NORTH SHEPPEY EROSION STUDY

VOLUME 1: COASTAL ADAPTATION STUDY

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Front Cover: St James Church, Warden, demolished in 1875 due to cliff erosion affecting the foundations.

EXECUTIVE SUMMARY

This report has been commissioned by Swale Borough Council. Cliff erosion is predicted to increase significantly over the next 100 years as a result of climate change with consequent adverse effects on the local community. The aim is to assess future cliff erosion taking account of the latest advice on climate change, and the impact that it will have on the local community, businesses, property and infrastructure. Guidance is given, so that the Council can provide appropriate advice to the public and make informed decisions regarding Planning issues. In addition, the advice will enable the public and businesses to plan ahead and mitigate the effects of accelerated climate change and coastal erosion on their lives.

Detailed maps are provided giving estimated positions of the eroded cliff top in 50 years and 100 years from now (2011). Various options are given regarding how private property owners and caravan site owners can plan and adapt if they are affected by erosion in the future. Costings are given for possible property purchase and lease back options by the Council. Roll back options are described in connection with possible relocation of caravan parks.

Damage to property, business and infrastructure due to cliff erosion has been costed over the 50 and 100 year time periods and discounted at present day values. These costs have been used to assess whether there is a financial case for undertaking any works along the 6.6km undefended frontage, not withstanding that the current Shoreline Management Plan sea defence policy is no active intervention.

1. BACKGROUND

1.1. CURRENT SITUATION

The shoreline over much of the length of the north Sheppey coast is in retreat and has been so for centuries. This is very much part of a natural process which has been taking place as sea levels have slowly risen and land levels have gradually dropped, both being the long-term consequences of the last (Pleistocene) ice-age. Added to this natural process are the effects of climate change and global warming. Global warming is an additional factor to natural climate change effects and has been linked to increasing levels of man-made greenhouse gas emissions on the global scale leading to accelerated sea level rise and other adverse climate effects.

Recent climate studies have confirmed that there are significant changes occurring within our climate; with bigger storms, increasing rainfall and rising sea levels. The amount of physical change depends on the degree of exposure of each length of coast and the underlying geology. Increasing rainfall in between longer periods of dryer weather can lead to increased weathering of cliff faces, with potentially more cutback of the cliff face. Higher sea levels result in larger waves attacking the coastline. The Sheppey coastline comprising of mainly London clay cliffs is therefore particularly susceptible to these effects. Therefore as a result of natural processes and climate change, historic erosion rates are set to increase significantly over the next 100 years and the local community will need to be suitably informed and adapt to these changing conditions.

The Shoreline Management Plan[24] policy for the undefended north coast between Minster and Warden Bay is for no active intervention.

There is no legal right to coast protection. Coastal defences are maintained and rebuilt using permissive powers under the Coast Protection Act, where it is economic to do so. Public investment has to be prioritized to get the best value for the tax payer. Along the north coast of the Isle of Sheppey, it has been previously ascertained that investment in major coast protection works is not good value for the tax payer and therefore this makes the case for the community to adapt to coastal erosion all the more important.

1.2. AIMS AND OBJECTIVES OF THE STUDY

The aims of the study are to assess the long term coastal erosion (next 100years) of the main undefended length of coastline between Minster and Warden Bay taking account of climate change in order to identify affected properties, businesses and infrastructure.

Major coastal defence works that would be necessary to halt cliff erosion are not financially viable over the undefended length of cliffs and also not permitted because of the SSSI status of the cliffs. It will therefore be necessary to adopt an adaptation policy. Adaptation is the process of managing the impacts of coastal change on communities and individuals, in advance of erosion or realignment, with the aim of reducing risk and mitigating the adverse effects.

Adaptation options will need to be developed and the local community engaged in their implementation.

The study will also set out options for holding the line along the currently defended Minster section of cliffs (unit 4a03) see site plan at Appendix A in line with the Shoreline Management Plan[24] recommendations. This study outlines both maintenance and capital works required, sufficient to allow a detailed submission to be made to the Environment Agency (EA) for approval of any proposed capital works.

1.3. BOUNDARIES

The study frontage covers the length of the north Sheppey coastline between Minster Town (Chalet Park) to Leysdown on Sea, a distance of 8.6km. Approximately 6.6km is undefended freely eroding cliff. Swale Borough Council is the responsible authority under the Coast Protection Act 1949 for managing this frontage. The coastlines to the west of the boundary at Minster and to the east of the boundary at Leysdown are managed by the Environment Agency. See Site Plan Fig. 1 at Appendix A.

2. DESCRIPTION OF SITE

For convenience, the coastal length has been split up into the following 5 areas:-

1. The Leas and Minster Cliffs sea defences. Fig. 2 at Appendix B.
2. Minster to Bugsby's Hole (Royal Oak Point). Fig. 3 at Appendix B.
3. Bugsby's Hole to Hens Brook. Fig. 4 at Appendix B.
4. Hens Brook to Barrows Brook (Eastchurch cliffs). Fig. 5 at Appendix B.
5. Barrows Brook to Warden Bay. Fig.6 at Appendix B.

In general, the undefended length of coastline between Minster and Warden Bay comprises a mix of residential property, caravan parks and agricultural land. Approximately 1000 caravans and 124 properties will be at risk over the next 100 years.

2.1 THE LEAS AND MINSTER CLIFFS

THE LEAS

The Leas covers a 700m length of coastline from the Chalet Park off the Broadway to Seaside Avenue. Extensive housing development is located along this section of cliff top. This section of coastline is protected from marine erosion by the construction of a sea wall, promenade, groynes and cliff regrading carried out in 1983/4. The height of the cliffs along the Leas is approximately 10 to 11m and regraded at a gradient of 1 in 5.5. (See typical cross section at Appendix C). A herringbone drainage system for the slopes has been provided. The drain trenches are sealed off with topsoil and grass. Prior to the sea wall, regrading and drainage, historic maps show that the frontage was protected by groynes only, the bulk of which were constructed during the 1960's, although the far west end appears to have been protected by groynes since at least 1896 and as a consequence, shows virtually no erosion since that time. Along the main length, however, historic erosion averages 0.11m per annum up until construction of the sea defences. At the eastern end, there is a sloping revetment comprising of granite boulders cast into the concrete slope of the apron. The sea wall, promenade and slopes are in good condition. However, the upper 2 to 3 planks to the groynes will need to be replaced in the next 5 years at an estimated cost of £179,000.

