Water and Environment Management Framework
Lot 3 – Engineering and Related Services

West Wight Coastal Flood and Erosion Risk Management Strategy

Appendix C - Coastal Processes and Geotechnics Summary

August 2015

Document overview

Capita | AECOM was commissioned by the Isle of Wight Council in October 2014 to undertake a Coastal Flood and Erosion Risk Management Strategy. As part of this commission, a brief review of coastal processes and geotechnics has been undertaken to inform the option development phase of the Strategy.

Document history

Version	Status	Issue date	Prepared by	Reviewed by	Approved by
1	Draft for comment	30th March 2015	George Batt – Assistant Coastal Engineer Jason Drummond – Principal Flood and Coastal Specialist	Jonathan Short – Senior Coastal Specialist	Tara-Leigh McVey – Associate
2	Updated following client comments	4th August 2015	George Batt – Assistant Coastal Engineer Jason Drummond – Principal Flood and Coastal Specialist	Jonathan Short – Senior Coastal Specialist	Tara-Leigh McVey – Associate

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Glossary

Accretion – The accumulation of sand or other beach material due to the natural action of waves, currents and wind

Aspect – The direction that the section of frontage faces or points towards

Astronomical tide – The tidal levels and character which would result from gravitational effects, e.g. of the Earth, Sun and Moon, without any atmospheric influences

Back beach – The section of beach extending landwards from the high water mark to the point where there is an abrupt change in slope or material; also referred to as the backshore

Beach profile – A cross-section taken perpendicular to a given beach contour; the profile may include the face of a dune or seawall, extend over the backshore, across the foreshore, and seaward underwater into the nearshore zone

Bed load – Sediment transport mode in which individual particles either roll or slide along the seabed as a shallow, mobile layer a few particle diameters deep

Climate change – Refers to any long-term trend in mean sea level, wave height, wind, speed, drift rate etc.

Coastal defence – A term used to encompass both coastal protection against erosion and sea defence against flooding

Dredging – Actions such as excavation, digging, scraping, draglining, suction dredging etc. to remove sand, silt, rock or other underwater sea-bottom material

Epochs – The three periods of time in which the Strategy is reviewed in. The first epoch is 0-10 years, the second epoch is 10-40 years and the third epoch is 40-100 years

Erosion – Coastal erosion can be defined as the removal of material from the coast by wave action, tidal currents and/or the activities of man, typically causing a landward retreat of the coastline

Estuary – Mouth of a river, where fresh river water mixes with the seawater

Event – An occurrence meeting specified conditions, e.g. damage, a threshold wave height or a threshold water level

Extreme – The value expected to be exceeded once, on average, in a given (long) time period

Fetch – The distance over which a wind acts to produce waves – also termed fetch length

Foreshore – The intertidal area below highest tide level and above lowest tide level

Groyne – Shore protection structure built perpendicular to the shore; designed to trap sediment and/or to reduce longshore currents

Landslide – A coastal landslide can be regarded as the movement of sediment from an area of elevated topography to the foreshore

Littoral zone – Zone from the beach head (the cliff, dune or seawall forming the landward limit of the active beach) seawards to the limit of wave-induced sediment movement

Response factors – Used in the Walkden and Dickson equation to estimate future shore recession. Represents the response time of the coast as a result of changing sea level rise rates

Return period – Average period of time between occurrences of a given event

Sea level rise – The long term trend in mean sea level

Sediment – Particles of rock covering a size range from clay to boulders

Seepage erosion – Can be defined as the condition when finer particles are carries out of the soil mass under certain hydraulic gradients. The consequence of seepage erosion is to cause progressive failure for a slope and finally slope failure occurs

Significant wave height – The average height of the highest one third of the waves in a given sea state

SMP (Shoreline Management Plan) – a high-level non-statutory planning document which provides a large scale assessment of the risk associated with coastal processes and presents the a long-term policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner

SMZ (Strategic Management Zone) – A group of Policy Units (divisions of the Strategy frontage arising developed in the SMP) with similar characteristics in which overarching, wider scale options to manage the flood and erosion risk are developed

Spit – A long, narrow accumulation of sand or shingle, lying generally in line with the coast, with one end attached to the land the other projecting into the sea or across the mouth of an estuary

