move seawards by up to 5m in places. This can be supported by Figure 3.10 which shows erosion of the dune face and subsequent accretion on the upper beach.

Overall these results suggest that whilst there has been short term storm activity, in the longer term the beach area in front of the dunes has been accreting. However, the data only captures the beach level changes and not the changes in the dunes themselves. It is likely that the dunes are eroding and to some degree providing the material that is causing beach levels to increase. Further assessment of the dunes has been considered by the preparation of topographic difference models (in Section 3.3.2.4 below).

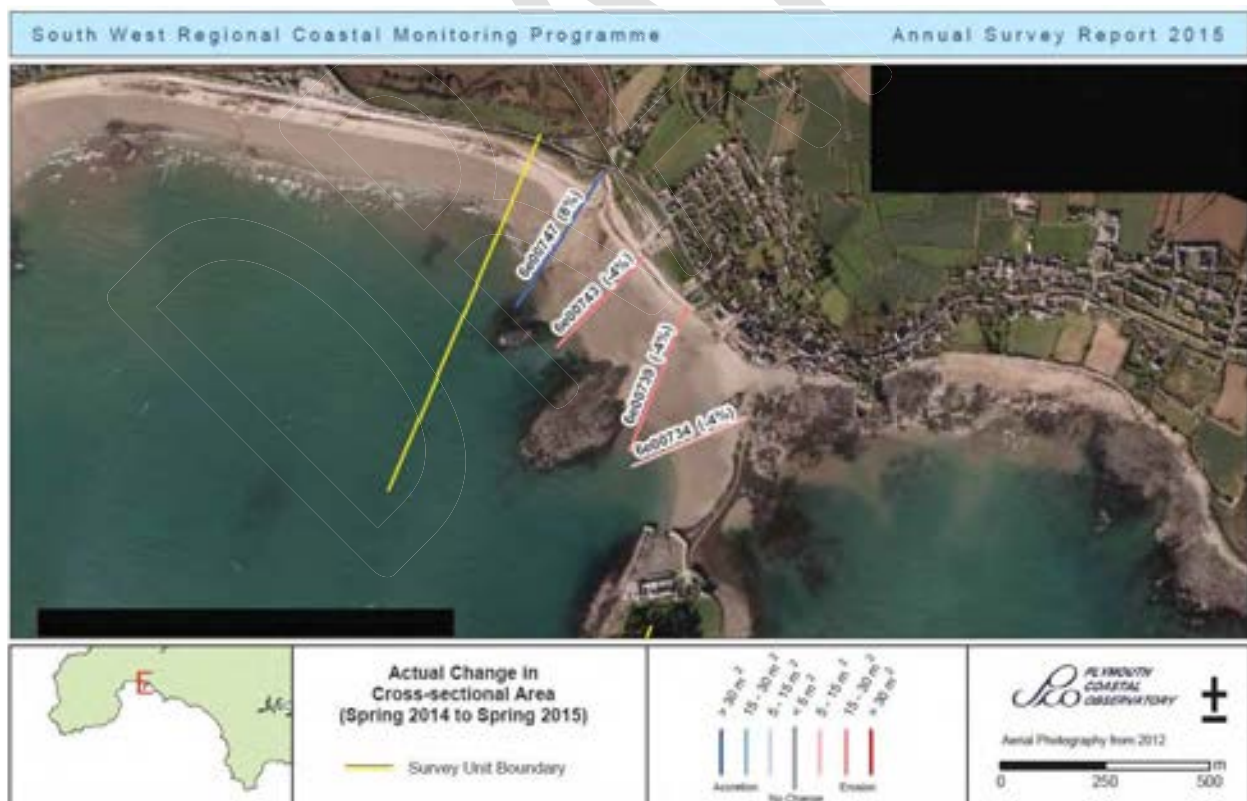


Figure 3.9 Beach profile change at Marazion 2014 to 2015 (source: PCO, 2015).

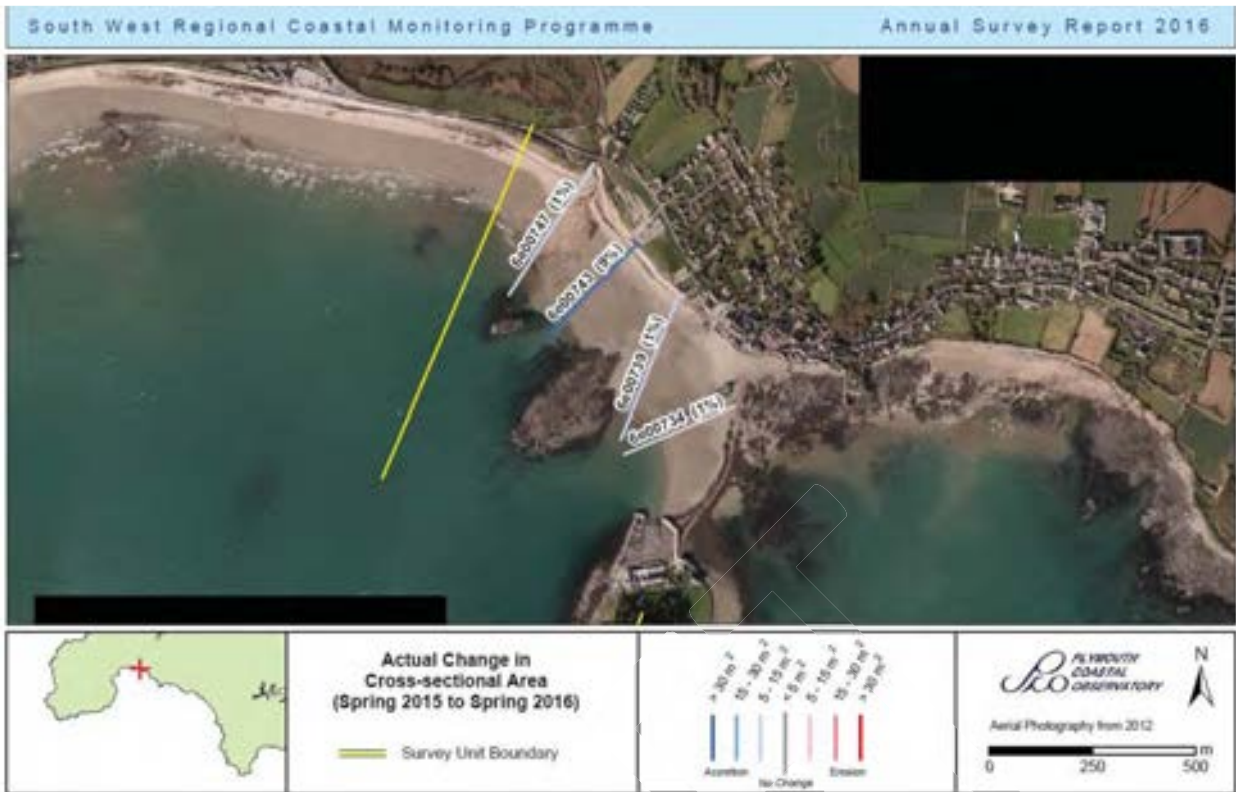


Figure 3.10 Beach profile change at Marazion 2015 to 2016 (source: PCO, 2016).



Figure 3.11 Beach profile change at Marazion 2007 to 2015 (source: PCO, 2015).

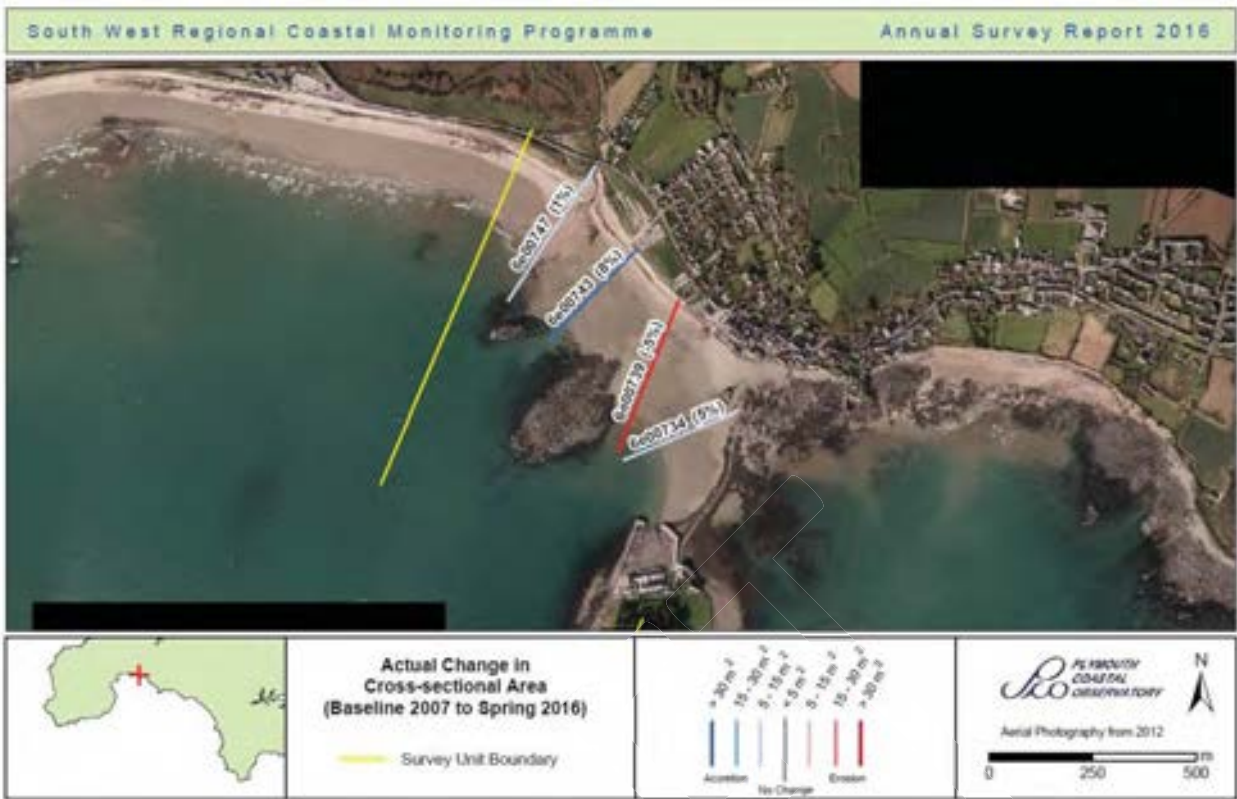


Figure 3.12 Beach profile change at Marazion 2007 to 2016 (source: PCO, 2016).

