



## **Taw Torridge Coastal Management Study:**

**Review of erosion adjacent to Northam Burrows  
landfill and recommendations for remedial action**

January 2013





## Taw Torridge Coastal Management Study

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## Contents

<b>1</b>	<b>Introduction .....</b>	<b>2</b>
<b>2</b>	<b>Background .....</b>	<b>3</b>
<b>3</b>	<b>Morphology changes at the Grey Sand Hills .....</b>	<b>7</b>
<b>4</b>	<b>Coastal processes at the site of reported erosion.....</b>	<b>10</b>
<b>5</b>	<b>Options to prevent further erosion.....</b>	<b>12</b>
<b>6</b>	<b>High level cost estimate .....</b>	<b>16</b>
<b>7</b>	<b>Conclusions and recommendations .....</b>	<b>18</b>
<b>8</b>	<b>References.....</b>	<b>19</b>
<b>9</b>	<b>Appendix.....</b>	<b>20</b>

#### Appendix A: Photographs

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## 1 INTRODUCTION

### 1.1 Aims and objectives

Black & Veatch were commissioned by the Environment Agency and Torridge District Council to review the causes of the recent accelerated coastal erosion of the north facing coastline, adjacent to the Northam Burrows landfill site.

The full terms of reference of the study are set out in Appendix A. These include:

- Review the causes of the accelerated erosion based on readily available data and expert assessment.
- Determine the likely alignment this erosion will take in the 1, 5 and 10 year epochs.
- Identify a preferred option to reduce further erosion of this discreet section and recommend methods and likely cost for implementing the option within an agreed budget range.
- Assess the likely impacts this preferred option will have on the immediate surroundings most notably the landfill and adjacent frontage.
- Consider any effects the option will have on longer term options for the site.
- Recommend and report on potential remedial measures.

### 1.2 Approach

This review is based on the existing information available for this coastline, collected as part of the Taw Torridge Coastal Management Study. (Refer to the end of this document for full references.)

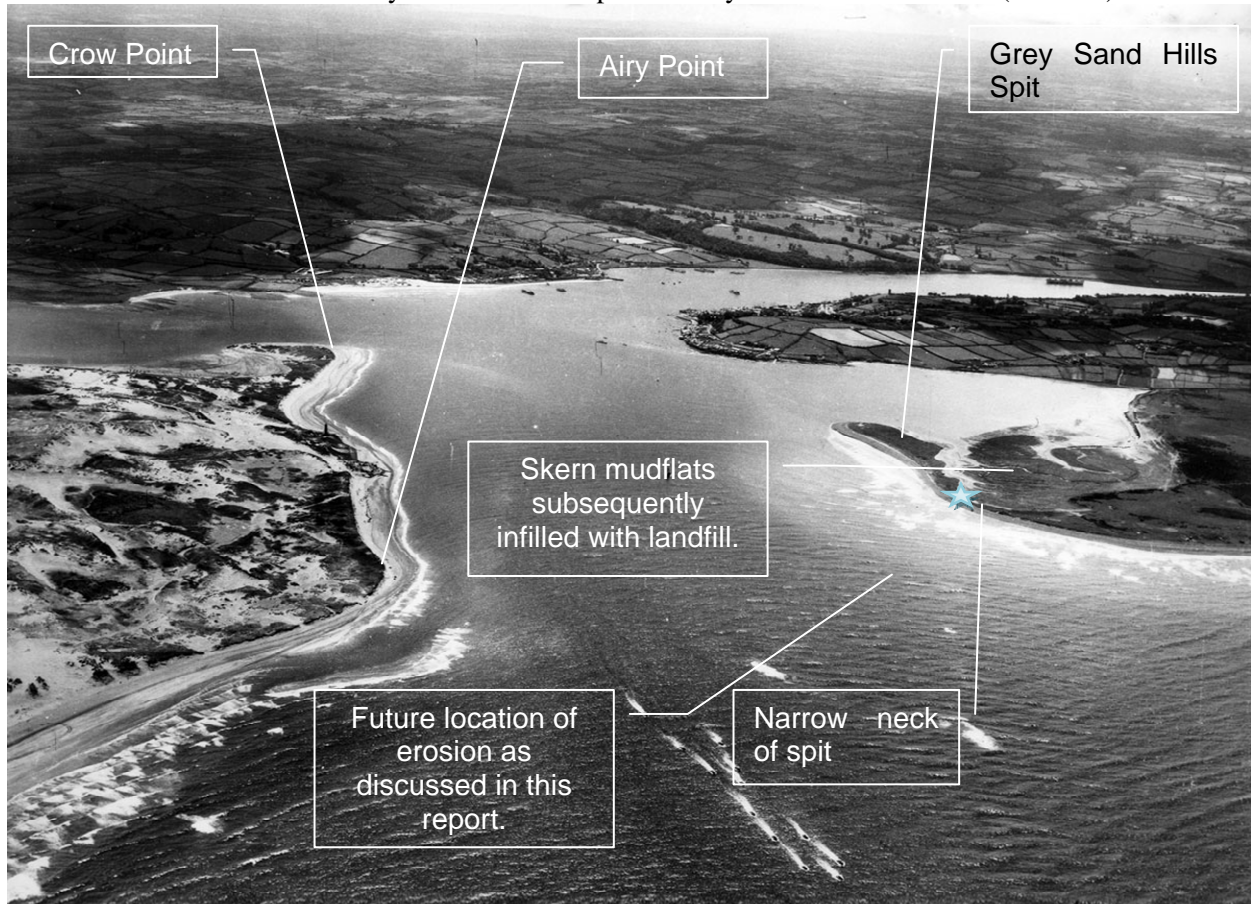
- Data collection - the assessment makes use of the following data sources:
  - OS mapping (MasterMap, 10k, 25k, 50k, and 250k)
  - LiDAR data – (March 2003, April 2006, November 2006, February 2007, February 2008, March 2008, March 2009, Sept 2009, Oct 2010)
  - Extreme tide level data
- Review of existing information - the following existing reports and studies have been collected and reviewed:
  - Shoreline Management Plan (1 and 2)
  - The Taw-Torridge Estuaries: Geomorphology and Management Report to Taw-Torridge Estuary Officers Group, Feb 2007.
  - Further Geomorphological Advice in respect of Westward Ho! SSSI. Oct 2005.
  - Draft Taw Torridge Estuary Flood Risk Management Study, Consultation document
  - Phase I and Phase II Site Investigation at Northam Burrows Former Landfill and Waste Recycling Site, Devon County Council, Jan 2009.
  - Mapping and reports on Landfill extent.

Our assessment also includes feedback from a site visit undertaken by members representing the Taw Torridge Estuary Forum in January 2012.