PHOTO 1 The Leas looking west

Major engineering works to the cliffs or sea defences are not required in the short to medium term, except for replacement of groyne planking. However, due to climate change and predicted sea level rise of approx 1200mm by 2115, see Table 5, it will be necessary at some stage to raise the rear wave wall to prevent overtopping and scour at the toe of the slopes.

MINSTER CLIFFS

The Minster section of coastline is defended by regraded and drained cliffs, and sea defences constructed in 1981 over a length of 900m. The defences comprise groynes, shingle beach, a front reinforced concrete wave reflector wall, asphalt promenade and a low stepped reinforced concrete rear wall. The beach is to the full height of the groynes and approximately 0.5m below the top of the front wave wall, and is considered to be adequate both in terms of dissipating wave energy and provision of toe weighting to provide stability to the slopes. The height of the defended Minster cliffs is about 35m.

Prior to the construction of sea defences, the cliffs were freely eroding. The slopes comprise London clay which has been regraded to a bilinear profile, generally having a gradient of approximately 1in 5 to 1 in 6 on the lower section of slopes and 1 in 4 to the upper section. The lower slopes are likely to be comprised of landslide debris and clay

fill. The upper 1in 4 slopes are likely to be comprised of intact clay. It is assumed that the upper slopes were steepened to 1 in 4 in order to avoid affecting nearby properties. See plan and cross section drawing CCC 2906-01 and 02 at Appendix C. The drainage comprises open gravel filled trenches laid out in a herringbone fashion. The associated manholes include a top biscuit which is bolted to the base slab with three long tie rods as a precaution against slope movement.

Hutchinson[2] surveyed this area in 1965 and reported that the cliff consisted of London clay thinly capped by the Claygate Beds and Brickearth. At that time, the predominant forms of instability were shallow slips and mud flows. The large mudflows were associated with land drains at the west end of the area and a small stream at its east end. There were no groynes at that time. However, a Swale Council report dated 1982 refers to dilapidated groynes existing at this location. There is no evidence of deep seated rotational basal slides at this site having occurred in the past.

The cliffs were previously surveyed in 2002 in connection with a scoping review and no signs of instability detected at that time. A recent survey carried out in September 2010 shows that the slopes remain stable although there were some drying shrinkage tension cracks at the crest of the slope and shallow movement due to seasonal shrinkage swelling of the clay affecting paths and steps creating trip hazards. It is recommended that the Council keep an inspection and actions record in respect of cliff paths and steps in order to mitigate any accident claims made against it.

Severe random cracking is evident to the asphalt surfacing of the promenade. Unsuccessful attempts have been made to seal this cracking with mastic asphalt. A previous survey had noted that the promenade had lifted up to 150mm in one particular area. This has since been successfully repaired. The promenade construction was believed to comprise 50mm asphalt on dry lean mix concrete with clay landslide debris as sub grade. Subsequent trial holes have confirmed the lean mix has been laid in two layers. Thermal expansion via the asphalt has caused the upper layer of lean mix to expand and separate from the lower layer resulting in the cracking and heaving movement of the overlying asphalt surfacing sometimes evident in the promenade. If this cracking worsens, it may present a tripping hazard to the general public. It would be advisable to allow for at least the replacement of the asphalt within the next 5 to 10 years at a cost of £300,000. The longitudinal joint between the promenade slab and the sea wall is in very poor condition, see Photo 3. To replace this with suitable filler and polysulphide sealant is estimated to cost £50,000.

The condition of groynes are reasonable, however, some wear of the planking and bolts is clearly evident on top planks and exposed planking at the lower end of the beach. The groyne and beach system at this location has worked well in providing a stable beach over the years and the best option will be to replace top 2 to 3 planks along the full length of the groynes and the exposed planks at the end bays. Traditional practice for UK marine structures (BS 6349: Part 1: 2000) has depended on using species such as greenheart, Balau, Oak, Douglas fir, Jarrah, Opepe or Pitch Pine for groyne piling. This reliance on a limited number of species can lead to the market exclusion of other timber species with the result that the full value of the exporting nations' forest products industry will not be realised and the diversity and sustainability of forests damaged. In an effort to address this the EA/Defra[30] now recommend the use of alternative hardwoods such as indicated at Appendix N. The estimated cost for replacing part of the groyne planking at Minster is £337,000 and will be needed in the next 5 years.

At the east end of the sea defences, a return wall has been cut into the slope. A significant build up of beach fronts this wall and there are no immediate concerns. However, future erosion of the cliff will result in the existing defence being outflanked at the eastern end of the defences (see Fig 1 overleaf). In order to protect the significant housing development at the top of the cliff, it is recommended that a rock armour revetment should be constructed similar to that recently provided at Warden Bay by 30 to 50 years from now. The estimated works cost at present day prices for a 350m long revetment comprising 1-3T rock armour at a gradient of 1 in 4 would be £1.6m. It would be difficult to achieve grant aid at the present time as the 100 year line does not affect many properties resulting in an inadequate cost benefit ratio. However, in the future with significant erosion having already taken place, together with possible changes in acceptance criteria, grant aid may be forthcoming. Notwithstanding the foregoing, the Council could implement a build up fund sufficient to meet the future capital costs of this work.