Still water level – Average water surface elevation at any instant, excluding local variation due to waves and wave set-up, but including the effects of tides and surges

Surge – Changes in water level as a result of meteorological forcing (wind, high or barometric pressure) causing a difference between the recorded water level and that predicted using harmonic analysis: may be positive or negative

Swell waves – Remotely wind-generated waves. Swell characteristically exhibits a more regular and longer period and has longer crests than locally generated waves

Tidal current – The movement of water associated with the rise and fall of the tides

Wave refraction – Process by which the direction of approach of a wave changes as it moves into shallow water

1. Introduction

1.1 Context

The Coastal Processes Report, 2014 (Appendix A) and additional key documents received from the Isle of Wight Council ('the Council') have been reviewed to identify, understand and apply the most pertinent coastal and geotechnical processes that should be taken into consideration during strategic option development. To compliment this, additional work on predicting still water levels and estimating erosion was also undertaken.

1.2 Purpose of this Report

This summary document is primarily intended to inform the baseline understanding underpinning the appraisal of Strategy options. Additionally, the review has provided outputs which have been used in the hydraulic modelling and the economic damage and benefit calculations.

The technical details for the development of the predicated extreme water levels are included in Appendix B. The technical approach to the prediction and mapping of future recession through changes in erosion rate are included in Appendix C.

Information such as the geology, sediment transport and wave heights at different locations will be utilised to ensure that the options developed are feasible and provide the best solutions to the problems of flooding and erosion.

For easy reference, the key observations have been collated and summarised for each Strategic Management Zone (SMZ) (Figure 1-1), particularly in defended areas, using key indicators to highlight the characteristics of the coastal regime, namely:

- Risks (in terms of flood, coastal erosion and landslides)
- Aspect and Exposure
- Water Levels and Waves
- Geology
- Sediment Transport and Coastal Change

1.3 Data/Reports Reviewed

The documents reviewed include:

- West Wight Coastal Flood and Erosion Risk Management Strategy Coastal Processes Report (Isle of Wight Council, 2014) – (included in Appendix A)
- Annual Survey Report 2013 Isle of Wight (Channel Coastal Observatory 2013)
- 2014 Update to the 2010 Report 'Adapting To Coastal Flooding In The Yarmouth Area in the 21st Century' (Yarmouth Coastal Defence Working Group, 2014)
- Adapting To Coastal Flooding In The Yarmouth Area in the 21st Century (Yarmouth Coastal Defence Working Group, 2010)
- Totland to Colwell Bay Landslide Assessment (Mott MacDonald, 2013).
- Cowes to Gurnard Coastal Slope Stability Study – Ground Behaviour Assessment (Halcrow, for Isle of Wight Council, 2000).
- Isle of Wight Strategic Flood Risk Assessment (Entec, 2010)

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- Isle of Wight Shoreline Management Plan 2 (Isle of Wight Council and Royal HaskoningDHV, 2010)
- Isle of Wight Coastal and Harbour Flood Mapping: Hydraulic Modelling Report (Royal HaskoningDHV, 2014)
- Isle of Wight Coastal and Harbour Flood Mapping: Inception Report (Royal HaskoningDHV, 2011)
- Cowes Outer Harbour Environmental Impact Assessment, Non-Technical Summary (undated, as available on www.cowesharbourcommission.co.uk , May 2015)

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Figure 1-1: Map of the study area showing delineation of Strategic Management Zones

2. Overview of Coastal Processes and Geotechnics by SMZ

This chapter presents a summary of present knowledge of coastal processes and geotechnics for each SMZ. There are several key sources of information that, unless stated otherwise, provide the following thematic observations or predictions:

- *Historic erosion rates:* West Wight Coastal Flood and Erosion Risk Management Strategy Coastal Processes Report (Isle of Wight Council, 2014)
- *Beach profile data:* Channel Coastal Observatory Annual Survey Report 2013 Isle of Wight (Channel Coastal Observatory 2013)
- *Existing extreme water levels:* Refer to Appendix B for the calculations of extreme water level.
- *Future erosion predictions:* Refer to Appendix C for the basis of future erosion predictions.

2.1 SMZ1: Needles headland (Fort Redoubt to southern limit of Totland Bay)

Risks

- Erosion
- Historic erosion rate of up to approximately 0.30m/yr; future erosion distance estimated to reach up to 60m.