## 2 BACKGROUND

### 2.1 Study Area

The study area is located on the south bank of the outer Taw estuary in North Devon at the northern extremity of the Northam Burrows in an area known as Grey Sand Hills. The Grey Sand Hills form an eastward facing spit in the Taw Torridge estuary as shown in Figure 2-1. The south side of the Grey Sand Hills spit was originally an area of mudflat and saltmarsh as shown on Figure 2-1, an aerial photograph of this area dated 1947. This clearly shows that the spit was very narrow at its western (seaward) end.



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*Figure 2-1 Aerial view of the mouth of the Taw Estuary in 1947 from the northwest*

The Skern area of mudflat and saltmarsh south of the Grey Sand Hills was progressively filled with landfill between the 1960s and 1994 when the site was closed. An aerial photograph of the study area in 2009 from Google Maps is shown on Figure 2-2, which also shows the location where the recent erosion which is the subject of this report is located.





*Figure 2-2 Aerial view of the Grey Sand Hills in 2009*

The topographic and bathymetric surveys of the northern part of Northam Burrows and the Taw estuary available for the Taw Torridge Coastal Management Plan are shown on Figure 2-3. This shows the deep channel of the Taw Torridge Estuary lying close to the Grey Sand Hills at the eastern end of the spit but located on the other side of the estuary at the western end of the Grey Sand Hills i.e. the low tide channel crosses from one side of the estuary to the other offshore of the Grey Sand Hills. The Admiralty charts and Pethick (2007) suggest this channel is cut in rock and so likely to be stable. At high tide, the Taw Estuary as illustrated in Figure 2-1 is around 1km wide between the Grey Sand Hills on its south bank and the sandhills between Airy Point and Crow Point on the north side.

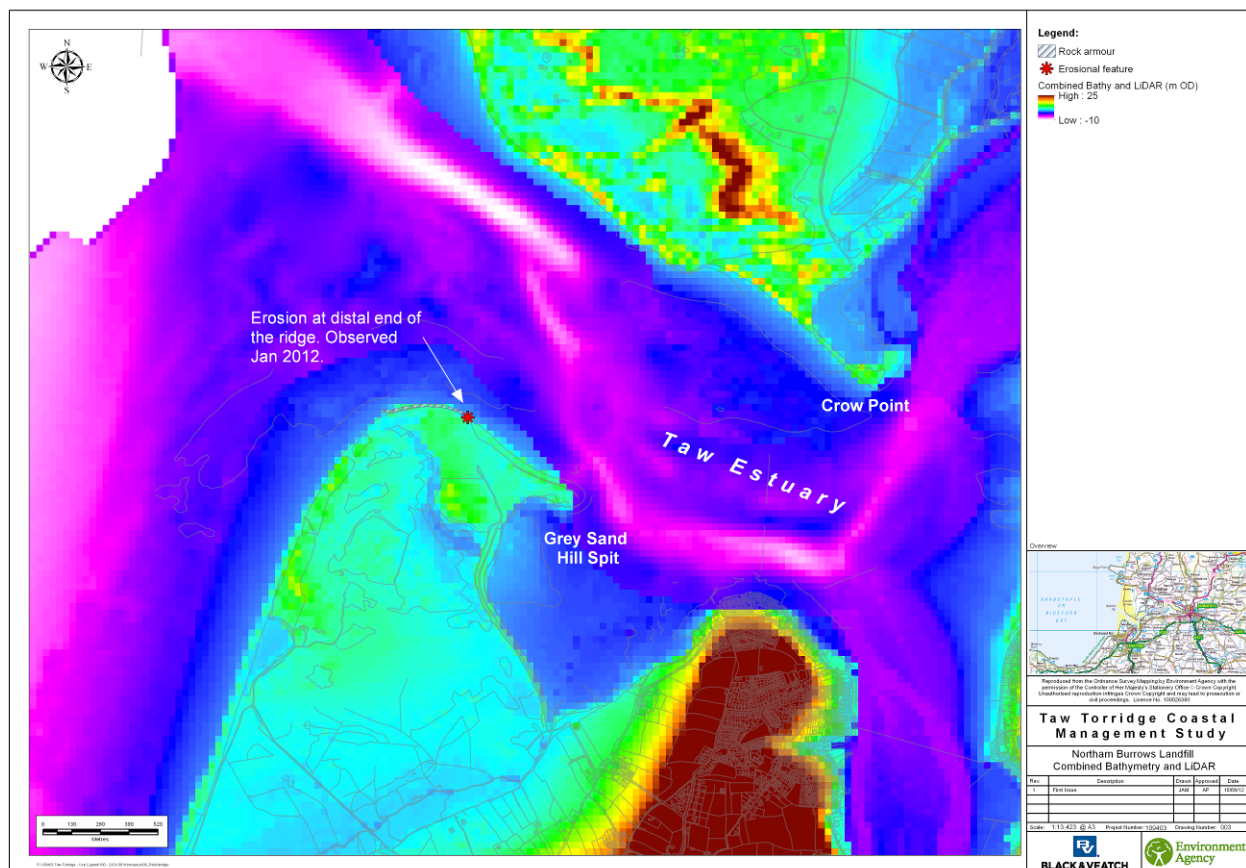


Figure 2-3 Bathymetry of the mouth of the Taw Estuary adjacent to Grey Sand Hills

At some time, possibly in 1978 (Keene 2009), rock armour was placed around the northern side of Northam Burrows ‘to protect the sandhills at Westward Ho! near the old coastguard station’. This report stated that the weight of individual stones was between 3 and 10 tonnes. The rock armour was reported to extend far enough away from the area at immediate threat into an area where the stones from the pebbleridge ‘naturally accumulate’ to avoid edge effects. There is no indication if this campaign provided all the rock armour currently in place on the northern side of Northam Burrows.

## 2.2 The landfill and location of the current erosion

The Northam Burrows landfill was formed between 1937 and 2004. The various phases of its development are shown on Figure 2-4. The northern boundary of the landfill is very close to the Taw Estuary for some of its length, probably close to the area shown on Figure 2-1 where the Grey Sand Hills spit is very narrow.