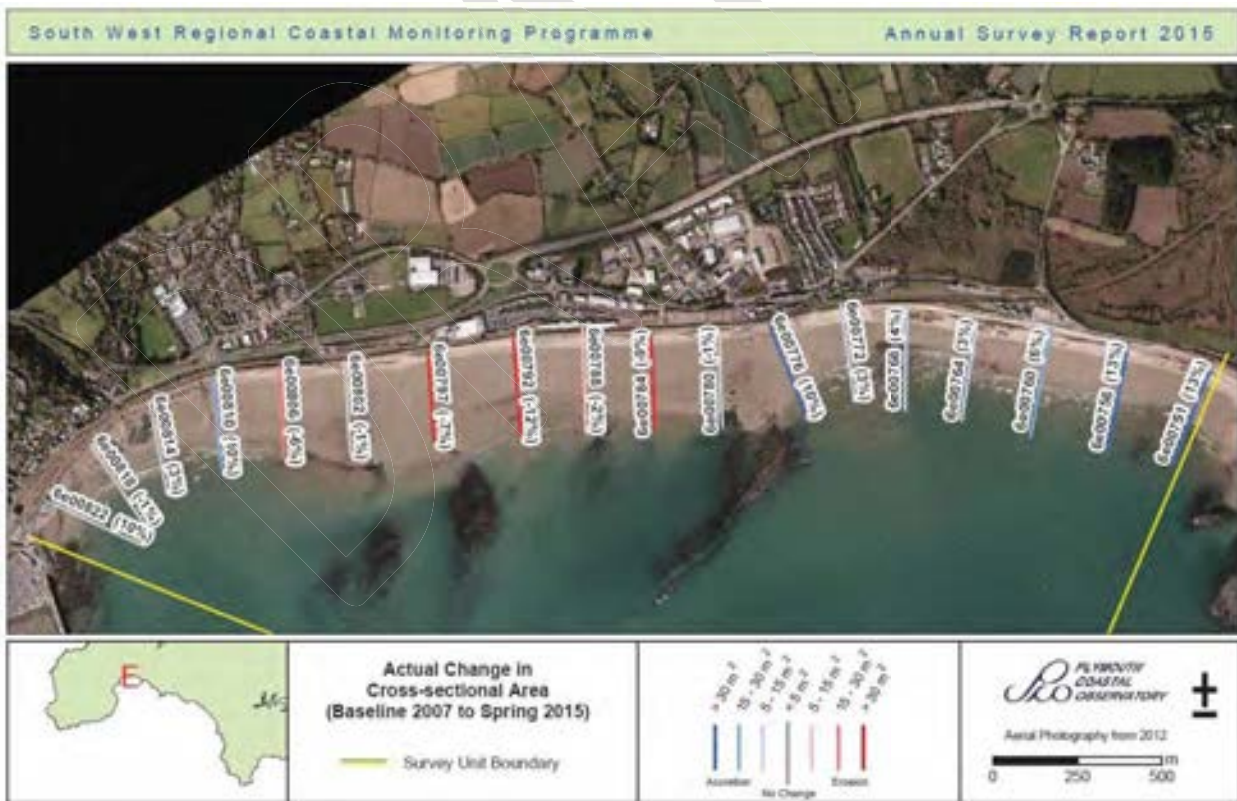


Figure 3.13 Beach profile change at Marazion 2007 to 2015 (source: PCO, 2016). The Marazion frontage is to the east of the yellow line.

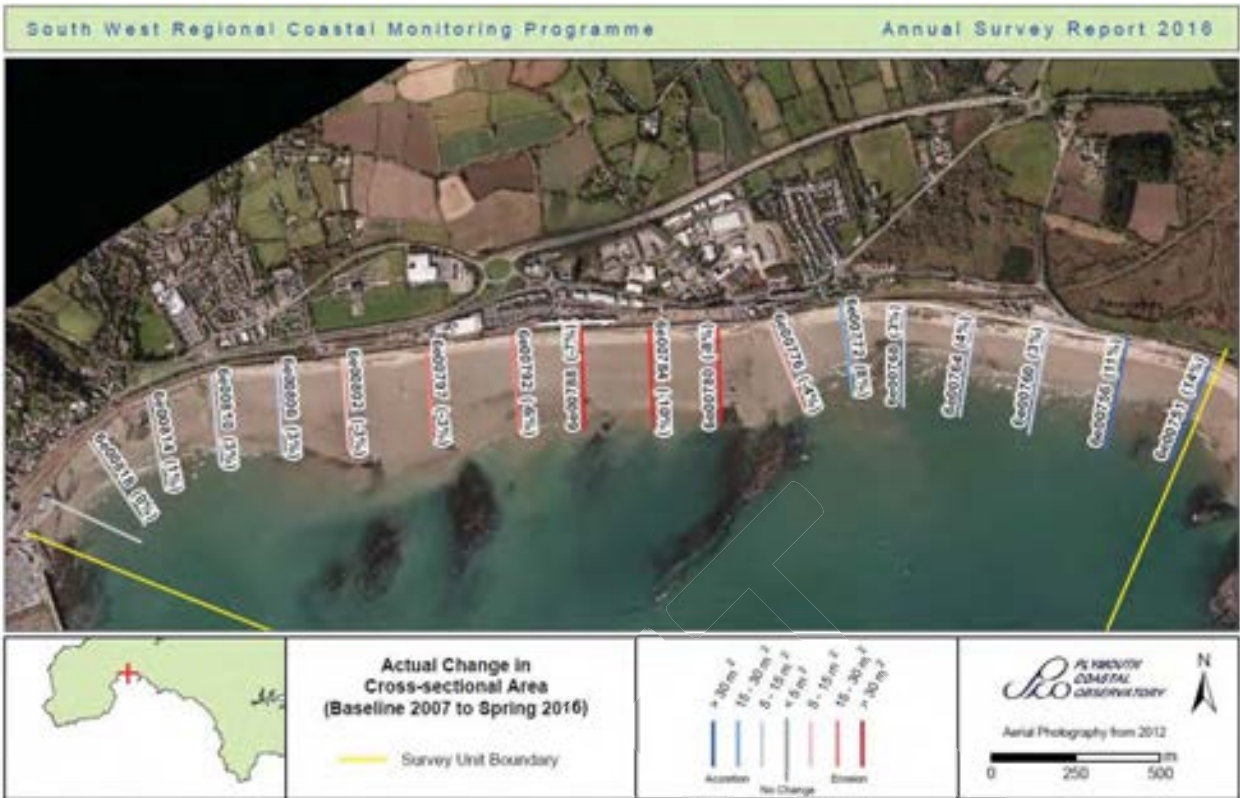


Figure 3.14 Beach profile change within Mounts Bay 2007 to 2016 (source: PCO, 2015a). The Marazion frontage is to the east of the yellow line.



Figure 3.15 MHWs contour change at Marazion beach. Red is 2014, Blue is 2011 and Purple is 2007. Background is 2012 aerial photograph for comparison.

3.3.2.4 Topographic Difference Models

A topographic difference model plot was calculated for Marazion using available LIDAR data from PCO. Unfortunately, no LIDAR data is available before 2011 or for 2015 and 2016 to look at more historic or recent changes, As such, the analysis was only able to examine the beach elevation change for the short-term (January 2011 to May 2014) and the long term (April 2007 to May 2014). Full details are provided in Appendix C, though the following summarises the findings:

Short term (2011-2014)

- The area of dunes west of the Red River (above the MHWS level) appears to have experienced significant erosion over 3 years with levels reducing by up to 2m (average 0.66m/year drop in level). The beach area to the east of this (above 2014 MHWS) and to the west of the Red River channel appears to have experienced accretion of material with levels increasing by up to 1.6m. The lower foreshore directly to the south and east of this area has also experienced accretion.
- On the east bank of the Red River channel some erosion has occurred but only over a relatively small area of the upper foreshore; this could have been influenced by local changes in the channel. Accretion has occurred closest to the dunes at the 2014 MHWS and above this level. However, below the 2014 MHWS level there has been erosion of the mid to lower foreshore; this trend extends further south east towards St Michael's Mount.

Longer term (2007-2014)

- The area of dunes west of the Red River (above the MHWS level) appears to have experienced significant erosion over 7 years with levels reducing by up to 2.2m. Conversely there has been some significant accretion directly in front of these two areas (up to 1.2m) but there is also an area directly south east on the lower foreshore which has experienced minor erosion (up to 1m reduction in bed levels). Accretion also can be observed to the west of the site along the upper and mid foreshore areas and to the east of the Red River channel on the upper foreshore of the beach particularly in front of the dunes.
- Closer inspection of Profile 6e00748L which cuts through the dunes shows that there was some erosion in the area above MHWS between 2007 and 2011 but mainly between 4.8mOD to 2.8mOD elevation (at or above HAT). However, on the lower foreshore there was significant accretion between MLWN (-1.25m OD) and MLWS (2.25mOD). Between 2011 and 2014 significant erosion of the face of the dunes occurs between 3.6m elevation to 6.9m. Between MHWS and MLWN bed levels have increased significantly during this time which is likely to be sediment eroded from the dune face which has been deposited onto the foreshore. This erosion and accretion is likely to have been influenced by the storms of 2013/14.
- Profile 6e00747 has experienced erosion between 2007 and 2011 mainly between 3.4m and 0.7mOD with corresponding accretion on the lower dune/upper beach. However, between 2011 and 2014 accretion appears to have occurred on the upper face but with little changes to the beach level. This is likely to be caused by changes in the Red River channel in this area.

3.4 Summary of Site Influences

Marazion is located on the south coast of Cornwall and is exposed to south-west Atlantic swell waves; however, it does afford some protection from direct wave action from St Michael's Mount and partially submerged rock platforms. The coastline is unique in that there is a small section of semi-natural dunes constrained by formal hard defences at either end; it is also constrained by a road and freshwater SPA site behind so the dunes are not able to naturally regrade and retreat back as they might do otherwise during storm periods (or in the longer term with sea level rise). Situated within the wider Mounts Bay there is minimal longshore transport at Marazion, instead the majority of material is transported cross-shore, with wind-blown sand supporting the dunes.

Results from recent data analysis show that between 2007 and 2014/15/16 beach levels have increased along the majority of the Marazion frontage; this is likely to have been fed by dune erosion from storms (which began in 2007 but erosion occurred most significantly between 2011 and 2014). Given the limited wind data but also the variety of beach response it is difficult to directly link changes in wind speed to the dunes. Unfortunately, there is no more recent profile data on the dunes or LIDAR data available to consider most recent changes between 2014 and today. Aerial photographs do however suggest significant erosion from changes in vegetation cover.

Dune erosion is likely to be periodic and dominated by storm events. Despite the increased material released by the dune erosion onto the beach, the dunes are unlikely to re-grow at the rate they were eroded. This is because of several reasons:

- 1) Windblown aeolian transport takes time to build dunes and in the meantime sediment is more likely to be redistributed alongshore within Mount's Bay; however, some material is likely to be transported onshore during storm periods and blown onto the dunes during recovery periods.
- 2) Even if sand is transported to the base of the dunes (for example during or post- storm periods), time and the optimum elevation is needed for vegetation to grow and stabilise. Vegetated areas then allow further growth of the dune. This is likely to be inhibited by regular public access causing dieback but also over compaction.
- 3) The dune itself is width limited due to the presence of the road behind – the dune is therefore not able to migrate backwards as it would do naturally and hence is being squeezed between the road and the sea. The dune base will therefore be unable to move and will experience periods of accretion and erosion which will limit how quickly it can grow.

3.5 Future Changes

The SMP2 (Royal Haskoning, 2011) predicts that with sea level rise the sand dune areas at Marazion would roll back and Marazion marsh behind would undergo frequent inundation, particularly during storm surges. The shoreline is predicted to retreat by up to 800m inland by 2105 (this is assumed to be once the Marazion Marsh is breached and flooding occurs under a No Active Intervention scenario). St Michael's Mount would be subject to erosion around the existing harbour and causeway area, with associated retreat of the shoreline and the Marazion town frontage could experience 100 to 200m of shoreline recession by 2105, if defences were not maintained (Royal Haskoning, 2009). The erosion of the frontage would likely result in significant sediment input into Mount's Bay which would increase the beach width and slow erosion over short period. It would also result in significant flooding impacts to the road, town and freshwater SPA designated habitat behind.