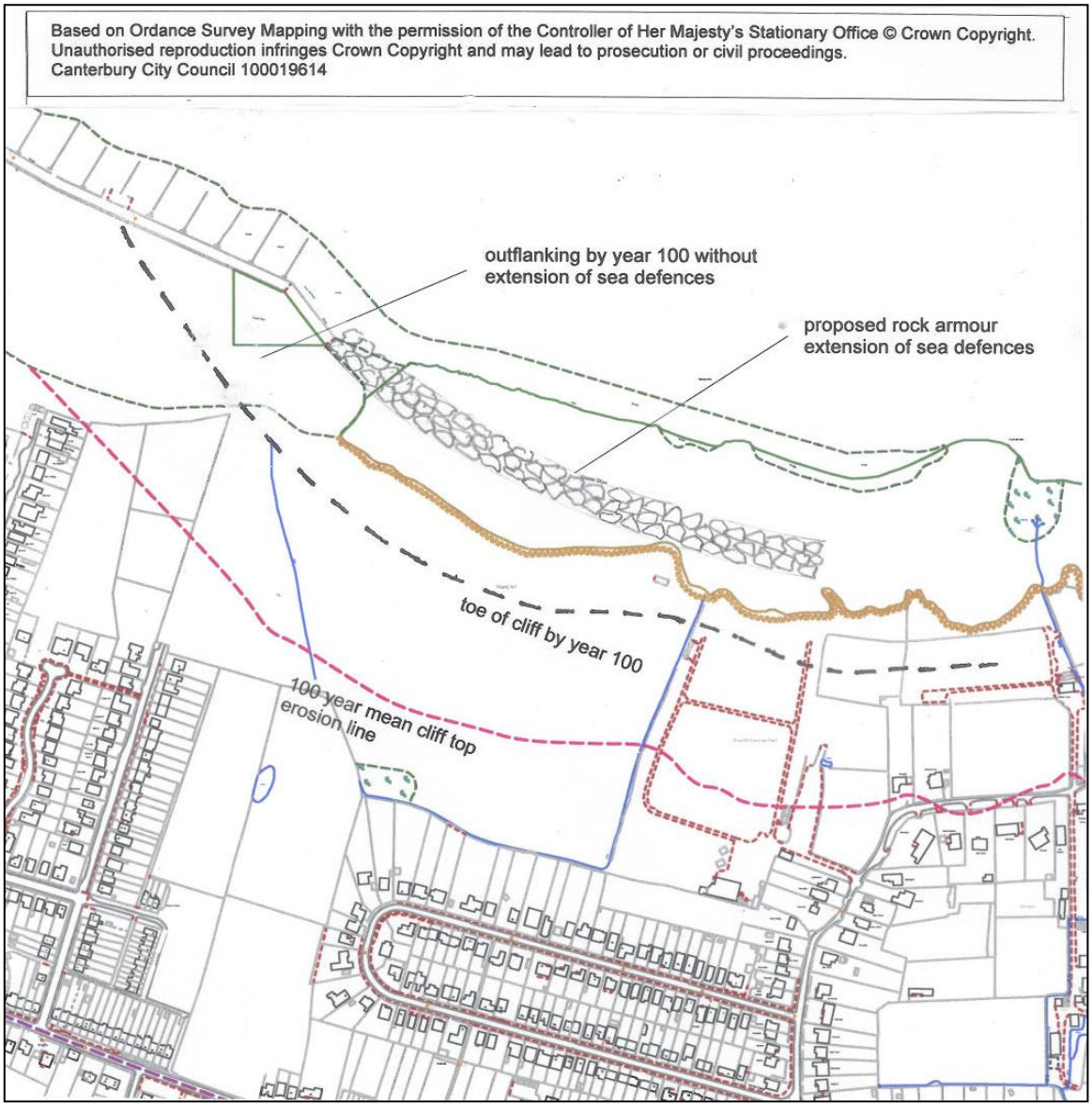

FIG 1 Showing outflanking of existing sea defences at Minster and proposed rock armour extension to sea defences.

PHOTO 2 East end of Minster defences showing return wall

The beach along this frontage has been monitored at 3 cross sections and the results show that there has been a very slight increase in beach volume over the past 10 years.

London clay slopes are subject to the phenomenon of delayed failure following cutting or regrading. The removal of overburden in this process immediately causes a lowering of pore water pressures to such an extent they may even go negative in value. This greatly improves the factor of safety of the slope against instability. However, with time the pore pressures start to rise until they reach equilibrium state. This process can take up to 50 to 60 years in London clay following cutting or regrading. However, an efficient drainage system can minimise this effect. Bearing in mind that it is 30 years since this cliff protection work, it is important that the drainage efficiency is maintained. It may also be beneficial to install piezometers to monitor the rise in pore water pressure in the upper I in 4 slopes. It was noted that at 3 cross sections along the cliffs, groups of instruments were sited. These have been investigated and found to be either casegrande piezometers or standpipes. Their reliability is in doubt and it is recommended that a group of 3 piezometers are installed in the upper section of slopes to monitor drainage efficiency. A limited investigation was also made of the lower longitudinal drain and associated manholes. This investigation identified a considerable build up of silt in the manhole chambers. Other measures that can be taken to maintain the stability of the 1 in 4 slopes are:

i. provision of a longitudinal cut off drain at the top of the slopes estimated cost £120,000.
ii. Clearing out the silt in the lower longitudinal drain and ensuring beach outfalls are clear and running free.
iii. The banning of soakaways associated with property development. Surface water to be drained to main drainage system, using site attenuation measures as necessary.
iv. Ponds and swimming pools to be drained to main drainage system, using attenuation measures as necessary.

SCHEME OPTIONS

Major engineering works to the cliffs or sea defences are not required in the short to medium term, except for replacement of groyne planking, promenade resurfacing work, replacement of joints and works at the east end of the sea wall to limit outflanking. The outflanking works should comprise a rock armour revetment similar to that recently used at Warden Bay.

It expected that the asphalt surfacing will require replacing within the next 5 to 10 years. The estimated cost of planing off the existing asphalt, tack coat, joints and new 50mm hot rolled asphalt surfacing is estimated to be £300,000.

Due to climate change and predicted sea level rise of approximately 500mm by 2095, see Table 5, it will be necessary within 30 to 40 years from now to raise the rear wall to prevent overtopping and scour at the toe of the slopes.

In order to monitor the efficiency of the herring bone drainage system and any rise in pore water pressures due to post excavation equalisation, it will be necessary to install 3 No. casegrande type piezometers in the upper slopes at a cost of £4,000. If monitoring identifies a long term trend of rising pore water pressures, then it will be beneficial to consider the installation of a longitudinal cut off drain near the top of the cliff which will intercept ground water emanating from the permeable deposits of the Claygate and brick earth strata. Consideration of planting with indigenous tree and bush species would be beneficial. Slope drainage outfalls on to the beach should be cleaned out on an annual basis.

The only other schemes worth considering are replacing the timber groynes with rock groynes at much wider spacing or replacing the shingle beach and groynes with a rock revetment. Both of these schemes would require extensive model testing, and particularly the rock revetment would significantly reduce the amenity value of the sea front. An essential requirement of any scheme would be to maintain beach levels at their current state in order to maintain toe weighting to the clay slopes.