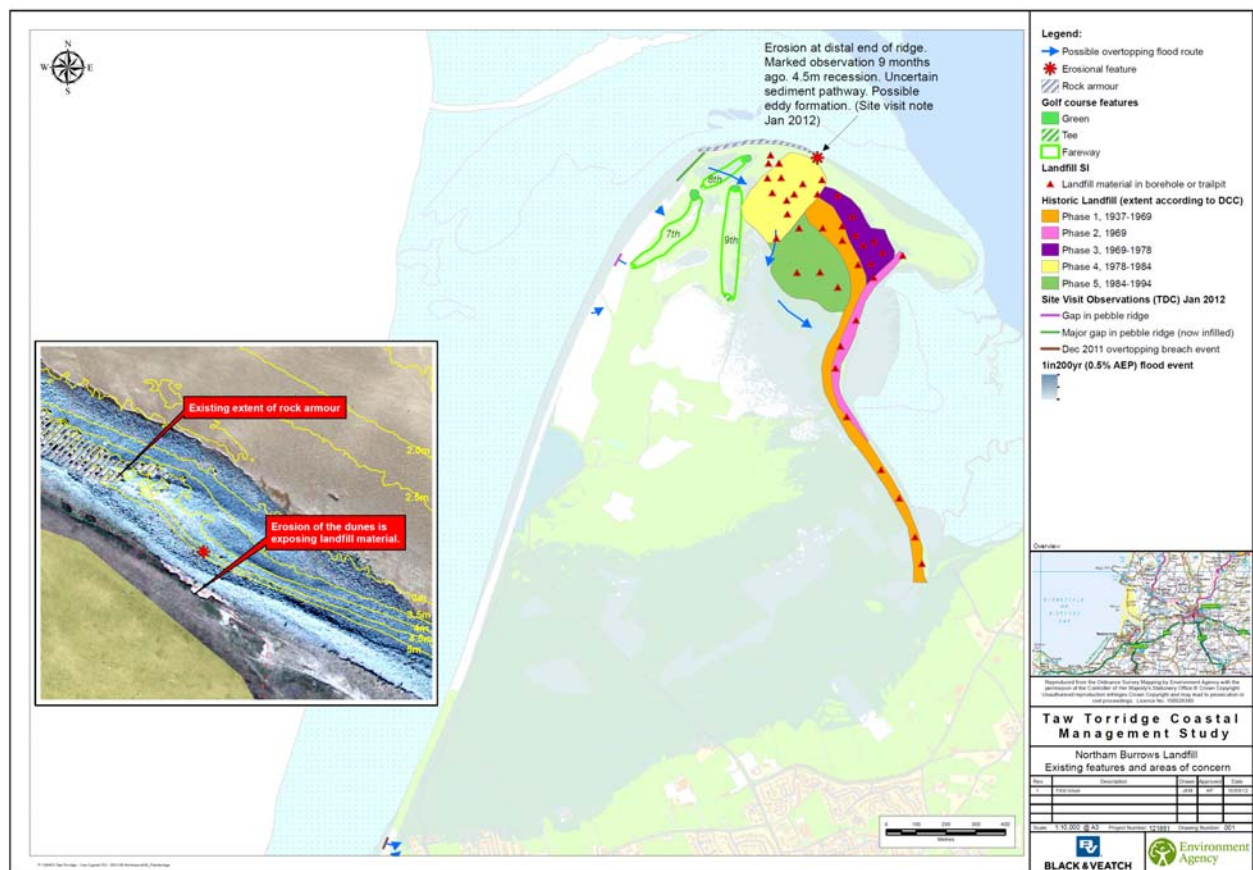


Figure 2-4 Northam Burrows Landfill Existing features and areas of concern

The notes made by the Technical Working Group site visit during January 2012 relating to this study area are included on Figure 2-4. The original notes report a series of areas of concern along the western face of the Northam Burrows adjacent to the golf course which are outside the scope of this review. These will be considered within the Pebble Ridge study commissioned as part of the Taw Torridge Coastal Management Plan. This report is limited to consideration of the erosion observed at the northern side of the landfill.

The existing rock armour does not extend along the full frontage of the landfill as it stops midway along the phase 4 area of landfill closest to the sea. This phase of the landfill was constructed between 1978 and 1984 so may well have been started at about the time the rock armour described above was laid.

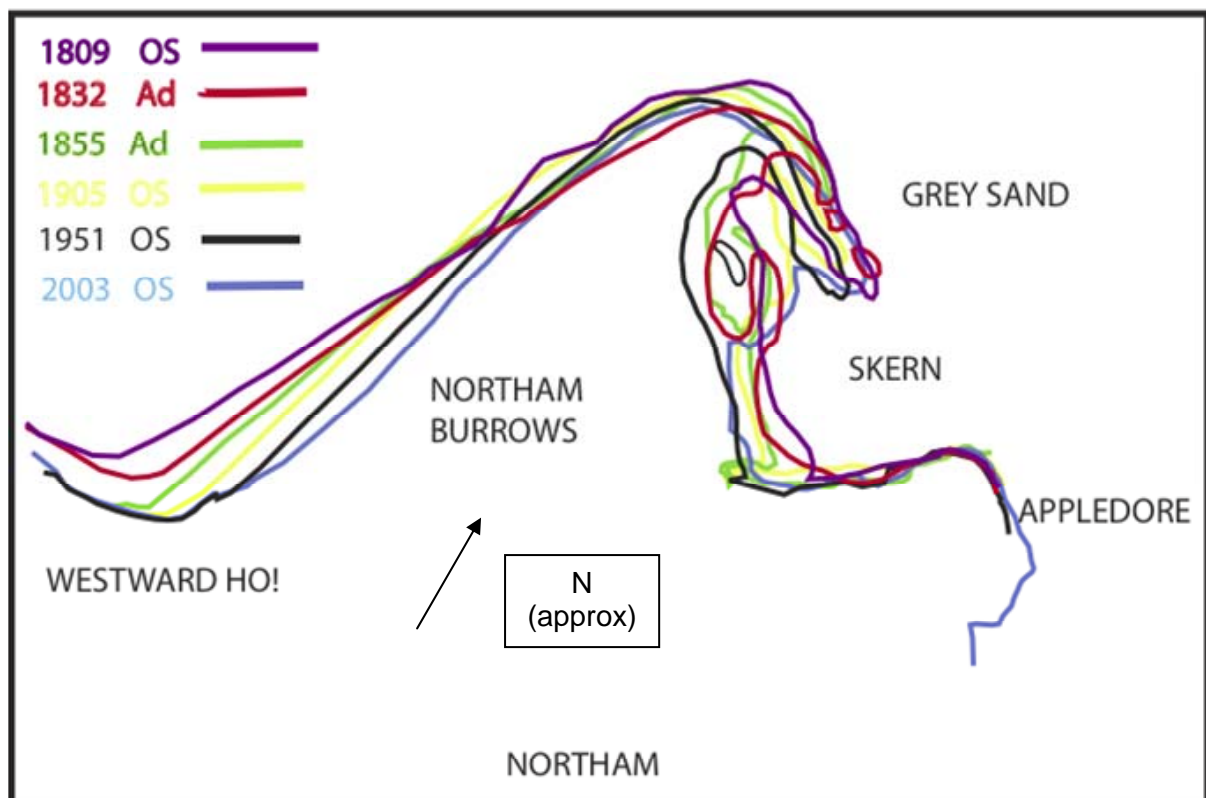
### 2.3 The draft SMP 2 policy for the landfill area

The forthcoming revision to the Shoreline Management Plan 2 (Halcrow 2010) recommends a policy of Hold the Line for the coastline adjacent to the landfill by "... continuing to protect the former landfill site" as noted in the brief.