Aspect and Exposure

- Exposed southerly to semi-exposed northwesterly aspect.

Water Levels and Waves

- Freshwater Bay: 2015 1 in 1 year water level is 1.47m increasing to 2.25m in 2115.
- Freshwater Bay: 2015 1 in 200 year water level is 1.98m increasing to 2.85m in 2115.
- Dominant southwesterly waves with significant swell wave activity from across the Atlantic from the south and south west, as well as energetic (storm) locally-generated wind waves; high wave energy (Isle of Wight Council, 2014).
- Maximum wave height, for a 1 in 1 year recurrence, is up to 5m on southern coast (Isle of Wight Council, 2014).

Geology and Landforms

- Steep to vertical chalk cliffs along the south coast to Alum Bay (Isle of Wight Council, 2014).
- Alum Bay is a west-facing bay cut into soft Eocene sand and clay sediments (Isle of Wight Council, 2014).
- At Headon Warren, complex landslides and partially active scarps have formed on the coastal slopes in a sequence of clays, sands and thin limestones. Weakly resistant Barton Clay and Sands outcrop at beach level (Isle of Wight Council, 2014).
- Cliff toe is sensitive to marine erosion and overall recession rates are rapid (Isle of Wight Council, 2014).
- Shingle beach at Alum Bay (Isle of Wight Council, 2014).

Sediment Transport and Coastal Change

- On the southern coast, foreshore profiles indicate no change or tendency towards erosion (2006-2011).
- Alum Bay foreshore profiles show erosion over the longer timescale (2003 to 2013), with more material lost in the north of the unit

2.2 SMZ2: Totland and Colwell bays (Southern limit of Totland Bay to Fort Victoria)

Risks

- Erosion including landsliding.
- Historic erosion rate of up to approximately 0.50m/yr; future erosion distance estimated to reach up to 100m.

Aspect and Exposure

- Semi-exposed westerly aspect with increased sheltering at northern end of zone.

Water Levels and Waves

- Totland and Colwell: 2015 1 in 1 year water level is 1.67m increasing to 2.45m in 2115.
- Totland and Colwell: 2015 1 in 200 year water level is 2.19m increasing to 3.06m in 2115.
- Exposed to dominant waves approaching from the north-west, west and south-west (Isle of Wight Council, 2014).
- The Needles headland provides shelter from waves approaching from the south and south-east (Isle of Wight Council, 2014).
- To the east, dominant waves are more heavily fetch-limited, whilst westwards the more exposed coastline receives attenuated and refracted swell as well as locally propagated waves (Isle of Wight Council, 2014).
- The offshore Shingles Bank refracts and dissipates incoming waves; reducing wave energy in some areas, where resultant wave energy is medium to low (Isle of Wight Council, 2014).
- Maximum significant wave heights of up to 2.36m and a 1 in 50 to 1 in 100 year frequency south of Fort Albert (Isle of Wight Council, 2014).

Geology and Landforms

- Cliffs at Totland and Southern Colwell Bays are composed of soft permeable strata overlying impermeable clays and are prone to recession through rapid seepage erosion, simple landslides and occasional deeper seated failures (Isle of Wight Council,, 2014) (e.g. Totland Bay winter 2012).
- Unprotected eroding low cliffs showing consistently rapid retreat in central and northern Colwell Bay (Isle of Wight Council, 2014).
- Narrow, sand and shingle, pocket beaches at Totland and Colwell (Isle of Wight Council, 2014).
- Sand and shingle beaches between Fort Albert and Fort Victoria (Isle of Wight Council, 2014).

Sediment Transport and Coastal Change

- Net west to east littoral drift (Isle of Wight Council, 2014).
- Rapid erosion of high cliffs along much of this shoreline yields large quantities of predominantly fine sediments i.e. non beach-building (Isle of Wight Council, 2014).