The Mount's Bay Strategic Assessment of Adaptive Frontages (Royal Haskoning, 2015) re-confirmed the pressure that the frontage faces with sea level rise and holding the line but estimates were significantly lower at 15-20m erosion over 100 years provided no defences are put in place (Figure 3.16 below compares the SMP predictions to Strategy estimates). The strategic assessment predicts that the dune will breach by year 45 but in the interim period the dunes will try to rollback with risks for the road and freshwater SPA behind. For comparison, the National Coastal Erosion Risk Map (NCERM) data has been plotted in GIS and the results are presented below (Figure 3.17). This dataset predicts that up to 250m of erosion could occur at Marazion over the next 100 years. NCERM takes the SMP policy, historical erosion rate data, geological and climate change data and applies a standard methodology to map coastal erosion risk nationally under a No Active Intervention scenario.

Overall there appears to be various estimates for the future retreat between 15m and 800m over the next 100 years (i.e. 0.15m/year to 8m/year) depending on different scenario assumptions. Whilst the estimates are variable it is likely that with sea level rise erosion will continue; key rocky platforms and outcrops will become more submerged and therefore intercept less wave energy (Royal Haskoning, 2015) and the beach levels will reduce. There will be minimal new sediment in the system to re-feed the beaches (and dunes) and maintain widths. Given the existing width of the dunes is approximately 35m wide, regardless of the estimates, there will be a potential risk of breach of the dunes in the near future, with implications for the road and freshwater habitat behind. However, further more detailed monitoring and assessment will be required to assess potential predictions in more detail. The Strategy recommends establishing a stakeholder group and undertaking a separate adaptation planning exercise within the next 2-5 years.

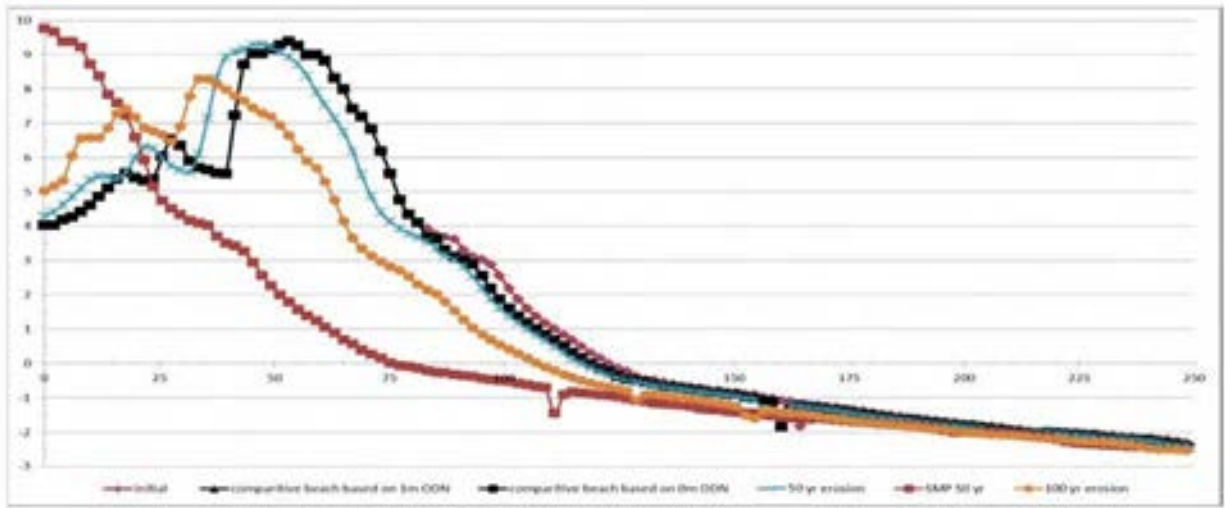


Figure 3.16 Predicted change at Marazion dunes over the next 100 years (Extracted from Royal Haskoning, 2015).

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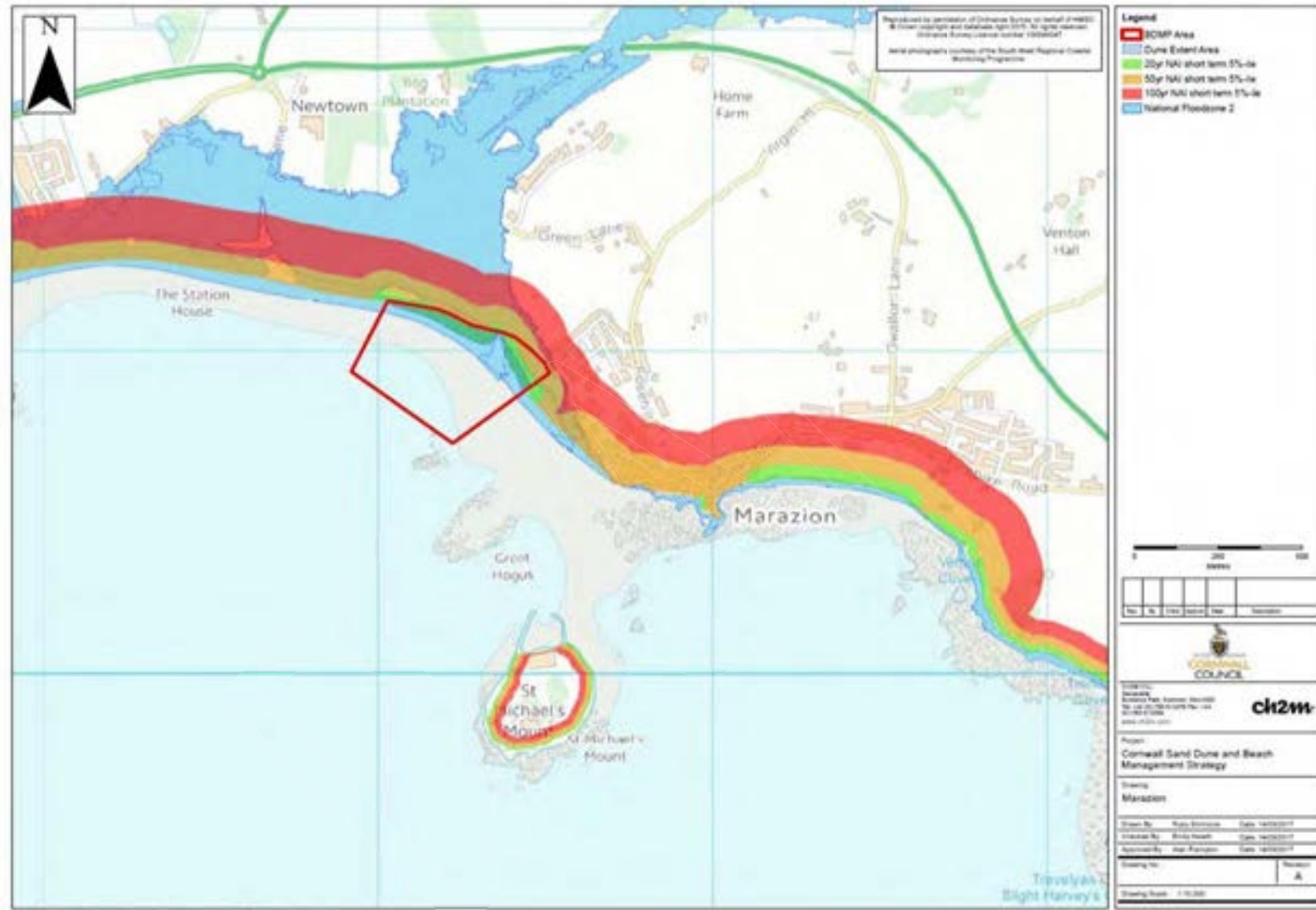


Figure 3.17 Flood and erosion risk projections for Marazion.

Beach & Dune Management Plan

This section covers the development of the Beach & Dune Management Plan and is divided into three sections:

1. Key Issues.
2. Management techniques to apply at Praa Sands.
3. Plan of Action.

4.1 Key Issues

The key issues to be addressed by beach and dune management activities include:

- Erosion of the dunes due to natural processes, including limited sediment in the system, increasing erosion risk to paths and backshore assets including highway.
- Uncontrolled public access within the dunes resulting in dune further erosion and littering.
- Outflanking of hard defence adjacent western end of sand dunes due to erosion.
- Wind-blown sand on highway.
- Constraints posed on dune system by backshore assets including highway and SPA prevent natural rollback.
- Potentially unfavourable BAP habitats and control of non-native invasive species within dune vegetation.
- Consideration of environmental impacts on designated features.
- Lack of information / data relating to beach and dune levels to inform management.
- Limited funding to undertake management activities.

4.2 Management Techniques to Apply at Marazion

This section discusses the management techniques to be applied at Marazion to manage the beach and sand dune system in a sustainable way for the next 50 years. These techniques have been identified from the *Sand Dune Management Techniques Preliminary Decision Support Tool* (see Appendix A) and determined to be appropriate for this location following detailed appraisal (see Appendix D).

A key issue at Marazion is dune erosion as a result of a combination of natural processes (storm events) and human impacts (trampling). This is a particularly significant concern at the western end of the dunes where dune erosion is already outflanking the adjacent hard defences, posing a possible risk of breaching of the defence line during storm events. Key recommendations in this BDMP therefore focus on managing these erosion pressures in the immediate future (next 20-40 years) by a combination of dune stabilisation and access management measures, whilst longer term solutions are investigated and implemented.

4.2.1 Dune Stabilisation

Management of the dunes has been attempted in the past by Cornwall Council and Natural England using dune fencing – though this appears to have been more for access management rather than dune stabilization and not implemented in an ongoing, consistent way.

The intent of the BDMP is therefore to implement dune stabilization measures in the form of fencing, combined with natural forms of stabilisation, such as planting, thatching, mulching, matting or sand binders and supported by appropriate signage. This would allow natural processes to

continue, help retain sand on the dune system and, assuming native plants are used, could have long term positive effects on BAP habitats. Over stabilisation of the dunes would however, not be desirable for habitats and risk of the dunes becoming un-dynamic and unable to react to pressures.

If stabilisation measures are required, access management and signage will be needed to prevent beach visitors trampling any establishing vegetation and hindering stabilisation of the dunes. Although these are relatively low cost measures, they would require ongoing commitment to management and maintenance, with the expectation being that storms will periodically erode stabilised areas and thus re-stabilisation will be needed to encourage post-storm recovery.

Any planned stabilisation measures should be discussed with Natural England prior to implementation, unless it is an emergency situation.