### 3 MORPHOLOGY CHANGES AT THE GREY SAND HILLS

#### 3.1 Changes over two centuries from old mapping

Keene (2008) has considered the changes in the shape of the Northam Burrows and Grey Sand Hills in his geomorphology of the North Devon coast presentation. He compared the outline of the Northam Burrows on Ordnance Survey maps from 1809 to 2003 as shown in Figure 3-1. All these Ordnance Survey maps show the spit at the northern limit of the Northam Burrows. In all the historic maps the orientation and plan shape of the spit is generally similar though the location of the northern boundary between the spit and the Taw Estuary and its eastward extent do vary. The maps from the surveys prior to 1951 show the natural evolution of the spit over 140 years before substantial landfilling of the intertidal area south of the spit began. The final outline, from 2003, excludes the area infilled by the landfill as it is no longer intertidal.



From Keene 2008

Figure 3-1 Changes in Northam Burrows outline 1809-2003

Prior to 1951, the shape of the spit and the intertidal area it protects were subject to significant changes that are assumed to have been driven by natural processes. Since 1951, the shape of the northern and eastern parts of the Northam Burrows and the spit has been increasingly modified by the presence of the landfill.

The features that seem most stable over the whole two centuries of mapping are the eastern end of the spit and the coastline at Appledore. The coastline fronting Westward Ho! is also fairly stable, though it is shown on a different alignment prior to 1855. The eastern limit of the Grey Sand Hills spit is relatively similar in all the maps apart from the 1832 and 1855 maps which show the spit to be shorter than in the other maps. However in the 1832 map it is notable that there are two small islets in the area normally occupied by the east end of the spit. The 1905 map showed that by that time, the eastern end of the spit had almost returned to its 1809 position; a position held throughout the 20<sup>th</sup> century.

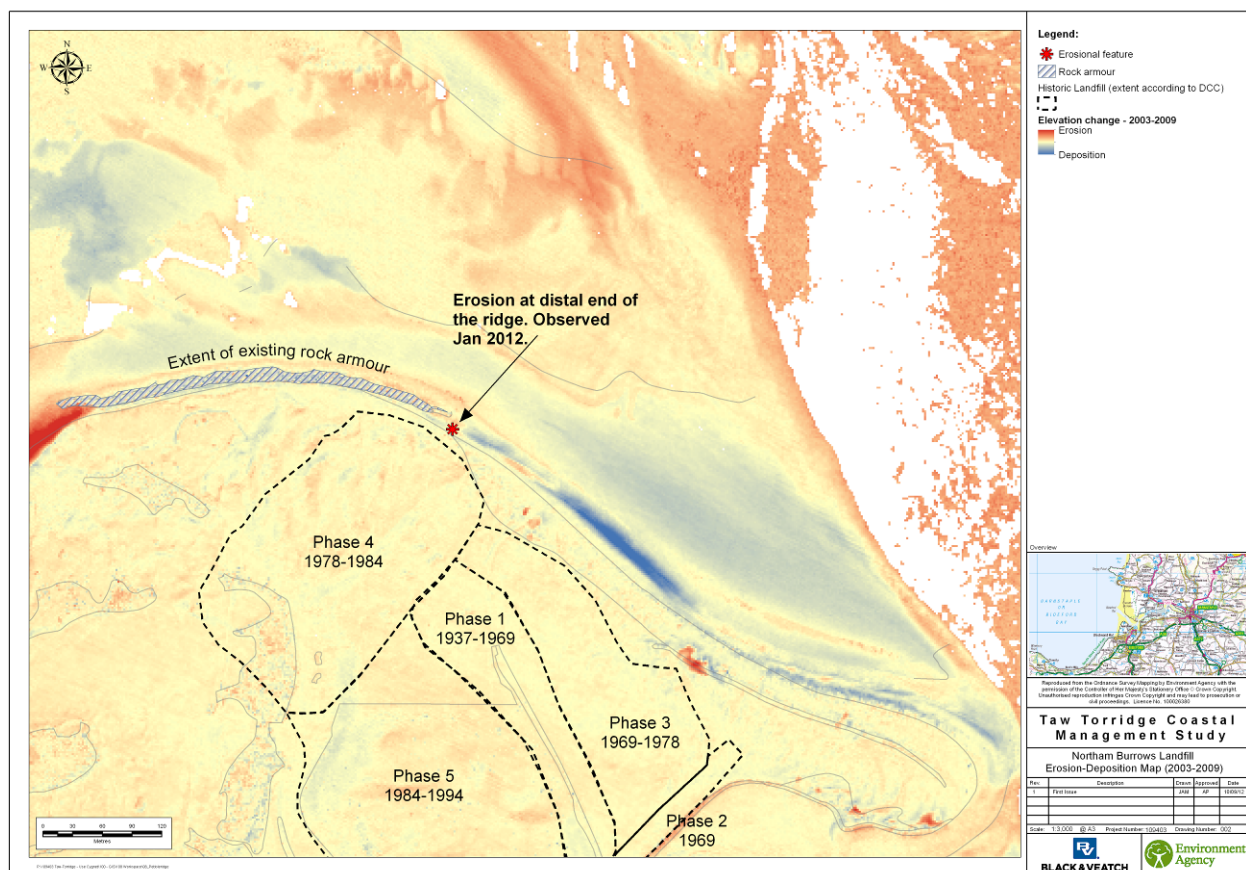
The mapping of Figure 3-1 suggests that the northern extent of the Northam Burrows has consistently retreated over the past two centuries. The 1809 map shows the Northam Burrows extending furthest

north. The 2003 map shows this northern limit of the Northam Burrows to have retreated by about 200m since 1809. This finding is slightly concealed because of a marked 12° counter-clockwise rotation in the alignment of the northern side of the spit between 1951 and 2003. This has had the effect of bringing the eastern end of the spit almost back to its 1809 position from the more southerly location in 1905 and 1951.

This historic mapping of the northern part of the Northam Burrows and of the Grey Sand Hills spit shows its general mobility but also its history of consistent retreat southwards by about 200m over the past two centuries. Pethick (2007) reported that the outer Taw Estuary was narrower than would be expected by regime theory, but did not identify the widening on the south bank over the past 200 years suggest by the mapping, which would be consistent with his view that the estuary is currently narrower than equilibrium. We have not considered how the northern bank of the estuary might have moved, if at all, over this period.

### 3.2 Changes since 2003

Between 2003 and 2009 there have been regular LiDAR surveys of the Northam Burrows, though unfortunately there have been none since September 2009. The LiDAR surveys indicate the short term changes in the northern coastline of the Grey Sand Hills spit over the six year period 2003 – 2009. Comparison of the changes between these dates in Figure 3-2 shows accretion at the eastern end of Grey Sand Hills spit and some localised erosion at the location where erosion was reported in January 2012.