By far the most economical option for the Council would be to replace the groyne planking to continue to maintain the existing high beach. The current arrangement works well as an amenity, as a sea defence and cliff stabilization measure and it would be better not to alter things too much.

PHOTO 3 Minster cliffs and sea defences looking west showing poor condition of asphalt surfacing and jointing.

2.2 MINSTER TO BUGSBY'S HOLE (ROYAL OAK POINT AREA)

There are no coastal defences along this length. See Fig. 3 at Appendix B.

The geology of this area comprises sandy gravelly clay in the upper layers, overlying sandy clay, (Claygate and Bagshot beds). The London clay forms approximately the lower two thirds of the cliff. It is apparent that the Claygate and Bagshot beds provide a source of ground water to the cliff face which is causing seepage erosion.

The main caravan site operators in this area affected by cliff erosion are Seacliff and Willow Trees at the west end and Lazy Days and Redcot at the east end of this length. Numerous service and drainage pipes were evident protruding from the cliff face. One foul sewer pipe from a cess pit discharges on to the cliff. Fly tipping was also evident.

PHOTO 4 Fly tipping near Royal Oak Point, cliffs highly vegetated.

PHOTO 5 View from Redcot Caravan park looking across to Lazy Days park showing numerous exposed pipes

PHOTO 6 Redcot Caravan Park. Caravan near cliff edge removed for safety.

2.3 BUGSBY'S HOLE TO HENS BROOK

There are no coastal defences along this length. See Fig 4. at Appendix B.

The west side of this small stream valley consists of brick earth capping London clay. The east side of the valley comprises pure London Clay. Hens Brook was running dry at the time of the inspection.

The main caravan site operator affected by cliff erosion in this area is Ashcroft Coast Holiday Park. It was evident that there has been recent slippage, see Photo 8. According to the site manager, 100m long and 2m width of land lost from cliff falls in February 2010. Aerial photographs show that there is a major mud slide emanating from the top part of the cliff roughly central along Ashcroft site boundary.

PHOTO 7 Looking west with Ashcroft caravan park in the background.

PHOTO 8 Recent mud run at Ashcroft Caravan Park. (Courtesy Canterbury City Council Strategic Monitoring)

2.4 HENS BROOK TO BARROWS BROOK (EASTCHURCH CLIFFS)

No formal sea defences exist along this length. However, four groynes were installed together with beach nourishment at this location in 1962. The groynes were provided solely to retain a beach amenity for the patrons of the caravan sites and not as a sea defence measure. The groynes have now almost disappeared and there is no amenity beach.

The cliffs at this location comprise almost entirely of London Clay. Hens Brook discharges at this location. The catchment area for this stream runs back as far as Eastchurch.

The west side of the small valley cut by this stream consists of brick earth capping London Clay; the east side consists only of London clay. The main caravan park

operators affected by cliff erosion at this location are Eastchurch Holiday Centre and Palm Tree caravan park. Barrows Brook was running dry at the time of the inspection.

PHOTO 9 Barrows Brook

2.5 BARROWS BROOK TO WARDEN BAY

WARDEN POINT

The cliffs at this location comprise almost entirely of London Clay. The main caravan operator affected by cliff erosion at this point is the Warden Springs holiday park. The erosion rate at this location is the greatest of the entire length of coastline being 1.42 m per year. As a result, the caravan park owner has moved caravans and hard standings well back from the cliff edge and allows only short term tented accommodation to occupy the sea ward end of the site. The last major deep seated land slide at this location took place in November 1971 when 30m of land was lost over a length of 200m. However, there are regular shallow cliff falls causing the rear scarp of the major landslide to regress landward. The average erosion rate of 1.42m per year is expected to increase to approximately 3.1m per year by 2110 taking account of climate change. (See para 9.1).

PHOTO 10 Warden Point just west of Warden Springs looking west towards Barrows Brook. A large pool of water collecting in a back tilt can just be seen rhs behind trees.

PHOTO 11 Looking east towards Warden Point and Warden Springs caravan park.

WARDEN BAY

The cliffs at this location comprise almost entirely of London Clay. Coastal protection works comprising a rock armour revetment was provided in 2007. Toe erosion by the sea has been prevented by the sea defence works over a length of 260m. The sea defence works comprise rock revetment with a 1 in 4 slope at a level of 4.5m AOD and 4m wide access berm. The rock is graded 1-3 tonne limestone and smaller bedding rock from a quarry near Boulogne. The access berm was topped with shingle excavated from within the footprint of the revetment. The rock armour is in good condition and remains in tight formation with no loose rocks. There should be a bi-annual inspection and in particular after severe storms of the rock armour. Any displaced rocks should be put back into position. A cut-off drain was provided at the top of the cliff on the seaward side of the unmade road, Cliff Drive.

Although the toe of the cliff has been protected from erosion by the new rock armour revetment, the cliff top will continue to erode by shallow landslides and weathering at an exponentially decreasing rate over the next 500 years or so until it reaches its natural angle of repose of 11º. See Fig 2 below. Over the next 100 years, the average cliff top erosion has been estimated at 0.35m/year over the main length of the new sea defence works and 1.07m per year at the western end at Warden Springs caravan park. Over the following 300 years, the average erosion rate is estimated to be 0.13m/year, slowly decreasing until the cliffs reach their natural angle of repose.