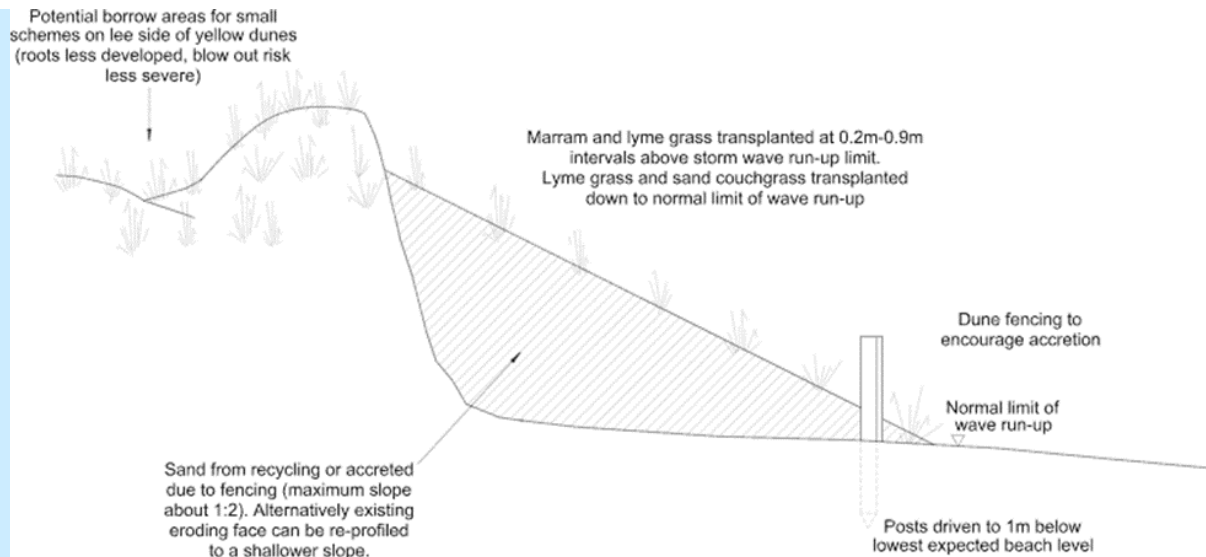
BOX 1 and BOX 2 provide specific guidance on dune planting and dune thatching respectively.

BOX 1: Dune planting guidance

- Planting should only include those species that are indigenous to the site to maintain the natural ecosystem.
- Plant marram grass (*Ammophila arenaria*) on the face of eroding dunes above the limit of direct wave attack.
- Plant sand couchgrass (*Elymus farctus*) or lyme grass (*Leymus arenarius*) along the toe of existing dunes to encourage the growth of new foredunes, as these species are tolerant to occasional inundation by seawater.
- Planting grasses from seed is not recommended in the very active foredune environment.
- Planting should be undertaken in the spring to maximise potential growth and minimise the risk of storm erosion.
- Dune planting schemes must be continuously managed to establish a vigorous growth and to repair natural or human damage.
- Re-profiling, thatching or fencing are normally required in association with planting to enhance dune recovery and to restrict public access or damage.
- Educational signage at backshore car parking areas or along footpaths should be used to explain management schemes and encourage public interest and support for the management objectives.

Example of dune planting

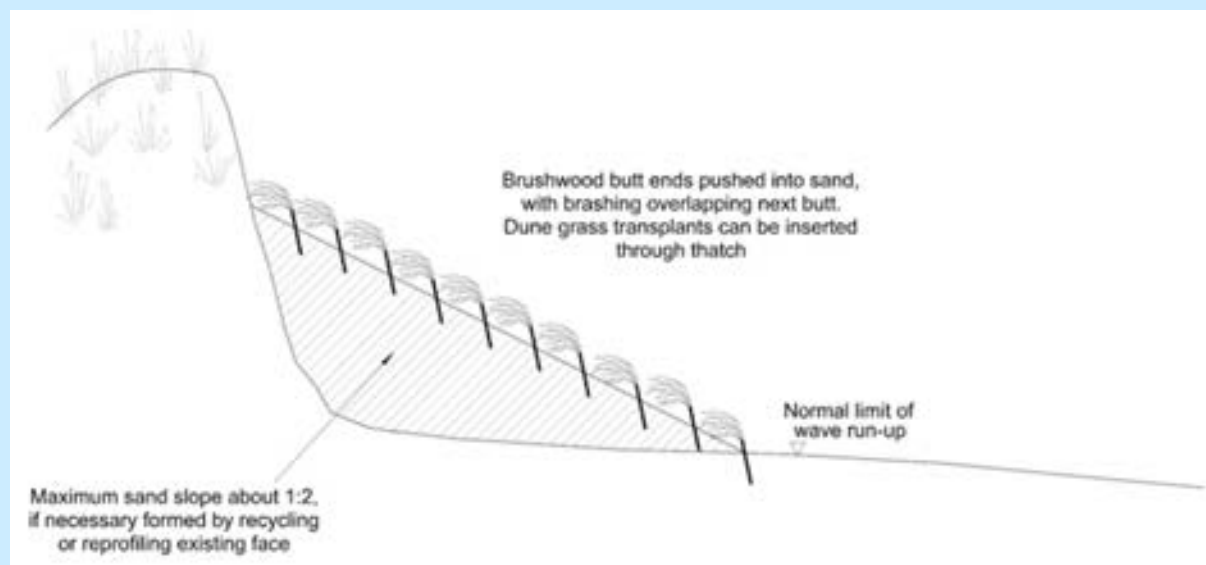




For further information, refer to http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.2.shtml (link correct when accessed on 27th September 2017).

BOX 2: Dune thatching guidance

- Materials can include timber or brushwood cuttings, must be degradable and should not introduce foreign seeds, live cuttings or pollutants that may damage the dune ecology.
- Conifer brushings (lower branches) from spruce or fir are preferred for their flat, fan shapes.
- Thatch should be laid to cover 20% - 30% of the exposed sand surface.
- Dune grasses should be transplanted through the thatch to promote sand retention and restoration of natural habitats.
- Thatching should not be undertaken on steep, freshly eroded slopes. The dune face should be regraded or built out with recycled sand prior to further works. A maximum slope of 1:2 is recommended.
- Thatching should not extend seaward of the line of normal wave run-up.
- Thatch must be regularly maintained to maximise effectiveness and to minimise impact on public use and visual amenity.



For further information, refer to http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.3.shtml (link correct when accessed on 27th September 2017).

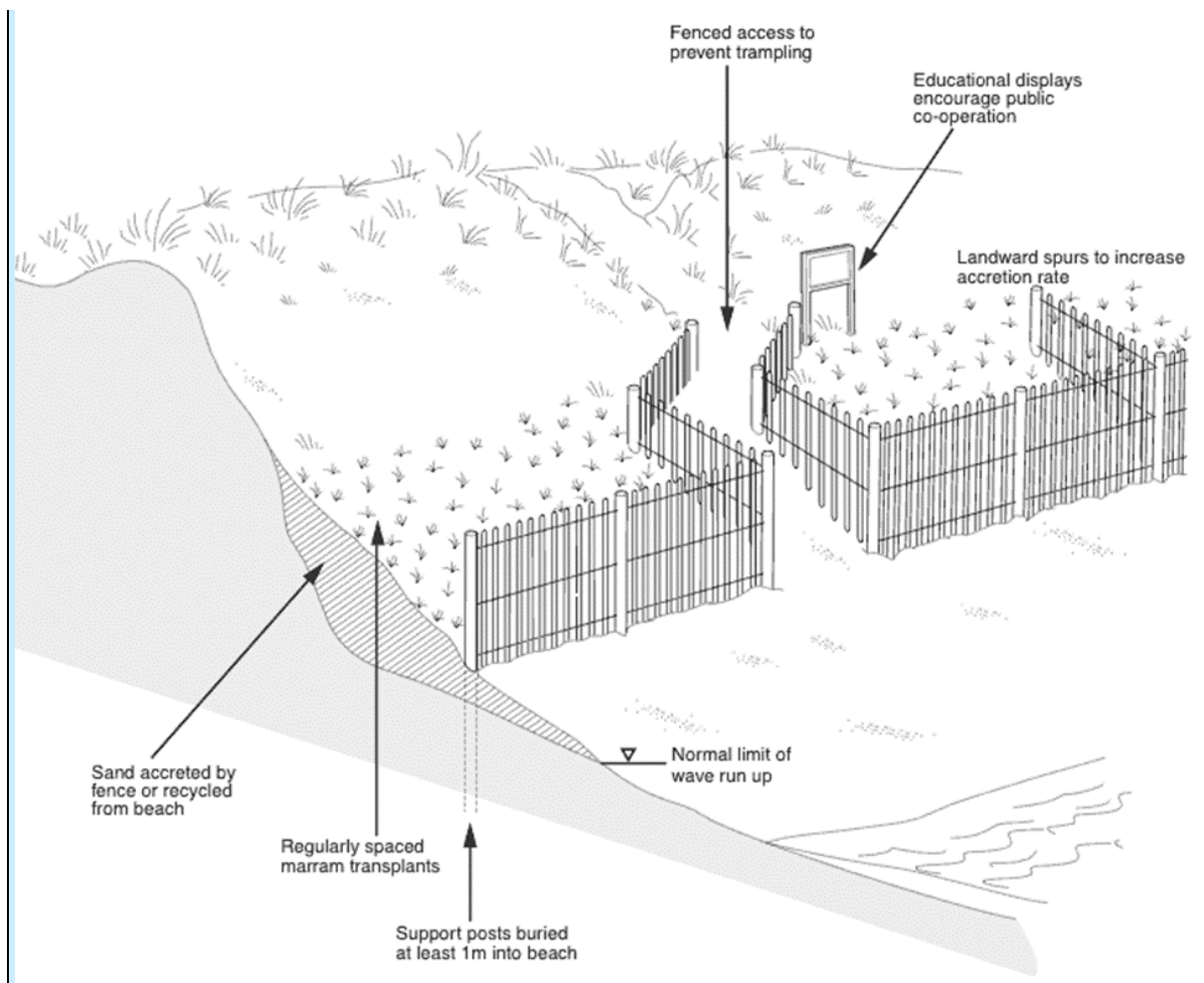
4.2.2 Morphological Modification

Repair and maintenance of current fencing to prevent access to vulnerable dune areas help minimise dune erosion by trampling. Dune management has taken place in the past with the installation of access control fencing, although this has not occurred consistently and none is currently present.

BOX 3 provides specific guidance on dune fencing.

BOX 3: Dune fencing guidance

- Fencing materials can include chestnut palings, brushwood, wooden slats or synthetic fabrics, dependent on required life, length of frontage, commitment to maintenance and vandalism potential.
- Brushwood is normally the cheapest material but has a life expectancy of less than one year.
- Synthetics can be low cost (strawberry netting), or expensive (polypropylene, nylon or composite wire/synthetic webs) and life expectancies vary from one year to decades. Maintenance is minimal, however synthetics should be avoided in areas likely to be heavily affected by storms to reduce hazards to swimmers, navigation and sea life if it becomes damaged.
- Chestnut paling fencing is commonly used and is widely available, easy to erect and has a life expectancy of 2-5 years.
- Fencing can be installed forward of the toe of the dunes where it will be subject to occasional wave attack during storms.
- Fencing posts should be buried to about 1m below the lowest expected beach level. Substantial timbers may be required at locations exposed to regular wave attack.
- Fencing should be constructed parallel to the dune face. Short spurs running landward up the dune face can also be beneficial to recovery in areas subject to dominant winds blowing at an acute angle to the shoreline.
- The void to solid ratio for any fence material should be between 30% and 50% to achieve effective sand accumulation.
- Fencing can be undertaken at any time of year and should be complemented with dune grass planting after the fencing is in place.
- Access routes through the dunes should be defined by the fencing at regular intervals along the dune face.



For further information, refer to http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.4.shtml (link correct when accessed on 27th September 2017).