Red erosion; blue accretion between March 2003 and September 2009

Figure 3-2 Grey Sand Hills accretion and erosion between 2003 and 2009 from LiDAR survey

It is important to note that erosion on this frontage was only found east of the area where erosion was found in January 2012. There was no change to the west of this point. Figure 2-4 shows that the rock armour terminates approximately 25m west of the point where erosion was reported. This suggests that the rock armour has stabilised the frontage to the west of the area where erosion was reported, but there

has been some localised erosion for a short distance to the east with a more extensive area of accretion since 2003 further east.

However, by using intermediate surveys to draw cross sections of the coastline at the site of the recent erosion in Figure 3-3, further detail on the recent changes can be revealed. The key point to note is that the majority of the changes have occurred around a level of +5mAOD. This is above the level of mean high water springs (3.9mAOD at Clovelly), which indicates the erosion is largely due to wave action during high tides rather than tidal flow.

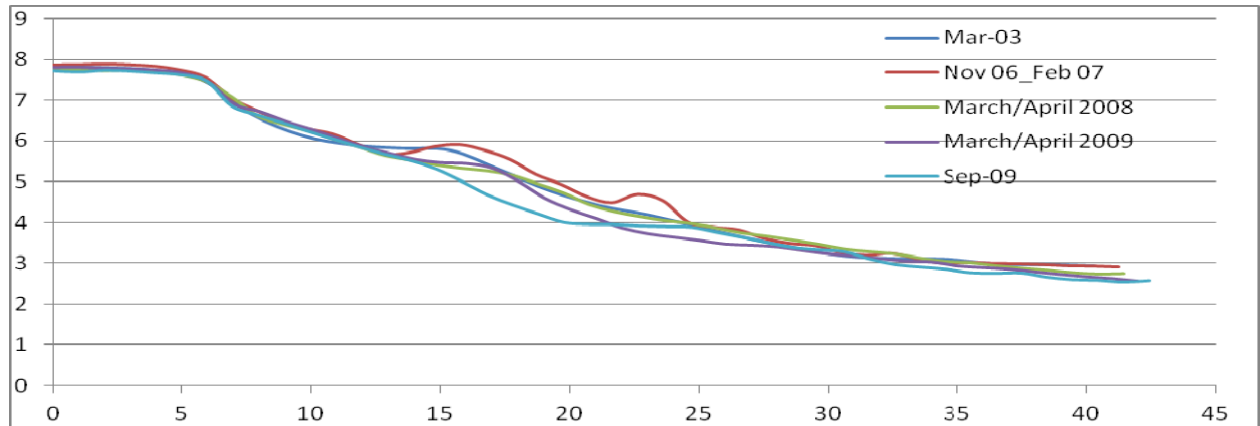


Figure 3-3 Cross section showing changes from 2003 to 2009 at the site of the recent erosion

The changes monitored by LiDAR since 2003 confirm that the coastline around the Grey Sand Hills spit is mobile with accretion occurring at the eastern end of the spit. These surveys also indicate that to the west of the area where erosion was reported in January 2012, the coastline was stable between 2003 and 2009. This is the area currently protected by rock armour.



## 4 COASTAL PROCESSES AT THE SITE OF REPORTED EROSION

### 4.1 Conclusions from mapping and surveys

The mapping over the past two centuries and the more recent LiDAR surveys since 2003 provide evidence that the area where erosion was reported in January 2012 is in an area where the coastline has historically been mobile. The LiDAR also indicates little movement to the west of the erosion site. We therefore agree with the statement in the Brief (Appendix A) by the Technical Working Group that ‘... *the section of the shore line protected by the rock armour appears to have been stable for some time...*’ We also agree with the statement ‘...*significant erosion is taking place on the unprotected ...area to the east of the rock armour.*’

We have not seen sufficient evidence to comment on the remainder of these statements which state that ‘...*the section of shore line protected by rock armour... has not hindered longshore movement of pebbles...*’ and a ‘...*sediment starved area east of the rock armour.*’ We have not seen evidence to support the movement of pebbles past the rock armour which if it occurred might prevent the area east of the rock armour from becoming sediment starved. There is, however, evidence from the LiDAR surveys of erosion immediately to the east of the erosion location, which could be compatible with sediment starvation.

We note that the LiDAR surveys and also the changes in the coastline between 1951 and 2003 point to accretion on the Taw estuary frontage at the east end of the Grey Sand Hills spit.

The Grey Sand Hills spit has been mobile over the past two centuries and if the coastline is not stabilised is likely to continue to move. Placing rock armour appears to have been an effective way of stabilising this length of coastline. However, at the end of a length of rock armour protection there is always a risk that erosion of the adjacent unprotected foreshore might occur. If coastal processes at a particular time favoured accretion, the presence of rock armour should not prevent accretion occurring provided the accretion is not dependent on longshore transport at the foreshore level protected by the rock armour.

### 4.2 Foreshore evolution over the next 10 years

It is almost impossible to predict reliably the evolution of the foreshore in an area of mobility such as the Grey Sand Hills spit, as it will be influenced by the direction and severity of wave action. However, over the long term there has been a trend for the northern part of the Northam Burrows to retreat at around 1m per year (annual average). This erosion has been prevented over about the past 30 years by the presence of rock armour along much of this northern shoreline. This may well provide a long term solution unless the foreshore seaward of the rock armour becomes lower, in which case there could come a time when the falling toe of the rock could cause the rock armour to move. This would be a particular risk if the low water channel moved to the Northam Burrows (south) side of the estuary. Fortunately the low water channel of the Taw Estuary appears confined within a rock cut channel on the north side of the estuary at this location so the risk of a new channel forming close to the Northam Burrows side is very low. However, a small risk of gradual reduction in foreshore level seaward of the rock armour leading to its eventual undermining remains. We, therefore, recommend 6 monthly monitoring of foreshore levels seaward of the rock armour using LiDAR, or similar remote sensing methods, at low tide.

The section of Grey Sand Hills spit that is not protected by rock armour remains free to move, and changes since 2003 indicate areas of both accretion and erosion at the eastern end of the Grey Sand Hills spit. This area has generally experienced accretion since 2003 but with localised erosion at the east end of the rock armour, with a note from the site visit of January 2012 reporting 4.5m erosion in 9 months (equivalent to 6m erosion per year).

These changes are generally consistent with the changes observed between 1951 and 2003 where a general long term pattern of coastal erosion on this frontage has been reversed over the past 50 years by a northerly realignment of the east end of the Grey Sand Hills spit. As the end of this spit is now close to its most northerly limit recorded in the past 200 years, we would anticipate that in the future, erosion of

the east end of the spit to the south is more likely than continued accretion to the north. The deep water off the east end of the spit makes it unlikely that the spit will lengthen.