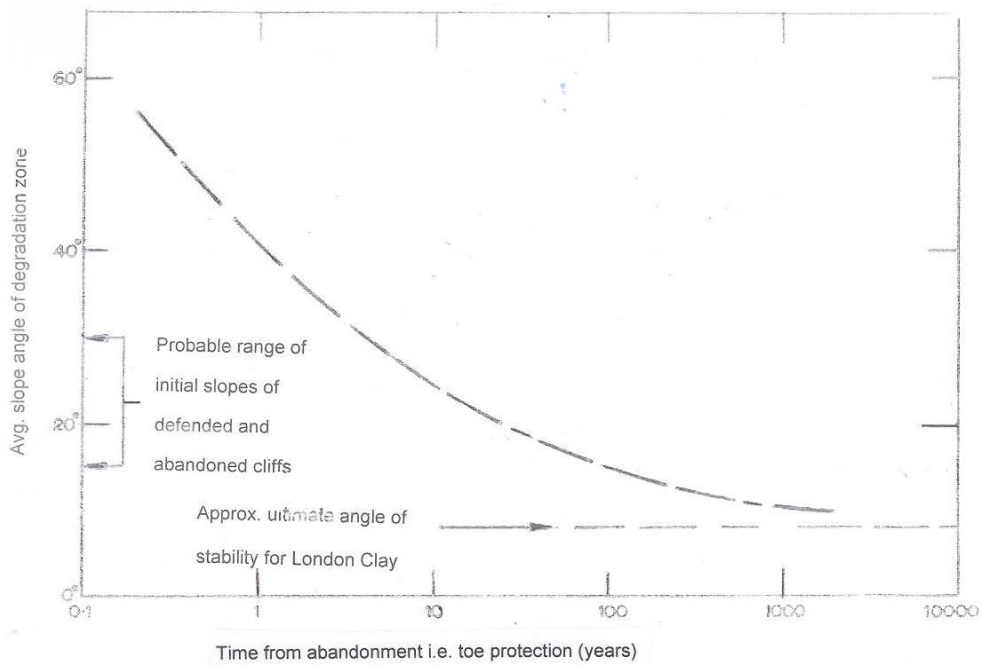

FIG 2 Slope angle with time from toe protection (abandonment) based on Hutchinson[2]

The rock revetment at Warden Bay protecting the toe of the cliff therefore reduces, but does not prevent erosion at the cliff top. The cliffs will fail by shallow slides, thereby exposing important geological features and maintaining important habitats. Since the area is a SSSI, this aspect enabled the project to gain approval from Natural England. It will, however, result in the loss of some properties, infrastructure and other undeveloped cliff top areas. This policy will provide a limited input of beach forming material to the shoreline, thus benefiting the fronting and down drift beaches. There is justification to maintain some of the current defences, at Warden and Leysdown-on-Sea in the long term due to the risk of flooding. However, there will be significant visual changes to the frontage, with higher, more robust defences required in the longer term and narrower/disappearing beaches, impacting on the character of the frontage. In the area of The Bay, realignment of the low lying shoreline is recommended, as there are limited assets at risk and this policy will reduce the impact of coastal squeeze. Warden Village and Leysdown-on-Sea are both tourist areas, separated by agricultural land and areas of nature conservation interest. The combined approach will benefit all the aforementioned aspects.

A site inspection on 28th January 2011 noted that there has been some recent shallow slippage (within past 6 months) which has resulted in the cliff top now being only 5m from the unmade road known as Cliff Drive. The road is likely to be affected in the next 10 to 15 years or so. Therefore, consideration will have to be given soon how to deal with this problem. See Fig. 3 below and drawing CCC 2906-03 at Appendix D. Options are:

1. Plans should be made to re-align the road closer to the boundary of Capri, Squire Gate and JR's. There are no public sewers within this road. This would be a fairly short term option.
2. Cliff Drive could be abandoned between Preston Hall Gardens and Sea Approach. The property JR's could make provision to access from Preston Hall Gardens and Capri could access from Sea Approach. However, Squire Gate will need to negotiate an access to Preston Hall Gardens via the property JR's. This option is preferred as it will last for a longer length of time.
3. The properties will be affected by erosion as the cliff moves to its safe angle of repose of about 8º (gradient 1 in 7). Property owners will need to consider relocating using the provisions of a purchase and lease scheme or a roll back scheme outlined in this report and which could be introduced by Swale Council.

PHOTO 12 Rock armour at Warden Bay revetment looking west

PHOTO 13 Rear scarp of recent slide now only 5m from Cliff Drive, Warden Bay

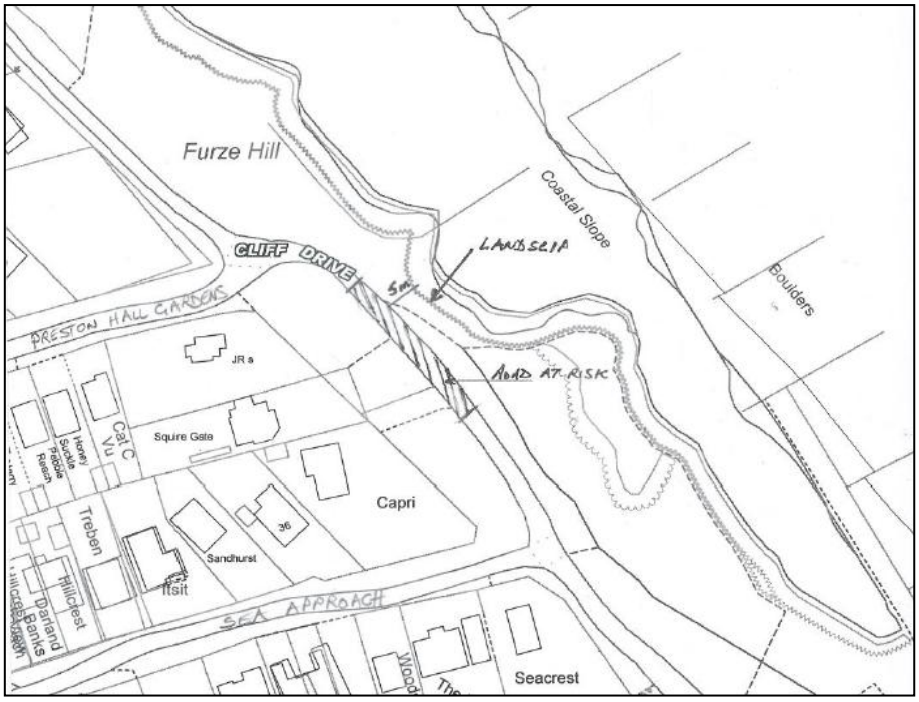

FIG. 3 Extent of Cliff Drive road at risk from cliff top erosion

3.0 HIGHER LEVEL PLANS

3.1 SWALE LOCAL DEVELOPMENT FRAMEWORK

A full list of the Local Development Documents for Swale, for inclusion in the LDF, are set out in the Local Development Scheme. As of March 2012, the main documents comprise:

Under preparation

- Swale Borough Core Strategy (DPD).
- Neighbourhood Plan for Faversham Creekside

Adopted

- Conservation Area Review SPDs (January 2012)
- Landscape Character and Biodiversity Appraisal SPD. (September 2011)
- Stones Farm Development Brief SPD (May 2011)
- Queenborough and Rushenden Masterplan SPD (November 2010)
- Sittingbourne Town Centre and Milton Creek Masterplan SPD (September 2010)
- Statement of Community Involvement (September 2008)
- Kent Design SPD (2008)
- Swale Borough Local Plan2008 (February 2008)

The Council signed the Nottingham Declaration in November 2007, acknowledging the increasing impact that climate change will have on the Community during the 21st century and it commits the Council to tackling the causes and effects of a changing climate on the Borough. Although flood risk issues due to climate change and sustainable drainage is referred to in the LDF, issues relating to coastal erosion are not considered.