4.2.3 Sediment Modification

Recycling of windblown sand from areas of accumulation in the car parks and along the road behind the dunes is likely to continue even with dune stabilisation measures. The current practice is to remove this sand from the area as it is considered “contaminated waste”; it is not placed back on the beach. The overall effect of removing sand from the road and car parks to landfill in this way is significant, as it denudes the natural system of sediment that is not being replaced by new, incoming sediment. Over time this will reduce the volume of sediment in the system, making it more vulnerable to storm impacts and increased risk of erosion leading to breaching and so flooding.

It would therefore be preferable to retain the sand from the road/car parks in the system, ideally by placing it on the dunes/in front of (seaward side) of the dunes (or in any new area of dunes created in the SPA landwards of the road, should the planned project to create dunes here proceed).

However, due to pollution issues, it is likely to be more appropriate to place it on the back of the dunes, thus retaining the volume of sediment in the system but not placing potentially contaminated/hazardous material directly in the marine environment. However, there are environmental and waste licensing issues that would need to be overcome to enable this to occur. BOX 4 sets out a suggested trial study that could be undertaken at Marazion in this regards.

BOX 4: Trial study to enable recycling of sand from car parks / roads to be placed on the back of the dune system rather than being removed from the system altogether.

In order to be able recycle sand from roads/car parks rather than removing it from the system altogether, it will first to be necessary to undertake a period of sampling and testing of the sand found on the roads/car parks to develop a picture of the level of hazard (biological/chemical) posed

by the sediment. Once this data is gathered, it will then be necessary to discuss the issue with the waste regulator (EA) and Natural England to first confirm that the level of hazard is sufficiently low enough to allow material to be placed on the back of the dunes, and then to confirm/agree the regulatory route to go down to agree this activity. It is likely this will require a site by site agreement, and so a pilot project testing this approach on just one site – potentially here at Marazion or at Porthtowan, Summerleaze or Widemouth Bay – could be undertaken to test the approach.

4.2.4 Ecological Modification

Within the dunes, invasive, non-native species, such as Japanese knotweed, montbretia, and sea buckthorn, can threaten the native dune wildlife. Removal of non-native invasive species will improve the condition of designated features. However, best practice methods should be used to minimise both impacts to protected species and risk of destabilising dunes. Removal of these non-native species by pulling up by hand or mechanically and treating with a biodegradable herbicide is required to have a positive long term impact on the improvement of designated features and BAP habitat.

In addition, it is suggested that these efforts to control invasive species should form part of a new dune habitat management plan for Marazion that sets out wider habitat management to maximise ecological gains in the area (including the SPA located landwards of the road behind the dunes). Such a habitat management plan should be developed in partnership with Natural England and other key stakeholders.

4.2.5 Access Management

Dune management has taken place in the past with the installation of access control fencing, although none is currently present.

Restricting access to certain areas, for example with the use of posts and rope or removable structures which have the benefit of easy removal, and signage / information boards, could help allow natural processes to continue, help minimise dune erosion and aid recovery of trampled areas. Redirection of existing routes would need to be considered carefully so as to not impact designated features. The implementation of specific route ways can however lead to a concentration of foot traffic in these areas, and focus trampling. Therefore, careful design of post and rope walkways would be required at appropriate locations and monitoring of erosion along pathways should be carried out regularly.

Safety issues may arise at the base (seaward end) of access tracks and steps/cliffing caused by dune toe erosion/beach lowering could be addressed by rerouting paths/tracks down to the beach.

BOX 5 provides further specific guidance on access walkways.

BOX 5: Access walkway guidelines

- Access routes should be clearly visible and defined.
- In general, construction of excessively wide access routes on coastal dunes limits the amount of vegetation that can grow. In general, they should be no wider than 4 feet (and preferably narrower) and extend no longer than necessary to provide access to the beach.
- Paths should follow the natural contours of the dunes rather than cutting straight lines susceptible to wind erosion.
- Rollout structures used on a seasonal basis are a good option. These temporary structures are not fixed to the ground and can be removed during the off-season to reduce the potential for storm debris and to allow the dune to function unimpeded when wind-driven sediment transport is generally higher and the demand for beach access is reduced.
- Construction activities should be timed to minimise or avoid impacts if they are in or adjacent to endangered or threatened species habitat.

- Construction that will remove plant cover and expose areas to erosion during the storm season (winter) is not recommended.
- For removable options non-wood materials such as bark chips or matting are low cost and have low impact on the environment.



Example of a removable access structure (Source: <http://lizardandpenrose.blogspot.co.uk/2012/03/under-boardwalk.html>; link correct when accessed on 27th September 2017).

4.2.6 Manual Maintenance

Increased provision of bins for both litter and dog waste during the summer months (beyond those in place all year round), strategically placed on the beach, along dune access routes, around the car parks and catering facilities should be considered to address seasonal litter issues. The provision of additional bins should match demand, and so the number could be reduced during the low season to current levels. Accompanying signage is also important as education has a big role to play with beach visitors encouraged not to litter but to take their waste home or put it in a bin.

Barbecue safe bins could be installed during the peak season close to designated barbeque areas, and beach recycling facilities should be made available alongside general refuse bins.

Local volunteer beach cleans could also be organized one or two times per year.

4.2.7 Public Awareness

Education of beach users in the importance of dune management could encourage people to respect the management techniques put in place. Information signs should be developed and situated at key locations, such as at beach/dune access points, and next to the car park pay and display machine, to explain the importance of the dunes and the management techniques being employed. Signage needs to be eye catching and should include information such as:

- The importance of the dunes at Marazion.
- The pressures on the dunes, including high visitor numbers and wave erosion.
- The impact of the actions of beach users on the dune system.

- Dune Management techniques in place and how they can help the dune system.
- How the beach users can contribute in protecting and enhancing the dune system.

Smaller repeater signs should be placed at strategic locations within the dunes. Educational leaflets could also be produced and placed at strategic locations. Signs indicating access routes should be clear and easily visible to make following the designated routes the 'easy option' for visitors.

Liaison with regular beach users could also be carried out through the development of a local beach user / 'friends' group, bringing together local residents, businesses, landowners and beach users. Cornwall Council could liaise with the user group, providing information on the site and management activities carried out and consulting local users on proposed techniques. Public awareness campaigns may also help to promote conservation of the dunes and promote dune recovery. All signage and associated management measures will require regular maintenance to be effective. This can be carried out by a dune warden if such a position were to be established.

Alongside educational information, a beach/dune warden could reinforce messages while also provide an authoritative figure to ensure management measures implemented are not damaged by the public. A warden could patrol the site conversing with the public and providing a contact between the beach/dune users and the beach/dune managers as an effective way of providing information to visitors during the summer months.

Figures 4.1 to 4.4 provide examples of different types of signage.

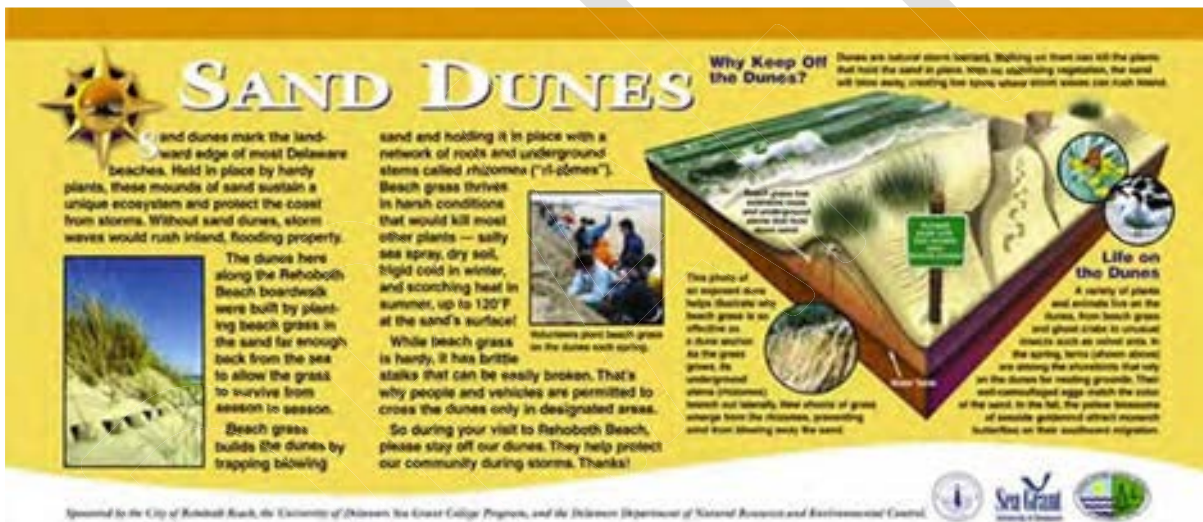


Figure 4.1 Sand dune educational signage example (from <https://www.deseagrants.org/sites/default/files/attachments/SandDune.jpg>; link correct when accessed on 27th September 2017).



Figure 4.2 Beach signage examples (from <http://www.screenmakers.com.au/services/parks-and-places/bondi-to-bronte-coastal-walk>; link correct when accessed on 27th September 2017).



Figure 4.3 Post and panel beach signage example, Exmouth (from <http://www.signsexpress.co.uk/branch/25/exeter/portfolio/28/post-and-panel/>; link correct when accessed on 27th September 2017).



Figure 4.4 Dune signage example, Studland Bay (from <http://www.earthstudies.co.uk/Geography/Coasts%20G3/Studland/Studland%20management.html>; link correct when accessed on 27th September 2017).

4.2.8 Monitoring

Beach surveys are currently undertaken by the South West Regional Coastal Monitoring Programme on a twice yearly basis, with additional post storm surveys following major storm events, if called out by Cornwall Council or the Environment Agency. The frequency of ongoing monitoring by the regional coastal monitoring programme could be increased or supplemented by local inspection to include post-storm events/post-winter surveys, and provide greater coverage of the beach, cliffs and dunes. This will provide information for later management decisions to inform of any patterns in the worsening of erosion within the dunes or lowering of beach levels fronting the dunes. Further detail is provided in Section 4.4.1.

Monitoring of dune vegetation by visual inspection should be undertaken regularly to assess the abundance and extent of vegetation, to inform revised assessment of the BAP habitat condition and determine if it is necessary to take action to further remove non-native, invasive species; giving consideration to whether or not doing so will adversely impact the stability of the dunes in the areas where vegetation clearance is proposed. Refer also to Section 4.4.1.2.

4.2.9 Funding

The availability of funding to deliver this management regime is a key challenge. Funding for monitoring by the South West Regional Coastal Monitoring Programme is only presently confirmed until 2021/22, and every effort should be made to support a funding bid to extend this programme beyond this date (refer to Section 4.2.8).

In order to implement the physical dune management measures themselves described in this BDMP, some funding is likely to be available from Flood and Coastal Erosion Risk Management Grant-in-Aid (FCERM-GiA) but a significant proportion of funding will need to come from other third-party sources. The Mounts Bay Strategic Assessment of Adaptive Frontages (Royal Haskoning, 2015) determined that FCERM-GiA could amount to about £3.69m over 40 years, leaving a requirement for £6.43m to be derived from other sources. One such possible source is the St Aubyn Estates, who have advised that they are willing to consider contributing towards the future management costs of the dunes. In the immediate future, the establishment of a local volunteer group (e.g. "Friends of Marazion Dunes") could also support delivery for dune management activities at a relatively low cost and should be considered as a contribution to the overall funding requirements. Such a group could

assist in dune management measures described above, as well as undertaking monitoring activities (refer to Section 4.4.1.2) and organising beach clean-ups etc. (refer to Section 4.2.6).