- Bays are relatively closed systems; intervening headlands between the bays inhibit sediment transport (Isle of Wight Council, 2014).
- Sediment inputs only from erosion of local cliffs (Isle of Wight Council, 2014).
- Seawalls, promenades and cliff drainage schemes prevent sediment inputs leading to falling beach levels observed over the past century (Isle of Wight Council, 2014).
- Totland Bay: Foreshore profiles are eroding (2004-2013). In places, particularly towards the south of the Totland pier, beach lowering is evident.
- Colwell Bay: Since 2004 (to 2013) the foreshore is generally stable with a small area of erosion to the south and accretion to the north of the bay. Net northeasterly beach movement is indicated by beach accumulations against groynes.
- Fort Albert to Fort Victoria: Most profiles show erosion (2004-2013) with up to 20% loss in cross-sectional area in one location and beach elevations lowering by up to 0.3m.

2.3 SMZ3: Yarmouth and the Western Yar (Fort Victoria to Port la Salle, including Freshwater Bay)

Risks

- Flood and erosion risks, but predominantly flooding.
- Historic erosion rate of up to approximately 0.30m/yr; future erosion distance estimated to reach up to 60m.

Aspect and Exposure

- Relatively sheltered, northerly facing, open coast.
- Includes estuarine tidal inlet (Yar Estuary).
- Also includes a section of exposed, southerly facing coast at Freshwater Bay.

Water Levels and Waves

- Yarmouth and Thorley Brook: 2015 1 in 1 year water level is 1.83m, increasing to 2.61m in 2115.
- Yarmouth and Thorley Brook: 2015 1 in 200 year water level is 2.35m, increasing to 3.22m in 2115.
- Freshwater Bay: 2015 1 in 1 year water level is 1.47m increasing to 2.25m in 2115.
- Freshwater Bay: 2015 1 in 200 year water level is 1.98m increasing to 2.85m in 2115.
- Locally strong tidal currents at the mouth of the Western Yar Estuary (Isle of Wight Council, 2014).
- The northwest coast of the Isle of Wight is sheltered from the open sea and incident waves generated in the West Solent are fetch-limited and generally are less than 1m in height and rarely in excess of height of 1.3m; Relatively low wave energy (Isle of Wight Council, 2014).
- The north-facing frontage is susceptible to locally generated waves within the Solent (and overtopping).
- On the south-facing frontage, there is significant swell wave activity as well as energetic locally-generated wind waves in Freshwater Bay (Isle of Wight Council, 2014).
- Maximum wave height, for a 1 in 1 year recurrence, is up to 5m at Freshwater Bay (Isle of Wight Council, 2014).

Geology and Landforms

- Soft clayey, late Eocene and early Oligocene strata of the Solent Group; mudslides are common (Isle of Wight Council, 2014).
- The Yar is made up of dominantly fine-grained estuarine sediments, up to 14m thick in a palaeovalley (Isle of Wight Council, 2014).

- Shingle (well-rounded and abraded flint cobbles) pocket beach at Freshwater Bay (Isle of Wight Council, 2014).
- Between Fort Victoria (Sconce Point) to Norton, the beach comprises a narrow strip of sand and gravel above a narrow muddy foreshore (Isle of Wight Council, 2014).
- Sand beach at Norton Spit.
- Narrow strip of shingle at Yarmouth Pier.

Sediment Transport and Coastal Change

- Weak littoral drift generally operates north eastward along the coast with the exception of local reversals on the eastern entrances to inlets; littoral drift is from both sides towards the Western Yar inlet (Isle of Wight Council, 2014).
- Between Fort Victoria and the Western Yar, coarse sediments drift eastwards and are retained in a spit at the mouth of the estuary (Isle of Wight Council, 2014).
- Net offshore transport of coarse bedload sediments at the mouth of the Yar (Isle of Wight Council, 2014).
- Dredging is periodically undertaken for navigation purposes at Yarmouth Harbour (Isle of Wight Council, 2014).
- Most of the erosion products are transported offshore and do not contribute to protect local beaches (Isle of Wight Council, 2014).
- Northern coast has been replenished in the past (Isle of Wight Council, 2014).
- Fort Victoria to Yarmouth foreshore profiles show stability between 2003-2013.
- Yarmouth to Port la Salle: Over the longer timescale (2003-2013), majority of profiles are eroding whilst minority are stable.
- Freshwater Bay is a re-entrant trap receiving sediment from both east and west (Isle of Wight Council, 2014).
- Freshwater Bay: Majority of foreshore profiles are stable between 2003 and 2013. Erosion at the flanks and accretion in the centre. Most change evident adjacent to The Albion Hotel; greater than 30% reduction in cross-sectional area between 2003-2013, resulting in beach lowering of approximately 2m.