3.2 EXISTING SWALE BOROUGH COUNCIL PLANNING POLICIES

Policy E5 Cliff Erosion and Unstable Land.

NOTE: This Policy will be removed when the Core Strategy is adopted and replaced with draft Policy DM3 Coastal Change Management Area.

Other than for minor extensions to existing premises, the Borough Council will not grant planning permission for built development in the area of Coastal Landslide and Rapid Erosion as defined on the Proposals Map. (Refer to Figs 2,3,4,5,and 6 at Appendix B which shows the position of the current line of Rapid Erosion). Additionally, on other potentially unstable land, the Borough Council will only grant planning permission after it is satisfied that there are effective remedial, preventative or precautionary measures to address the risk concerned.

Policy B6 Holiday Parks

1. Planning permission will not be granted for any new static holiday caravans and chalets outside of the holiday park areas as shown on the Proposals Map. The upgrading and improvement of existing static holiday caravan and chalet sites will be permitted (including their conversion from one to the other), but should take place within existing site boundaries wherever possible.

In exceptional circumstances (such as when land is lost due to coastal erosion), or where it can be clearly demonstrated that on-site upgrading and improvement is not practicable or viable, minor extensions to existing static holiday caravan sites will be permitted where they would result in no overall increase in the existing number of accommodation units and would:

a. be part of a scheme to upgrade and improve the quality of tourist accommodation and other amenities on the site; and
b. result in a significant and comprehensive improvement to the layout, design and appearance of the site, together with a high standard of landscaping which will reduce the overall impact of the site in the landscape; and
c. have no unacceptable impact on the local environment.

2. Planning permission will be granted for new or improved facilities on the holiday parks provided they are:

a. of a type and scale appropriate to the site or park they are intended to serve; and
b. where feasible, made available for use by the local resident population.

The supplement to Planning Policy Statement 25 requires local authorities to identify areas likely to be affected by physical changes to the coast and refer to these areas as the *Coastal Change Management Areas.* This report has assessed future erosion rates based upon the latest scientific data, and has estimated 50 year and 100 year erosion lines based upon mean emission scenarios, see paragraph 9.1.

3.3 SWALE COUNCIL DRAFT POLICY DM3 COASTAL CHANGE MANAGEMENT AREA (DRAFT FOR CONSULTATION)

1. A Coastal Change Management Area has been defined around the coast of Swale, as shown on the Proposals Map. Within this area the following criteria will apply:
   a. New residential building, or conversions of existing buildings to residential use, will generally not be permitted (subject to the exceptions in the criteria set out below);
   b. All other development, redevelopment, extensions and intensification of land uses will only be permitted where it can be demonstrated that it will result in no increased risk to life or significant increase in risk to property; and
   c. Certain types of essential infrastructure and Ministry of Defence installations (4) may be permitted.
2. Planning applications for all development within the Coastal Change Management Area's 50 and 100 year erosion zones must be accompanied by a Coastal Erosion Vulnerability Assessment.
3. Within the 50 year indicative CCMA Erosion Zone only development directly related to the coast, such as beach huts, cafes, car parks and sites used for holiday caravans and camping may be permitted. All development will be subject to temporary planning permission.
4. Within the 100 year indicative CCMA Erosion Zone, in addition to the above, the following types of development may be permitted, subject to temporary planning permissions. In all instances clear, costed plans to manage the impact of coastal change on the development and the service it provides must be submitted:

   a. Commercial or leisure activities requiring a coastal location and providing substantial economic and social benefits to the community;

b. Key community infrastructure, which has to be sited within the CCMA to provide the intended benefit to the wider community;

c. Subdivision of properties, including residential subdivision; and

d. Limited residential extensions that are closely related to the existing scale of the property.

5. In order to make provision for development and infrastructure that needs to be relocated away from the Coastal Change Management Areas within Swale applications for relocation will be considered on their merits where:

a. the proposed development replaces that which is forecast to be affected by erosion within 20 years of the date of the proposal;

b. sites within the built-up area boundary are prioritized over sites outside the built-up area boundary;

c. the scale of the proposed relocated development relates directly to the original site;

d. the new development is located an appropriate distance inland from the Coastal Change Management Area indicated on the CCMA/Proposals Map and where possible it is in a location that is close to the coastal community from which it was displaced; and

e. the existing site is either cleared and made safe or put to temporary use beneficial to the local community.

3.4 THAMES GATEWAY PLANNING AREA

The frontage is within the Thames Gateway Planning Area the emphasis of which is to support economic regeneration of the Isle of Sheppey via improvements to the port at Sheerness, an adequate supply and range of new housing all within an overall context of protecting important landscape and nature conservation sites.

3.5 SHORELINE MANAGEMENT PLAN

The Isle of Sheppey coastline is covered by the policies in the Isle of Grain to South Foreland Shoreline Management Plan 2010. The areas covered by this report are:

Unit 4a03 Minster Town:- Hold the line for the short, medium and long term.

Unit 4a04 Minster Slopes to Warden Bay:- No active intervention for the short, medium and long term.

Unit 4a05 Warden Bay to Leysdown-on-Sea:-Hold the line and managed realignment for the short, medium and long term.

3.6 BARTON'S POINT BEACH MANAGEMENT PLAN

The Environment Agency are to develop a beach management plan for the Northern defences on the Isle of Sheppey, between Garrison Point and Royal Oak Point (see plan at Appendix E), in line with guidance from the CIRIA beach management manual V2 2010. Management Unit 1 of this Plan overlaps The Minster and The Leas section covered by this report. There is currently limited beach data and therefore additional beach profile locations are recommended to be included in the regional monitoring programme. There are proposals in this plan to recycle excess beach from the section fronting the Minster cliffs to Bartons Point. There are concerns that this will have a detrimental effect on the cliffs behind which are stabilized by the toe weighting of the beach and sea wall system. To ensure stability of the slopes, it will be essential to maintain the beach at their current levels. It has been agreed that excess beach, if it occurs, is not to be removed without a prior appraisal of the affect on cliff stability undertaken by engineers from Canterbury City Council. The upper part of the beach is more or less consistently at the top of the groyne planking and needs to be maintained at this level in order to provide adequate toe weighting to maintain the stability of the coastal slopes, and in particular to prevent localized toe failures.