Given that the foreshore level at which the greatest movement has been observed in the LiDAR surveys is above the high tide level of spring tides, the most likely cause of movement is wave action rather than currents. Tidal currents are generally at a minimum close to high tide level, but if there is a north or north east wind blowing onto this coastline the fetch at high tide is a maximum. **This suggests wave action from the north east is the most likely cause of coastline evolution of the Grey Sand Hills spit.**

We would not expect, but cannot exclude the possibility, that the recent high rate of erosion of 6m per year reported at the northern tip of the landfill will continue. We would probably expect a long term erosion rate closer to 1m per year based on the long term trend, suggesting a possible erosion of 10m over the next decade. However, this general rate is unlikely to apply in the rather untypical circumstances at the end of the existing rock armour.



## 5 OPTIONS TO PREVENT FURTHER EROSION

### 5.1 Scope of options

The review of coastal processes around the northern side of the landfill has shown this section of coastline to be mobile. The dominant process is erosion, though accretion has occurred in the particular area of interest over the past 60 years because of a realignment of the eastern end of the Grey Sand Hills spit. The most likely immediate cause for erosion at the location where it was identified in January 2012 is wave induced erosion of an unprotected area immediately to the east of the section protected by rock armour. The end of a section of wave protection is always more liable to damage than sections where there is no change in defence type because of the localised flow changes where the bank properties change.

We therefore consider that extending wave protection to the east is the favoured solution to the observed erosion problem as where the existing armour finishes is currently a focus of erosive forces. Also, the transition from hard to soft defences in this zone causes eddies which further enhance the erosive environment. Extending the rock beyond this erosive zone and feathering the design into the neighbouring soft slope will manage this erosion. To avoid a similar local erosion area immediately beyond any extension to the rock armour, we recommend that the extra wave protection is taken beyond the area where the landfill is close to the estuary. The wave protection should not be taken too far beyond the area where it is required to protect the landfill to allow the remainder of Grey Sand Hills spit to evolve as naturally as possible within the constraint identified in the SMP of protecting the landfill *in situ*. This approach will also minimise the cost of the works though leave a small risk that further extension to the wave protection may be required in future if it is not taken far enough.

From the mapping of the landfill area in Figure 2-4, we anticipate that the boundary of the landfill remains close to the estuary for about 50m beyond the end of the armour and that the location where erosion was reported is about 25m beyond the end of the armour. Further east the landfill edge is further from the estuary with the mapped edge of the landfill about 30m away from the estuary around 100m beyond the east end of the existing armour. This would suggest that wave protection is required for at least 60m beyond the existing end of the rock armour and that if it is taken 100m beyond the existing end, the landfill edge should be sufficiently far from the coastline to not be at risk of exposure over the 20 year epoch considered for assessment in the Brief.

Annual monitoring of the coastline by checking the location of the coastline against fixed stakes along the northern edge of the landfill is recommended to provide early warning of any erosion occurring so that timely extension or repair of the wave protection can be provided before the landfill is at serious risk of being exposed.

### 5.2 Wave protection methods

#### 5.2.1 *Do Nothing*

This is the baseline against which other options are evaluated in an economic assessment for funding for coastal erosion works. A Do nothing option would take no action to repair the existing erosion and would allow it to take its course. The risk is that erosion would continue in this area and expose more of the landfill and allow more of its contents to escape into the natural environment.

Although the likely future evolution in the erosion is difficult to predict, continuation of the long term erosion trend of 1m per year experienced on this frontage would lead to 10m erosion over 10 years with the attendant risk of erosion and exposure of the landfill.

#### 5.2.2 *Rock armour*

The existing wave protection is rock armour. This protection has performed acceptably for the past 30 years and so a 60 to 100m extension to the armour to prevent exposure of the landfill at its eastern end is a possible option.

Outline rock sizing for the extension has been calculated based on the need to protect against short period waves that may be generated by a north easterly wind blowing across the estuary, as well as longer period swell waves approaching from the west that could refract around the headland. The wave buoy that has been in place in Bideford Bay since 2009 has recorded waves of up to 8.4m in height and with periods up to 17 seconds between 2009 and 2011. These waves will not directly attack the revetment as the height of these waves will be significantly reduced through refraction and shoaling effects, but this does not affect the period. Therefore the effect of these longer period waves needs to be considered in design.

#### *Design conditions*

Design water levels as shown in Table 5-1 have been based on the tide levels at Appledore which is approximately 2km further up the estuary from the site.

*Table 5-1 Design water levels*

HAT	MHWS	MHWN	MLWN	MLWS
5.52	4.32	2.02	-1.58	-2.98

Figure 3-3 indicates that considerable amounts of erosion have occurred between 3.5 to 6mAOD but the profile below 3mAOD appears to be stable. Waves can only reach the eroding slope on a high tide, and consequently wave heights will be depth limited. The outline design wave climate is shown in Table 5-2 below, together with associated water level.

*Table 5-2 Design wave climate*

Case	Description	Hs (m)	Tp (sec)
1	Wind generated wave from 330°	1.2	3.3
2	Max depth limited wave height at +5mOD with coexistent worse case period	1.2	7
3	Max depth limited wave height at HAT (+5.52mOD) with coexistent worse case period	1.6	8

Case 1 is the extreme short period wind generated wave and has been determined based on the 1 in 100 annual probability wind blowing across a 9km fetch from the north east. Cases 2 and 3 are the longer period waves that may refract around the headland. The effect of refraction and shoaling is difficult to quantify by hand for complex bathymetry such as is the case in this area, therefore for the purposes of these outline calculations, the maximum depth limited wave height that could occur for a given water level has been considered. The wave period has been taken as the worst case for the given wave height (wave periods greater than a critical value are less damaging than periods below the critical value as they tend to surge up the rock armour as they break onto the slope rather than plunge onto the rock). It is noted that these depth limited waves are likely to be conservative and give an upper bound wave climate that the rock may be exposed to.

The sizing calculations show that 300 to 1000kg rock armour would provide sufficient protection against these expected design wave conditions, although if Case 3 did occur for a sustained period of time this may result in some movement of the stones (but not enough to cause failure of the revetment). This is considered to be acceptable as Case 3 is likely to be a very rare event.

It is noted that this specified rock size is smaller than the 3-10t rock that forms the existing rock armour, but this is to be expected as the area of erosion is more sheltered than the length of shoreline that is currently protected.