This funding issue will be a key consideration for the Mounts Bay Strategy to investigate in the coming years as it develops. To support that work, the Coastal Change Adaptation Planning Guide for England (Halcrow, 2015) includes a matrix to aid and guide consideration of funding efforts when developing locally-specific adaptation approaches, and this is provided here for ease of reference as Figure 4.5. Cornwall Council and the Environment Agency should actively seek partnerships with developers/businesses/communities to raise funds to enable delivery of future FCERM activities.

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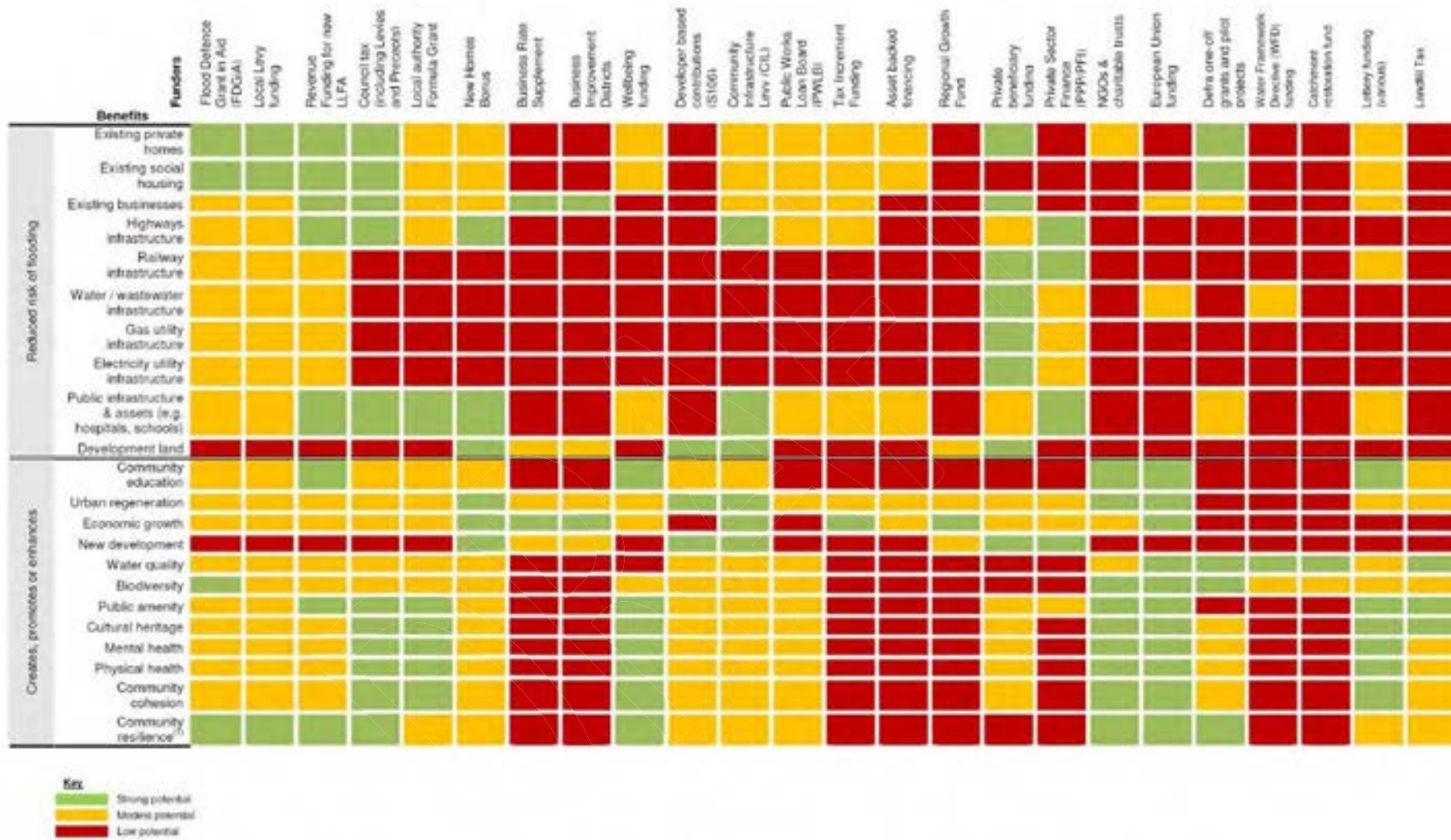


Figure 4.5 Example of a matrix of potential funding sources (from Halcrow, 2015).

4.3 Plan of Action

Table 4.1 provides a summary of the recommended actions at Marazion discussed in Section 4.2. Reference should also be made to the site actions summary map (see Figure 4.6 or Appendix E) that indicates where on the site specific actions relate to.

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Table 4.1 Recommended actions for Marazion

Issue	Recommended Management Action	Timing	Who Should Action	Risk Identification		When by?	Reference: Links all correct when accessed on 27 th September 2017
				Risk	Mitigation		
Erosion of dunes increasing erosion risk to paths and backshore assets.	<ul style="list-style-type: none"> Fence off vulnerable areas and set up planned access routes. Construct post and rope along access paths. Where bare sand areas do not re-establish implement stabilisation techniques such as planting and where necessary matting/ binding to stabilise vulnerable areas. 	<ul style="list-style-type: none"> Establish fencing and access routes prior to main tourist season. Planting in Spring – prior to peak tourist season. In general planting tends to be most successful in early March. 	Cornwall Council, in discussion with Natural England and working with local beach users /volunteers.	<ul style="list-style-type: none"> Exclusion zones not abided by. Planting does not establish. 	<ul style="list-style-type: none"> Educational information signs and liaison with beach users to ensure the role and importance of the exclusion zones are understood. Select robust species. Plant when conditions are most favourable (early Spring). 	Annually each Spring from 2018	PLANTING - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.2.shtml FENCING - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.4.shtml THATCHING – http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.3.shtml
Uncontrolled public access within the dunes resulting in dune erosion.	<ul style="list-style-type: none"> Fence off vulnerable areas and set up planned access routes. Construct post and rope along access paths. Implement a zoning scheme discouraging visitors from vulnerable zones and providing facilities such as barbecue areas in less vulnerable zones. Where bare sand areas do not re-establish implement stabilisation techniques such as planting and where necessary matting/ binding to stabilise vulnerable areas. 	<ul style="list-style-type: none"> Establish fencing and access routes prior to main tourist season. Planting in Spring – prior to peak tourist season. In general planting tends to be most successful in early March. 	Cornwall Council, in discussion with Natural England and working with local beach users /volunteers.	<ul style="list-style-type: none"> Exclusion zones not abided by. Planting does not establish. 	<ul style="list-style-type: none"> Educational information signs and liaison with beach users to ensure the role and importance of the exclusion zones are understood. Select robust species. Plant when conditions are most favourable (early Spring). 	Annually each Spring from 2018	PLANTING - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.2.shtml FENCING - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.4.shtml THATCHING – http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.3.shtml
	<ul style="list-style-type: none"> Education of beach users so the sensitivity of the dunes is understood. Design information boards and leaflets outlining the importance of the dunes and the vulnerability of the dune system. Place boards and repeater signage at strategic locations throughout the site. Employ a designated warden to patrol the site. 	<ul style="list-style-type: none"> Design boards and display prior to main tourist season. 	Cornwall Council, working with local beach users /volunteers.	<ul style="list-style-type: none"> Beach users do not read or abide by signage. 	<ul style="list-style-type: none"> Design clear, attractive signage which will catch the eye of beach users and provide easy to understand information. Place signage at strategic locations to ensure they are seen by beach users. 	Spring 2018	SIGNAGE – https://rnl.org/-/media/rnli/downloads/rnli-guide-to-beach-safety-signs-flags-and-symbols.pdf?la=en Warden scheme has successfully been implemented at Perranporth. Nature walks are implemented at Perranporth and Gwithian.
	<ul style="list-style-type: none"> Liaise with regular beach users, local residents, landowners to improve understanding of the dune system and encourage users to be 	<ul style="list-style-type: none"> Meet for discussions just before main tourist season to ensure messages are 'fresh' and can be 	Cornwall Council working with local beach users /volunteers.	<ul style="list-style-type: none"> Regular beach users, local residents, landowners are not interested in dune management and do not pass on the 	<ul style="list-style-type: none"> Identify the relevant persons who will be using or working at Marazion beach/dunes and interacting with other beach users. 	Ongoing from 2018	Successful liaison with mountain board instructors successfully reduced the impacts of mountain boarding on steep bare sand dunes at Gwithian Towans.

Issue	Recommended Management Action	Timing	Who Should Action	Risk Identification		When by?	Reference: Links all correct when accessed on 27 th September 2017
				Risk	Mitigation		
	<p>considerate of the dune system.</p> <ul style="list-style-type: none"> A local user group to be developed to facilitate this. 	implemented during the peak season.		<p>information to others.</p> <ul style="list-style-type: none"> The wrong people are identified and the message is not spread effectively. 			
Access issues onto the beach and public safety with low beach levels.	<ul style="list-style-type: none"> Monitor access routes for safety issues. Re-route paths/tracks down to the beach 	<ul style="list-style-type: none"> Assess and implement before peak season. 	Cornwall Council working with local beach users /volunteers.	<ul style="list-style-type: none"> Safety issues if drop is left at the end of the steps when beach levels are low. 	<ul style="list-style-type: none"> Monitor access to the beach and implement actions to address safety issues when required. 	Annually each Spring and Autumn, and after notable storms.	
Wind-blown sand on road and car parks resulting in removal of sediment from the system.	<ul style="list-style-type: none"> Implement stabilisation techniques in key locations such as planting and fencing where necessary matting/ binding to stabilise vulnerable areas. Undertake sampling and testing of the sand found on the roads/car parks and analyse data. Discuss and confirm the level of hazard. If appropriate confirm/agree the regulatory route to go down to agree this activity. Recycling sand to the back of the dunes if sand is low level contamination. 	<ul style="list-style-type: none"> Planting in Spring – prior to peak tourist season. In general planting tends to be most successful in early March. 	Cornwall Council, in discussion with Natural England.	<ul style="list-style-type: none"> Planting does not establish. Pilot project not undertaken or is unsuccessful (i.e. sand has high level contamination levels), meaning sediment is continued to be removed from the system once it is blown into the car park, thus denuding the volume of sediment in the system and increasing vulnerability. 	<ul style="list-style-type: none"> Select robust species. Plant when conditions are most favourable (early Spring). 	Ongoing from 2018	<p>PLANTING - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.2.shtml</p> <p>FENCING - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.4.shtml</p> <p>THATCHING – http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_1.3.shtml</p>
Increased littering on the beach during summer months.	<ul style="list-style-type: none"> Increase provision of bins in strategic locations and accompanying signage. Increase emptying of bins during the high season. Provide adequate recycling facilities. Provide Barbeque safe bins. 	<ul style="list-style-type: none"> Spring to Autumn. 	Cornwall Council working with local beach users /volunteers.	<ul style="list-style-type: none"> Littering poses risk of pollution and is not aesthetically pleasing to beach users, so also poses risk to amenity use and subsequent impact on local economy. 	<ul style="list-style-type: none"> Promote beach users to be responsible and put rubbish in bins/take rubbish home. Provide bins at access points along with signage to promote messages. Undertake voluntary beach cleans to involve local community at least 1 or 2 times per year (Spring / Autumn). 	Annually from Spring to Autumn, from Spring 2018	<p>LITTER FREE COAST & SEA – https://www.litterfreecoastandsea.co.uk/</p> <p>MARINE CONSERVATION SOCIETY BEACHWATCH – http://www.mcsuk.org/beachwatch/</p>
	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Design signs and boards and display prior to peak tourist season. Maintenance of signage to be carried out annually or as appropriate. 	Cornwall Council working with local beach users /volunteers.	<ul style="list-style-type: none"> Beach visitors ignore signage and continue to hold barbecues and drop litter. 	<ul style="list-style-type: none"> 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. 	Ongoing from Spring 2018	<p>SIGNAGE – https://rnli.org/-/media/rnli/downloads/rnli-guide-to-beach-safety-signs-flags-and-symbols.pdf?la=en</p>
Control of non-native invasive species within dune vegetation.	<ul style="list-style-type: none"> Remove non-native species by hand or mechanically and treat 	<ul style="list-style-type: none"> Short / Medium term. 	Cornwall Council working with	<ul style="list-style-type: none"> Further spread of non-native invasive species with 	<ul style="list-style-type: none"> Monitor and remove non-native invasive species. 	Annually from 2018	