3.7 ENVIRONMENT AGENCY AND COUNCIL POLICY

There is no legal right to a sea defence. Sea defences are maintained and rebuilt using statutory powers where it is economic to do so. Investment in flood risk management must reflect current circumstances and priorities. Some areas that once warranted public investment may no longer do so. The Environment Agency has to prioritise all flood and coastal erosion defence work to get the best value for the tax payer while meeting its legal obligations. Funding from central government to the Environment agency is actually being reduced by 6% in 2012/13.

3.8 THE MEDWAY AND SWALE ESTUARY PARTNERSHIP

The Medway Swale Estuary Partnership is a voluntary forum that seeks to address the various issues currently facing the estuary. It consists of 14 organisations from the private, statutory and voluntary sectors, which have a common interest in promoting a sustainable future for the estuary. The partnership's work is centred on raising awareness of the estuary and its associated issues, managing competing demands and increasing knowledge of the estuary through research, publications and educational activities.

3.9 COASTAL COMMUNITIES 2150 PROJECT

Coastal Communities 2150[33] and beyond (CC2150) is a €2.9m INTERREG communications project to engage vulnerable communities who are at long-term risk from coastal climate change.

The Project was approved by in December 2010 and runs from January 2011 to Dec 2013. The INTERREG 2 SEAS programme is funding 50% of the €2.9m costs. Project partners are Kent County Council, Hampshire County Council, the Environment Agency, and partners in the Netherlands and Belgium.

4. HISTORICAL AND COASTAL EVOLUTION

The London Clay exposed between Warden and Eastchurch Gap (and onwards towards Minster) encompasses around a million years of sedimentation, dating from the early Eocene epoch of the Palaeogene period, 52-51 million years ago (see geologic timescale at Table 1). At this time southern England was located approximately 40°N of the equator, 10°S of its present latitude, comparable to Spain today. The average annual temperature across southern England at this time was approximately 23°C, compared with the present-day figure of around 10°C.The prehistoric evidence reveals Kent (including the Isle of Sheppey) lay beneath a warm, shallow sea (<100m), the nearest significant landmass was perhaps 30+ miles away for much of this time. As a result conditions on the sea floor were relatively undisturbed, allowing fine particles of sediment suspended in the water column to gradually settle; however short-term fluctuations in tidal currents and sea level introduced sand to the area throughout this time, particularly towards the end. Life during the Eocene was abundant, the relatively near landmass was covered by lush tropical vegetation and fringed by a swamp-like environment, providing habitat for mammals, birds and insects, whilst at sea marine life flourished. The diversity of life is represented in the fossils found at along the unprotected foreshore which include both marine and terrestrially sourced organisms, the latter consisting largely of pyritised twigs, fruits and seeds, and in rare instances insects that were transported by tidal currents. In very rare cases the fossilised remains of birds and mammals have also been discovered.

Over the last two million years the climate of Britain has varied tremendously with periods of temperate climate interrupted by repeated advances and retreats of glaciers and ice sheets. Collectively these periods have become known as the Ice Age (we are still in one of the temperate phases). The ice sheets did not reach as far south as Kent, but the influence of the alternating cold and warm phases can still be seen in the landscape.

Deposits from this time typically include gravels deposited in river floodplains, which form terraces at various heights on the valley sides, and head. Head comprises angular pieces of rock and soil derived locally from the extensive frost shattering of rocks and the subsequent movement of this material down valley slopes. Large areas of clay-with-flints, derived from the weathering of material overlying the present-day chalk, occur across the North Downs and wind-blown, fine-grained sediment known as loess is also found across much of north Kent.

During the early Holocene Period (between 13,000 BP and the present day), a steady retreat of the ice sheets was seen which led to an increase in sea levels and a readjustment of the earth's crust following the relief of weight imposed by the huge mass of the ice sheets. These changes have had varied effects across the European continent. For example, in Britain, loss of the ice sheet resulted in settlement of the land mass in southern England and an increase in land levels in Scotland, roughly divided by a 'hinge' along the line of the Scottish Borders. In 10,000 BP Great Britain was connected to continental Europe by a land 'bridge' near the Dover Straits, whilst to the north, the east coast of England was separated from Belgium and Holland by the North Sea. By about 8,000-5,000 years BP, in what was known as the mid-Holocene Period, the rate of sea level rise was starting to slow down and the major erosion and weathering processes which had led to vast quantities of eroded material being transported from both fluvial and coastal sources was also reducing. During this period sea level rise was continuing much more slowly and this led to the creation of many low-lying, inter-tidal areas at the interface between the land and sea. Coastal erosion resulted in the severing of the mass of land between the North Sea and the English Channel about 7,500 years ago helping to create the map of Europe much as we know it today. The severing of this connection resulted in much stronger currents and significant sediment transport around the Channel coasts before settling down to a regime similar to that of the present day. A progressive on-going rise in sea levels led to the flooding of many existing river valleys around the European coast forming features such as estuaries, creeks, mudflats and salt marshes, and this process has been ongoing since then.

In southern England the dramatic rise in sea levels between 10-6,000 BP, by as much as 100 metres, resulted in aggressive coastal erosion leaving many parts of the coastline in a vulnerable, oversteepened state. The effect of the erosion process has been to de-stabilise some coastal frontages resulting in a legacy of landsliding and instability problems.

Incidents of rainfall over geological periods have also resulted in activity or inactivity in terms of geomorphological processes. The extent of coastal erosion and the amount of winter rainfall are two factors which can influence coastal landsliding activity and research has identified that the period from 1700 to 1850 was a particularly active one in southern England (Brunsden and Lee[34], 2000).