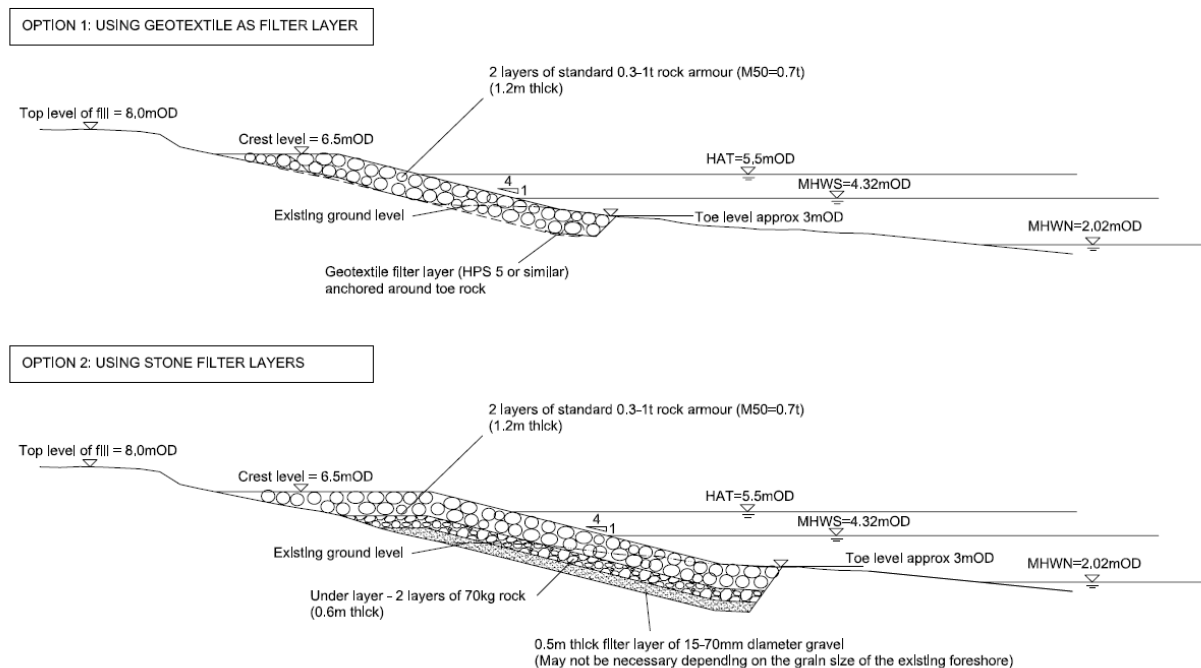
#### *Filtration requirements*

Some method of filtration and separation will be required between the rock armour and the existing foreshore to prevent wash out of the underlying material. This can be achieved through the use of a

geotextile filter layer, or by using smaller stone filter layers. The use of a filter layers requires more material than a geotextile, however if there is a sufficient supply of adequately sized rock on the foreshore this may be an economic option.

### *Indicative geometry*

Figure 5-1 shows indicative cross sections of the two options. Detailed design of the armour will need to take into account the slope of the foreshore, and it will need to tie into the existing armour at the west end (details of which, such as crest and toe levels, are presently unknown). The cross sections are based on the most up to date survey information of the area from September 2009, but it is possible that the existing foreshore is significantly different from that shown here (note these do not represent any works undertaken after September 2012).



*Figure 5-1 Indicative rock armour sections*

The crest level of 6.5mOD gives a 1m freeboard above highest astronomical tide, and the toe level of 3mOD means that the protection extends below the level that is currently experiencing erosion. The dug in toe shown on both options will allow the foreshore level to drop to some extent (approximately 0.5m) without the revetment being undermined, but if long term monitoring shows that the level is dropping more than expected, then additional rock may be needed at the toe.

The slope as shown on the figures is 1 in 4. The design however has been carried out on the basis of a 1 in 3 slope, as it may be that the existing slope differs to that shown on this section and designing for a steeper slope is more conservative.

It will be important to tie the revetment into the existing foreshore to avoid the possibility of any end effects which would cause further erosion at the end of the armour protection. The end of the armour should be graded to give a smooth transition to the natural foreshore. It may be necessary to excavate in order to achieve this, but the final geometry can only be determined once the exact geometry of the existing slope is known. A full survey of the area would be needed before any detailed design is carried out.

### 5.2.3 Other methods

Other methods of wave protection such as the use of interlocking cellular concrete blocks are unlikely to provide sufficient protection against the longer period waves and therefore have not been considered as part of this study.

## 5.3 Sources of materials

### 5.3.1 Local material on the foreshore

One possible source of material is 'loose' rock armour found locally on the foreshore that is not part of the existing rock armour wave protection. If this material has been dislodged from the existing rock armour the question arises why has it been dislodged?

This could be because it is small and so has been moved by a previous storm: in this case it is likely to be moved in a future storm and so is unlikely to be suitable for an extension to the rock armour protection.

The other alternative is that the rock is of adequate size to resist the waves but was poorly placed initially and so became dislodged during a previous storm. However, if properly placed in an extension of the rock armour it would be suitable for future use.

Using rock that is currently lying on the foreshore of adequate size to resist the waves is an acceptable approach but unless the quantity available is large, it seems unlikely to provide sufficient volume to extend the rock armour by the 60 to 100m required.

### 5.3.2 Using material at Crow Point

There is rock armour protection in place at Crow Point. The value of this rock armour in protecting the Taw Estuary has been challenged by Pethick (2007). He noted that in the initial SMP (Halcrow 1998) there is the comment that '*At Crow Point the spit shelters the inner estuary to incident wave attack and so its integrity is crucial*', but strongly disagreed with this SMP finding as he considered with support from examination of historic charts that Crow Point is formed on top of an intertidal bar that he considered likely to remain if the dunes disappear. Pethick also reports, quoting the SMP (Halcrow 1998), that the behaviour of the Crow Point spit had been the subject of a Public Inquiry in 1981.

In the revised SMP2 (Halcrow 2010) the authors anticipate that with a No Active Intervention policy the rock armour at Crow Point will remain during the Short Term epoch (up to 2025) but will fail towards the end of the Medium Term epoch (2025-2055). The SMP commentary on No Active Intervention suggests that if the defences at Crow Point are breached '*this is not thought likely to fundamentally change the estuarine regime, as it has been suggested (Pethick 2007) that the dunes sit on top of a sub aerial feature which will continue to both provide a sediment pathway into the outer estuary and to dissipate wave energy*'.

The policy recommended in the SMP2 (Halcrow 2010) for Crow Point and Crow Neck '*is one of **managed realignment**. During this epoch (short term) detailed studies will investigate the importance of this feature in protecting the inner estuary*'. This indicates the SMP2 authors would like further studies before deciding whether to back the original SMP (Halcrow 1998) or the Pethick (2007) assessment.

Assuming the suggested detailed studies have not been undertaken, removing the rock from Crow Point would prejudice this uncertainty. If this action caused damage in the estuary those responsible for moving the rock would be liable for the damage. If nothing is done and the rock remains in place, but deteriorates over time because it is not maintained, there should not be any liability on the authority owning the asset as damage would be the result of a natural process, noting that flood defence and coastal protection are permissive powers and failure to act does not usually attract liability.

We therefore recommend that on legal grounds the rock at Crow Point is not reused unless adequate studies have been completed to determine if its removal will cause any problems in the estuary. This would not change the liability for any damage but reduce the risk of unforeseen damage.