Issue	Recommended Management Action	Timing	Who Should Action	Risk Identification		When by?	Reference: Links all correct when accessed on 27 th September 2017
				Risk	Mitigation		
	with a biodegradable herbicide. <ul style="list-style-type: none"> Monitor dune vegetation. 		local beach users /volunteers.	subsequent deterioration in (potential) BAP habitat condition.			
Dune habitat management.	<ul style="list-style-type: none"> Develop and implement a wider dune management plan to guide all aspects of managing dune habitat for ecological gain. 	<ul style="list-style-type: none"> Medium term. 	Cornwall Council and Natural England, working with local beach users /volunteers.	<ul style="list-style-type: none"> Potential for ecological gains limited if not managing habitat of whole dune system is a planned way. 	<ul style="list-style-type: none"> Develop and implement a wider dune management plan. 	December 2018	
Lack of information / data relating to beach and dune levels to inform management.	<ul style="list-style-type: none"> Implement monitoring scheme and response regime. Coastal processes to continue to be monitored as part of SWRCMP, ideally incorporating additional requirements identified (refer to Section 4.4.1.1). Asset condition to be assessed by regular walkover visual inspections, supported by fixed aspect photography and reporting (refer to Section 4.4.1.2). 	<ul style="list-style-type: none"> Post storm inspections/surveys to occur within one or two tidal cycles of storm event. Coastal processes monitoring to be as per SWRCMP programme (refer to Section 4.4.1.1). Walkover inspections at least each spring and autumn and after notable storm events, with report produced after each inspection (refer to Section 4.4.1.2). 	Cornwall Council in conjunction with Plymouth Coastal Observatory.	<ul style="list-style-type: none"> Requirement for post storm survey not identified soon enough and beach profile has readjusted. Lack of appropriate data to make informed decisions to manage coastal risk. 	<ul style="list-style-type: none"> Identify threshold storm conditions to initiate post storm surveys. Work with SWRCMP to ensure capture required coastal processes data. Liaise with Plymouth Coastal Observatory to ensure Marazion is a key site for post storm surveys. Ensure summary reports are produced after each visual walkover inspection and that these document actions to be taken. Establish a Citizen Science approach to enable information captured by local beach users to supplement data for intervening periods (support by establishing means for local beach users to submit data and information on what is useful to submit). 	Ongoing from 2018	<p>SOUTH WEST REGIONAL COASTAL MONITORING SCHEME - http://www.channelcoast.org</p> <p>MONITORING INFORMATION - http://www.snh.org.uk/publications/online/heritagemanagement/erosion/appendix_2.shtml#a5</p> <p>CITIZEN SCIENCE GUIDE – https://www.ceh.ac.uk/citizen-science-best-practice-guide</p>
Limited funding to undertake management activities.	<ul style="list-style-type: none"> Actively seek partnerships with developers / businesses / communities to raise funds. 	<ul style="list-style-type: none"> Short, medium and long-term. 	Cornwall Council and Environment Agency	<ul style="list-style-type: none"> If funding is not available to undertake FCERM activities when and how it is best to do so, then there is a risk that no works will occur, increasing risk of erosion as a result. 	<ul style="list-style-type: none"> Assess potential beneficiaries and develop a partnership funding strategy to guide discussions with potential funding partners. Seek funding commitments from partners. 	Ongoing from 2018	<p>FCERM FUNDING GUIDANCE – https://www.gov.uk/guidance/flood-and-coastal-defence-funding-submit-a-project</p> <p>Partnership funding and collaborative delivery of local flood risk management: a practical resource for LLFAs – http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=17085</p>

[MAP TO BE PRODUCED AND ADDED HERE]

Figure 4.6 Site Actions Summary Map for Marazion (copy also provided in Appendix E)

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4.4 Monitoring and Response

4.4.1 Survey Requirements

4.4.1.1 Coastal processes monitoring

Monitoring of coastal processes is to continue to be undertaken until at least 2021 by the South West Regional Coastal Monitoring Programme (SWRCMP). The SWRCMP survey schedule for Marazion is shown below in Table 4.2.

Table 4.2 SWRCMP survey schedule for Marazion (from http://www.channelcoast.org/southwest/survey_programme_schedule/; link correct when accessed on 27th September 2017).

Survey Schedule		
Survey Type	Frequency	Profile Spacing / Survey Extent
Topographic Baseline	1 Per 5 Year Phase	50m to MLWS
Topographic Interim	Spring and Autumn	150m to MLWS
Bathymetry	1 Per 5 Year Phase	50m Profiles to 1km Offshore
Aerial Photography	1 Per 5 Year Phase	MLWS
LiDAR	2013/14	MLWS
Habitat Mapping	1 Per 5 Year Phase	As Required

Figures 4.7a and 4.7b below show the location of the baseline and interim beach profiles measured at Marazion (refer also to Figure 3.9 to 3.15 above).

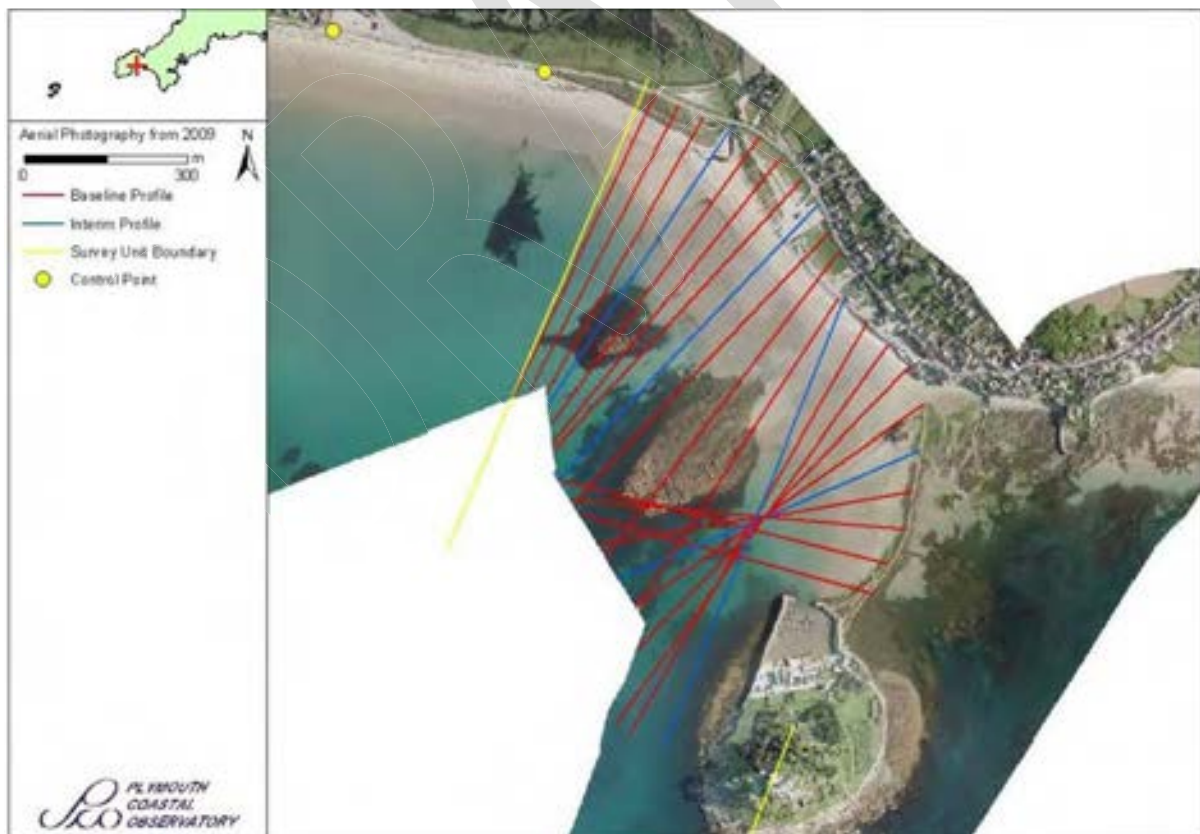


Figure 4.7a Location of beach profiles currently measured by the South West Regional Coastal Monitoring Programme at Marazion within cell 6eSU10-1 – Marazion (Source: Plymouth Coastal Observatory).

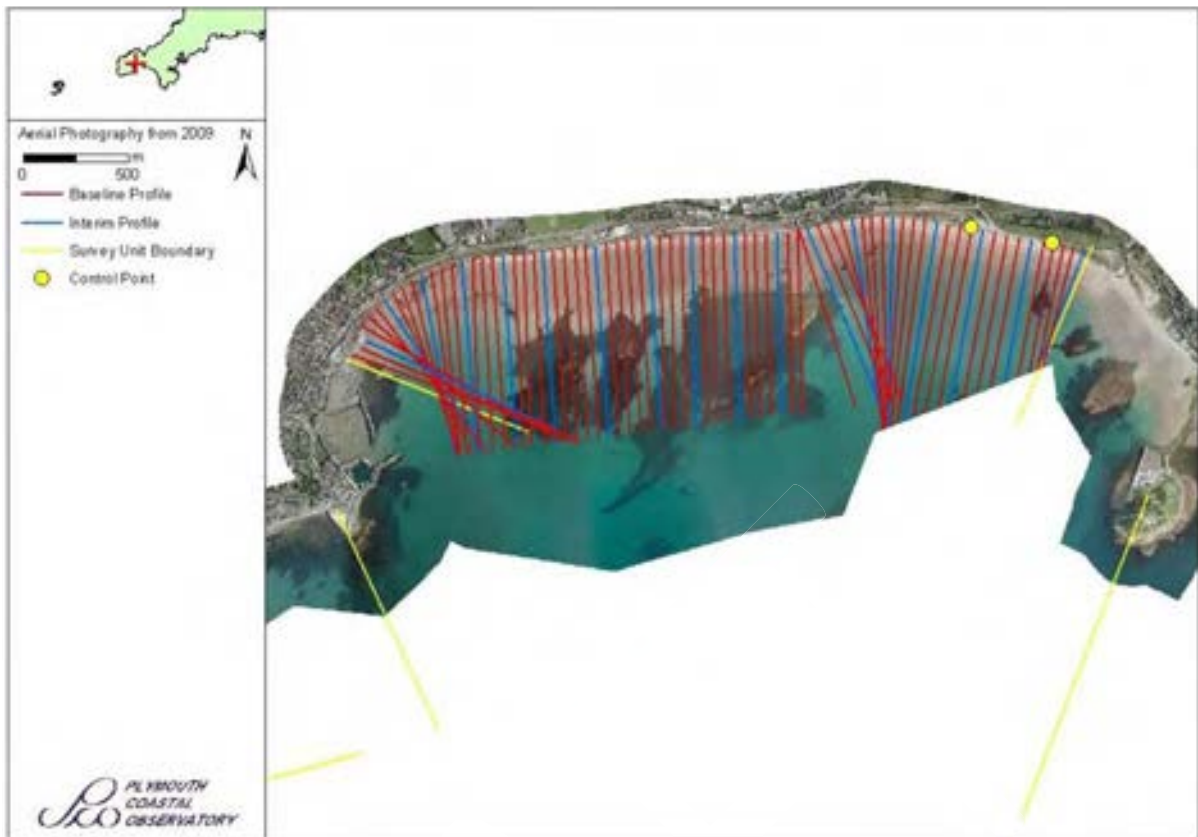


Figure 4.7b Location of beach profiles currently measured by the South West Regional Coastal Monitoring Programme at Marazion within cell 6eSU10-2 – Mounts Bay (Source: Plymouth Coastal Observatory).