The cliffs are eroding rapidly, producing relatively large quantities of fine-grained sediments and relatively small amounts of sand and shingle. Erosion rates are discussed in detail at section 9.1 in this report. However, it should be mentioned that the shore platform, beach and cliffs were stripped for septaria and pyrite copperas stone from the London Clay up to about 1914 when the trade ceased to be profitable. This would have increased recession rates. Pyrite readily decomposed to produce green vitriol (ferrous sulphate), which was used to produce dyestuffs and medicines.
Bands of harder, cemented clay, known as cement stones within the Clay, have yielded a diverse range of marine fossils including starfish, crabs, lobsters, fish, turtles, bivalves and gastropods. The collection of cement stones to burn to produce Roman or Parker's Cement started in the early nineteenth century. By the 1830's nearly all of the cement stones had been removed from the north coast of Sheppey leading to increased erosion and concern from the adjacent landowners. By the mid-nineteenth the discovery of Portland Cement, made from the readily available Chalk and Gault Clay from elsewhere, led to a cessation in the trade by 1914.

The cliffs along the northern shoreline of the Isle of Sheppey are eroding rapidly and given their fine-grained composition (dominantly London Clay), they provide a large source of fine grained sediment to the overall Thames estuary and its tributary estuaries in north Kent and Essex (the Thames Estuary System) and more broadly, the southern North Sea. (Nicholls, Dredge & Wilson)[13]. The sinks for this sediment are unclear, but it is likely that the estuaries and marshes in the Thames Estuary System are important in this regard over the long-term.

The intertidal zone comprises a variable coarse-grained beach above a wide (100m-500m), low gradient (0.5º-2º) shore platform cut into the London Clay. There is a littoral drift divide at Warden Point. The surface of the platform is actively degrading under present conditions. Sea-ward of low water is a wide shallow platform covered in sand (British Geological Survey 1997)[16]. The 2m and 5m depth contours (below chart datum) occur 2km and 4-6km seaward of chart datum, respectively.

The spring tidal range is about 5m The dominant direction of wave approach is from the NE with a fetch into the North Sea.

5. GEOLOGY AND GEOMORPHOLOGY

The Isle of Sheppey lies on the south shore of the Thames Estuary about 70km east of London. The cliffs on the north of the isle expose over fifty metres vertically of London Clay formation capped by Virginia Water formation (Lower Bagshot beds) and shallow 3m depth of Pleistocene gravels filling depressions in the clay surface. See geological plan at Appendix F which is based upon the Geological Survey of Great Britain[16].

The London Clay at Sheppey is approximately 52-51million years old and is of the lower Eocene period of the Ypresian stage. London Clay is a very stiff heavily over-consolidated clay with a high shrinkage and swelling potential. Sheppey itself covers divisions of the upper C (At Warden Point, D (Between Warden point and Minster) and E (At Minster) Zones. The best zones for fossils are E and C, fossils are less common between the two points (Bed D). See Table 1 below.

Table 1 Geological Details

Palaeogene	**Oligocene**	Chattian	23.8 to 28.5 mya
		Rupelian	28.5 to 33.7 mya
	Eocene	Priabonian	33.7 to 35.5 mya
		Bartonian	35.5 to 40.5 mya
		Lutetian	40.5 to 49.5 mya
		Ypresian	49.5 to 54.8 mya
	Paleocene	Thanetian	54.8 to 57.0 mya
		Selandian	57.0 to 60.5 mya
		Danian	60.5 to 65.0 mya

Ypresian 49.5 - 54.8 million years ago (mya)		
FORMATIONS AND DEPOSITS		**LOCATIONS**
Poole Formation		
London Clay	London Clay Basement Bed	Ramsholt Bawdsey Whitecliff Bay
	Division A	**Isle of Sheppey** Walton-on-the-Naze
	Division B	Ramsholt Maylandsea
	Division C	Nacton Levington Bawdsey
	Division D	Bognor Regis Herne Bay Harwich Whitecliff Bay Wrabness
Harwich Formation		Harwich Wrabness
Blackheath Beds		Abbey Wood
Claygate Beds		**Isle of Sheppey**
Oldhaven Beds		Herne Bay
Reading Formation		Herne Bay Whitecliff Bay

6. AERIAL PHOTOGRAPHY

Aerial photography sources referred to in preparation of this report was principally photography from the Coastal Strategic Monitoring project administered by Canterbury City Council.

The photography undertaken is ortho-rectified and oblique at a frequency of 5 years.

7. LIDAR AIRBORNE LASER SCANNING

7.1 CONTOURS

Cross section profiles of the cliffs were developed from Lidar airborne laser scanning. Contours were at 1m height intervals.

7.2 HISTORIC DATA

The Environment Agency ABMS (aerial beach management survey) data is available from 1990. Ortho rectified photos are available for 2001, 2005 and 2008. Lidar dates back to 2005 in this area.

7.3 CURRENT DATA

Lidar is currently flown annually at the soft cliff sites and intermittent years or wider at sites of hard cliffs or heavily defended beaches. Profiles are run through the Lidar to create cross sections which are compatible with the SANDS software which allows a clear comparison between data sets. Further to this, it is possible to create difference models which calculate the difference in elevation between two sets of Lidar; highlighting areas of gain or loss from year to year. This is useful for marking cliff slumps or areas or erosion. Contour maps are decipherable from the Lidar data.

The most recent ortho-rectified aerial photography was flown in 2008 and is used under the Lidar to allow bearings and cliff edge proximity to nearby infrastructure.

7.4 FUTURE DATA COLLECTION

The collection of annual Lidar data on soft cliffs will continue for a minimum of 5years (2016-17) as they are not monitored through topographic survey techniques.

The next ortho-rectified photographs are scheduled for 2012-2013, which will allow a visual comparison with the previous aerial flights from 2001, 2005 and 2008.

7.5 EXAMPLES (SEE APPENDIX L)

1. A comparison of ortho-rectified photos
2. Lidar
3. Contour Map
4. Difference Model (2005-2010)
5. SANDS cross section of a cliff slump

8. HISTORIC ORDNANCE SURVEY RECORDS

In preparation of this report, historic O.S maps at 1:10,000 and 1:2500 scale were obtained from a company called Envirocheck, who have secured rights from Ordnance Survey to provide these types of documents. These plans were provided digitally in a layered format whereby comparisons and measurements could easily be made between any particular years.

Copies of plans dating from 1869 were used to ascertain average historic erosion rates of the cliff along the north Sheppey coastline. The cliff top line shown on the various plans was used as this is considered to be a more reliable reference point than the cliff toe and also more relevant to the study, since loss of land at the cliff top will be more apparent, and of concern to the community.