### *5.3.3 Rock stored at Annery Kiln*

There is a potential supply of rock armour stored at Annery Kiln. This is described as around 150 tonnes of rock of 0.75 to 1 tonne blockstone. This blockstone is illustrated in Figure 5-1. The properties of this rock have not been determined, but the sizing calculations show that the weight of the rocks would be sufficient for use. However the cross section shown in Figure 5-1 required approximately 35t of rock per metre length of revetment, and therefore there would only be enough rock here to provide around four to five metres of protection, which is not adequate for this purpose.



*Figure 5-2 Blockstone at Annery Kiln*

### *5.3.4 Local quarries*

There are a number of quarries in Cornwall that may be able to supply the required rock armour. Two quarries that have been used to supply recent rock armour jobs designed by B&V include the West of England Quarry (diorite) in Porthoustock, and Caradon Quarry (granite) in Liskeard.

## **6 HIGH LEVEL COST ESTIMATE**

A high level costs estimate for the profiles shown in Figure 5-1 are shown in the table below for 60m (approx 2,100tonnes) and 100m (approx 3,500 tonnes) length. This shows that the option without the geotextile is considerably more expensive, but it is thought that the costs for stone under layers could be significantly reduced if a suitable local supply of material was available (such as material already on the foreshore).

Option	60m length	100m length
1: Using geotextile as filter layer	£120,000 (~£2000/m)	£195,000 (~£1950/m)
2: Using stone filter layers	£230,000 (~£3840/m)	£375,000 (~£3750/m)

The estimate has been based on quoted prices for previous rock armour work, and has been cross checked against the unit costs for rock placement works as quoted in the Flood Risk Management Estimating Guide (EA, 2010). The costs also include 25% for contractor's preliminaries and 10% for design in addition to the construction costs. It should be noted that these costs are very high level and that costs for rock armour revetment works are dependent on the source of the armour, access constraints and availability of plant, and vary a great deal from site to site. A 60% optimism bias has therefore been included in the estimate.



## 7 CONCLUSIONS AND RECOMENDATIONS

This review has concluded that:

- The landfill is eroding in the area of concern by an average of 1m per year over at least the previous 100 years and this erosion has accelerated recently.
- The erosion is likely to be caused by wave action driven by north easterly winds.
- Protection of the landfill by extending the existing rock armour eastwards by 60m in the first instance would be appropriate and effective.
- Crow Point should not be considered as a source of rock fill material until more detailed coastal modelling has assessed if the impact of removing the rock bar on the inner estuary is acceptable or not.
- The protection may need to be extended further in the future depending on the results of the monitoring recommended below.

Recommendations to progress this as a project are:

- Carry out a detailed topographic survey of the area to ensure adequate detailed design and tie in details.
- Carry out detailed design, ensuring to use the rock available from Annery Kiln or similar approved.
- Identify a sufficient source of material to be able to firm up costs.
- Install monitoring stakes as part of the final design to be able to accurately assess local rates of erosion, to provide a warning if the protection needs extending further in the future.
- Monitor the ground levels at the stakes on at least a 6 month basis and immediately after notably stormy weather (noting the preceding weather conditions if surveyed post storm event, including wind direction).

It is noted that emergency works have been carried out to manage the consequences of some rapid erosion in this area that has exposed some of the landfill material. These works were carried out with an understanding of the recommendation of this report and do not change the issues or recommendations discussed here.

## 8 REFERENCES

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## **9 APPENDIX**

### Appendix A: Brief

## Appendix A: Brief

### **Pebbleridge, Northam Burrows Study – Additional Works**

#### **Update to Torridge DC Brief April 2011**

##### Introduction and Overview

Northam Burrows Country Park lies within an Area of Outstanding Natural Beauty and forms part of the United Nations Biosphere Reserve. The Burrows is a Site of Special Scientific Interest, with approximately 253 hectares of grassy coastal plain with salt marsh and sand dunes. It also provides one of the access points for the 2 miles of Westward Ho! beach, as well as being home to the Golf Course of the Royal North Devon Golf Club and providing common rights for grazing. At the Northern point is a former Landfill site.

This whole area is protected from coastal erosion and flooding by a natural Pebbleridge, which extends northwards from Westward Ho! for about 2,500m until it reaches the mouth of the estuary of the rivers Taw and Torridge.

Historically, works to recharge vulnerable elements of the pebbleridge were undertaken, although this has not been carried out in recent years. More recently the ridge has diminished, suggesting that the source and supply of pebbles through long-shore drift appears to have slowed.

The forthcoming SMP2 states that the pebbleridge should be allowed “to roll back and naturally become more aligned with the dominant wave direction. This realignment...will be managed by extending defences at Westward Ho! and continuing to protect the former landfill site”

##### Update

Following a site visit by the Taw Torridge Officers Working Group on 17<sup>th</sup> January 2012 it was observed <insert photos> that a section of the distal spit at approx SS4467731845 appears to be particularly vulnerable to scour or wave damage resulting in a X by Y metre section being eroded in addition to the general realignment of the frontage. This section of erosion was first identified as an issue in <date>.

*As taken from the site meeting discussion "The technical working group have identified that while the section of the shore line protected by rock armour appears to have been stable for some time and has not hindered longshore movement of pebbles, significant erosion is taking place on the unprotected and sediment starved area to the east of the rock armour. ' Will moving outlying rock armouring shorewards and or downdrift to the vulnerable face assist in retaining the sediment and support protection here without compromising the protection currently offered by the rock armour or impacting erosion rates elsewhere and secondly what contingency for protection should be put in place to provide short term protection should it become evident that the landfill is under immediate threat of significant erosion, "*

On site it was also suggested that it could just be a temporary gap in sediment supply that has left that end exposed and created the erosion that was observed. It was noted in conversation that should it be identified that additional rock armour will be required there was a possible source of rock armour at Crow Point on the opposite side of the estuary. It will be necessary to assess the relative merits of using this material as opposed to importation of fresh rock armour if the preferred option recommended additional rock armour was required.

##### Objectives

In addition to the original brief, the objectives for this extra work are to

- critically appraise the assumptions and answer the questions raised by the Technical Working Group highlighted in context above

- determine the coastal processes and site conditions, using readily available data and expert assessment, that are the cause of this accelerated erosion
- determine the likely alignment this erosion will take in the 1, 5 and 10 year epochs
- within a budget range of <to be advised > identify the preferred option, alignment and type of defence to reduce future erosion along this discreet section
- recommend method/s and identify likely cost of implementing the preferred option
- assess the likely impacts this preferred option will have on the immediate surroundings, most notably the landfill site and adjacent frontage
- consider any effects the preferred option will have on the longer term options for the site
- Deliver a standalone technical summary report that identifies the above objectives to allow the Technical Working Group to determine the most appropriate and cost effective approach to reducing the erosion identified at the site
- Deliver this stand alone report (electronic and 2 paper copies) on the specific objectives identified in advance of the main study and the Torridge District Councils' study of Pebbleridge
- Append this report to final study report

It is envisaged the investigation will develop a range of options and recommendations for appraisal, and will take into consideration requirements over the 0-20 year epoch.