Whilst the work of the SWRCMP is to continue to be the primary means of monitoring the physical processes at Marazion, Cornwall Council should liaise with the SWRCMP team to seek to ensure survey data provides the information required at this location to inform future management decisions, namely:

- Ensuring that profile lines surveyed extend landwards to the road behind the dunes in all locations, to capture changes in the whole dune area.
- A photograph should be taken of the dune face at the time of each profile survey. The photograph will provide information on vegetation cover and dune face characteristics such as slumping or cliffing.
- Capture more than two regular surveys per year, and for all profile lines (i.e. interim profile locations should be all baseline locations, not just a sub-set of them).
- Utilise drones to capture Lidar and/or orthorectified aerial photography data more frequently than currently programmed.
- Monitoring of volume of sand blown over onto road and frequency of removal/recycling of material back onto beach.

This additional monitoring data will provide further information on aspects including the beach level, position of the dune front, and the dune shape which will aid future reviews of this BDMP.

4.4.1.2 Asset condition monitoring

In addition to the coastal processes monitoring data collected by the SWRCMP described in Section 4.4.1.1, Cornwall Council should undertake regular walkover surveys to monitor the issues identified in this report, and the success of any management measures implemented. This should include a visual assessment of aspects such as:

- General condition of beach, dunes and other assets.

- 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/walkways or fencing.
- Growth and spread of vegetation in planted areas.
- Vegetation coverage and condition.
- Distribution and abundance (i.e. increase/decrease) of invasive species.
- Embryo dune formation at the dune toe.
- Consideration of whether or not trigger levels, as defined in Section 4.4.2, have been reached.

These visual condition inspections should be undertaken at least each spring and autumn, and following notable storm events.

The condition of fencing should be monitored on a regular basis, particularly after storms, busy summer periods, and public events on the beaches.

These visual inspections should also include fixed aspect photography at key problem areas including access routes subject to erosion and also bare sand areas (i.e. take photos at the same location of the same view on each inspection).

Regular monitoring of implemented management techniques should be carried. Dunes are dynamic systems and the effectiveness of management techniques may not be consistent. Through monitoring, the dune management techniques in place can be regularly assessed and adapted to improve effectiveness and prevent the continuation of unsuccessful techniques that do not benefit the dune system.

A brief inspection report, including photos and summary of findings and actions to be taken, should be produced after each inspection and copies retained alongside this BDMP.

These activities could also be supported with data collected in intervening periods by local beach users (i.e. establish a “citizen science” type approach). This would need to be supported by Cornwall Council to provide guidelines to local users on what information is useful to record, and mechanisms for submitting information to a central repository where it can be analysed etc.

4.4.2 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 is only available from Spring 2007 to present. Due to the short time period involved, this dataset does not provide enough information for specific measured trigger levels to be defined at this time. Action and Emergency trigger states have therefore been developed for the dunes based on assessment of the data available, the dune characteristics and engineering judgement. These trigger levels are to be reviewed and refined when the BDMP is next reviewed,

taking into account the greater amount of monitoring data that is expected to be available by that point (assuming that the monitoring needs defined in Section 4.4.1 are implemented).

4.4.2.1 Action conditions

The Action State is defined as the beach/dune level at which intervention is required. At Marazion 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.

Table 4.3 outlines the key indicators for action conditions and the criteria for assessing whether action conditions have been reached. Refer also to the site actions summary map in Figure 4.6 above.

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 4.3.

Table 4.3 Action conditions and responses

Criteria	Likely consequence	Response
Unacceptable area of bare sand		
<ul style="list-style-type: none"> Area 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 in size. 	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> Fence off bare sand areas to prevent access and enable recovery. If vegetation does not establish following fencing, and area of bare sand is of concern, implement dune stabilisation planting following discussion with Natural England. Implement rotation of access routes to aid recovery.
Access Points eroded to a level at which they cause a health and safety risk		
<ul style="list-style-type: none"> Access points eroded (or where beach levels have dropped) to form a high step which is not safe for pedestrians and is at high risk of causing injury. Access point has been eroded to form a steep cliffed step for more than one season. Erosion is continuing and access is becoming more difficult and/or a greater health and safety risk. 	<ul style="list-style-type: none"> Access is eroded at start of the peak season and is likely to be worsened by high foot traffic throughout the peak season. 	<ul style="list-style-type: none"> Consider re-routing pathways away from the eroded area where possible. Fence off and stabilise the eroded access route to enable it to recover. Introduce “dog legs” wherever possible in access routes to prevent uninhibited wind-blow.
Cliffing of dune front		
<ul style="list-style-type: none"> Cliffing of the dune front as a result of wave action is at a height that can cause a health and safety risk and is present along a significant length of frontage which cannot be easily avoided by visitors. Cliffing of the dune front has been present for more than one season and hence is not likely to be a post storm response followed by recovery during calmer conditions. 	<ul style="list-style-type: none"> Further storm conditions predicted which are likely to cause further erosion of the dune front and increased cliffing, and potentially pose risk of loss of assets to erosion. 	<ul style="list-style-type: none"> Ensure monitoring of dune front is carried out to provide information on trends in the dune front position and to monitor whether cliffing worsens to emergency state. If erosion of beach and dunes is a consistent issue, commission study to assess whether beach nourishment or another soft engineering solution is justified.

Criteria	Likely consequence	Response
<ul style="list-style-type: none"> Cliffing is becoming steeper and higher as erosion continues with no sign of recovery. Cliffing erodes dune back to a point where there is an imminent risk of loss of assets. 		<ul style="list-style-type: none"> Fence off area that forms a health and safety issue and apply dune stabilisation measures such as planting to reduce instability and make the dunes more resilient against erosion. Most suitable if significant storm conditions are not predicted in the immediate future and dune front is not exposed to constant wave action.
Missing Management Infrastructure		
<ul style="list-style-type: none"> Infrastructure removed or damaged by beach users such as; signage removed or vandalised, planks taken from board walks, fencing removed. Due to missing infrastructure beach management measures are impaired. Trend is continuing with more infrastructure being removed or damaged by visitors. 	<ul style="list-style-type: none"> Missing infrastructure noted immediately prior to and during the peak season, and more is likely to be removed/ damaged until the end of the season. 	<ul style="list-style-type: none"> Assess why management has been damaged/ removed and whether an alternative form of management would be more successful. Replace missing infrastructure with the same or an improved form to enable management measures to be effective. Implement/ increase educational signage and leaflets and ensure liaison with beach users and local instructors to encourage visitors to consider the need for dune management and the implications of damaging/ removing management techniques. Implement/increase presence of dune warden.
Wind-blown sand		
<ul style="list-style-type: none"> Sand built up in car park and along roads. 	<ul style="list-style-type: none"> Impairment of access routes and road/car park, health and safety issues. Reduced volume of sand in beach-dune system leading to increased vulnerability. 	<ul style="list-style-type: none"> If sand is on road or car park, <u>subject to pilot project</u>, preference is to remove sand from road/car park and place at the back of the dunes so as to not remove sediment volume from system.

4.4.2.2 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 Marazion the 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 4.4 outlines the key indicators for Emergency Conditions and the criteria for assessing whether emergency conditions have been reached.

If emergency conditions are reached, re-profiling of the beach and dunes may be considered to ensure the safety of beach users and pathways may need to be temporarily re-routed. Further

studies should then be carried out into long term solutions. Responses to Emergency Condition Indicators are suggested in Table 4.4.

Table 4.4 Emergency conditions and responses

Criteria	Likely consequence	Response
Pathways eroded leading to erosion of dune system and unsafe pathways		
<ul style="list-style-type: none"> • Pathways 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/ pathway has eroded to the magnitude stated when beach visitor numbers are significant 	<ul style="list-style-type: none"> • Beach/ dune users could fall and be injured in the immediate future 	<ul style="list-style-type: none"> • Re-route access pathways to avoid eroded areas using fencing and signage. Fence off eroded areas to enable recovery with planting and dune stabilisation methods applied as necessary • If erosion is close to beach, and sand is available, carry out re-profiling of pathway by adding sand to eroded areas to remove unsafe cliffing and large steps
Steep and dangerous cliffing of dune front		
<ul style="list-style-type: none"> • Cliffing of the dune front leads to unstable dune front, possible with an overhang, which causes a health and safety issue. • Steep dangerous cliffing present during tourist season when high visitor numbers predicted. 	<ul style="list-style-type: none"> • Danger of sand falling onto beach/ dune users. 	<ul style="list-style-type: none"> • Re-profiling of the beach and/or dunes. Bulldozers can be used to move sand from lower down the beach to eroded areas, to remove dangerous overhangs from the cliffed dune face or to make the dune face less steep. The requirement for this should be carefully assessed to ensure economic justification and minimum damage to the dune system. • Fence off dangerous areas until a solution is implemented or the dune face readjusts.
Missing or Damaged Management Infrastructure		
<ul style="list-style-type: none"> • Infrastructure removed or damaged by beach users resulting in management techniques being ineffective such as: <ul style="list-style-type: none"> ○ signage removed or vandalised, ○ planks taken from board walks ○ fencing removed. • Infrastructure lost or damaged during peak season when high visitor numbers are forecast. 	<ul style="list-style-type: none"> • Dune management techniques are ineffective e.g. <ul style="list-style-type: none"> ○ Fencing is removed allowing access to vulnerable areas • Wooden planks missing from boardwalks etc. (if installed) cause significant health and safety hazard. 	<ul style="list-style-type: none"> • Replace or repair management infrastructure as soon as possible to ensure effective management can continue. • Increase presence of dune warden.

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Appendix A
Sand Dune Management Techniques
& Preliminary Decision Support Tool
v2.0

(NB: See accompanying CD to access the tool, which is only provided in digital format)

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Appendix B
An Overview of Coastal Sand Dunes

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Appendix C
Baseline Report

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Appendix D
Options Appraisal

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Appendix E
Site Actions Summary Map

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Appendix F
Summary Leaflet