2.4 SMZ4: Newtown coast (Bouldnor cliff to Thorness Bay, including Newtown Estuary)

Risks

- Erosion on the open coast, and flooding of Newtown Estuary and Little Thorness.
- Historic erosion rate on the coast of up to approximately 0.40m/yr; future erosion distance estimated to reach up to 80m. Potential for Newtown spits to retreat at rates in excess of historic rates of approximately 0.62m/yr.

Aspect and Exposure

- Relatively sheltered, northwesterly facing, open coast.
- Estuarine tidal inlets at Newtown Estuary and Thorness Bay.

Water Levels and Waves

- Existing and predicted water levels are greater than Yarmouth, but less than Gurnard, since water levels increase from west to east along the northwest coast of the island.
- Locally strong tidal currents at the mouth of the Newtown Estuary (Isle of Wight Council, 2014).
- The northwest coast of the Isle of Wight is sheltered from the open sea and incident waves generated in the West Solent are fetch-limited and generally are less than 1m in

height and rarely in excess of height of 1.3m; Relatively low wave energy (Isle of Wight Council, 2014).
- The frontage is susceptible to locally generated waves within the Solent.

Geology and Landforms

- Narrow, sand and gravel, back beach between Bouldnor and Newtown Harbour (Isle of Wight Council, 2014).
- Cliffs developed within the clayey strata of the Bouldnor Formation, Bembridge and Osborne Beds and Plateau Gravels (Isle of Wight Council, 2014).
- Coastal slope degrades by deep-seated rotational slides and by mudsliding (Isle of Wight Council, 2014).
- Newtown Estuary occupies a low valley complex, protected by twin gravel spits shielding diverging branches of the estuary (Isle of Wight Council, 2014).
- In-filled low valley at Thorness Bay fronted by a gravel beach (Isle of Wight Council, 2014).
- Much of lower foreshore between Newtown Harbour and Gurnard comprises fine muds (gravel on upper foreshore) (Isle of Wight Council, 2014).

Sediment Transport and Coastal Change

- Large quantities of primarily fine sediments contributed to West Solent by cliff erosion (Isle of Wight Council, 2014).
- Weak littoral drift generally operates north eastward along the coast with the exception of local reversals on the eastern entrance of the Newtown Estuary; littoral drift is from both sides towards the estuary (Isle of Wight Council, 2014).
- Between Yarmouth and Egypt Point, coarse sediments drift eastwards; some are retained in Newtown Estuary spits; some material moves onward to collect within Thorness Bay (Isle of Wight Council, 2014).
- Generally negligible change in bathymetry profiles between 2006-2011.

2.5 SMZ5: Gurnard and Cowes headland (Gurnard Luck to Cowes Parade)

Risks

- Flooding (Gurnard Luck and Gurnard-Cowes parade), erosion and landslide reactivation.
- Historic erosion rate of up to approximately 0.30m/yr; future recession distance estimated to reach up to 60m.
- Potential for landslide reactivation: if triggered (through failure of defences protecting the toe of the landslide area) erosion could result in 2.00m/yr (average) retreat through reactivation of the developed coastal slopes.

Aspect and Exposure

- Relatively sheltered, open coast with northerly/northwesterly aspect.

Water Levels and Waves

- Gurnard: 2015 1 in 1 year water level is 2.35m increasing to 3.13m in 2115.
- Gurnard: 2015 1 in 200 year water level is 2.88m increasing to 3.75m in 2115.
- Cowes: 2015 1 in 1 year water level is 2.45m increasing to 3.23m in 2115.
- Cowes: 2015 1 in 200 year water level is 2.99m increasing to 3.86m in 2115.
- Sheltered from the open sea; incident waves generated in the West Solent are local, fetch-limited and generally less than 1m in height. Rarely in excess of height of 1.3m; low wave energy (Isle of Wight Council, 2014).

- The frontage is susceptible to overtopping.

Geology and Landforms

- Coastal slopes formed in soft Palaeocene, Eocene and Oligocene materials (clays, marls and limestones) and mantled by relict landslides (Isle of Wight Council, 2014).
- Coastal slopes of Oligocene strata form a prominent headland separating the Medina River and Estuary from the Western Solent (Isle of Wight Council, 2014).
- Beaches comprise sandy gravels (Isle of Wight Council, 2014).
- Much of the lower foreshore between Gurnard and Egypt Point, Cowes, is comprised of fine muds (Isle of Wight Council, 2014).

Sediment Transport and Coastal Change

- Weak littoral drift generally operates north eastward along the coast as far as Egypt Point (Isle of Wight Council, 2014).
- Re-activation of cliff recession supplies predominantly fines to the Solent (not beaches) (Isle of Wight Council, 2014).
- At Gurnard Luck, an eroding beach profile at the western end of the frontage (immediately east of the mouth of the Luck) has lost 15-30% of cross-sectional area between 2003 and 2013. In contrast, a beach profile at eastern end has gained more than 30% in area, with accretion of 0.3m mid-profile.
- Gurnard Cliff: minor accretion evident along the entire profile length (5-15% increase in cross-sectional area).
- Gurnard Cliff to Cowes Castle: Most profiles have shown little change or minor accretion (5-15% increase in cross-sectional area) from 2004 to 2013.

2.6 SMZ6: Cowes, East Cowes and Medina (Cowes Parade to Old Castle Point, East Cowes)

Risks

- Key risk is flooding, plus areas of erosion and slope failure.
- Historic erosion rates of under 0.30m/yr; future erosion distance estimated to reach up to 60m.
- On the East Cowes headland (near Old Castle Point), there is potential for additional slope failure and retreat, as evidenced by the recent (April 2014) landslip that affected the Esplanade.

Aspect and Exposure

- The majority of the unit is a relatively sheltered, estuarine environment, with the Medina Estuary orientated north to south, however, there is a more exposed northeasterly and northwesterly coastal aspect at mouth of Estuary.

Water Levels and Waves

- Cowes and East Cowes: 2015 1 in 1 year water level is 2.45m increasing to 3.23m in 2115.
- Cowes and East Cowes: 2015 1 in 200 year water level is 2.99m increasing to 3.86m in 2115.
- Locally strong tidal currents at the mouth of the Medina Estuary (Isle of Wight Council, 2014).
- Northeasterly facing frontage experiences low energy waves generated within the Solent (Isle of Wight Council, 2014).

- Outer breakwater (in construction) designed to reduce the wave climate to less than 0.3m in height in the area of the new marina and across much of the outer harbour (Isle of Wight Council, 2014).

Geology and Landforms

- Reactivation of cliff recession (East Cowes) supplies predominantly fine sediments to the Solent (not beaches) (Isle of Wight Council, 2014).
- Medina Estuary lies in a wide shallow valley with a shallow incline on either side; sediment build up upstream has formed characteristic mudflats (Isle of Wight Council, 2014).

Sediment Transport and Coastal Change

- Very weak, westwards directed, littoral drift occurs from Old Castle Point towards the Shrape breakwater at mouth of Medina estuary (Isle of Wight Council, 2014).
- The Shrape Breakwater prevents input into Cowes Harbour from the east.
- The new, detached, outer breakwater will also have an effect on sediment transport at the mouth of the Medina estuary, but it will still be possible for sediment to be transported along the western shoreline).
- Cowes Harbour entrance represents a drift convergence boundary (Isle of Wight Council, 2014).
- Although maintenance dredging of approximately 4,000 tonnes per year is undertaken upstream of Cowes Harbour to maintain the channel to Newport Harbour, the channel is mainly self-scouring (Isle of Wight Council, 2014).
- Medina Estuary's dominant ebb tidal flow generates net offshore flushing of incoming shoreline sediments (Isle of Wight Council, 2014).
- At East Cowes, between 2004 and 2013, profiles have remained stable and show some minor accretion (5-15% of cross-sectional area).

Appendix A
Coastal Processes Report – Isle of Wight Council, November 2014

West Wight
Coastal Flood and Erosion
Risk Management Strategy

Isle of Wight Council

Coastal Processes Report
November 2014

Planning Policy, Isle of Wight Council

Note:

This report is a 2014 update of '*Appendix C: Baseline Process Understanding, C1: Assessment of Shoreline Dynamics*' from the Isle of Wight SMP2, 2010. Updated information includes incorporating new Annual Coastal Monitoring programme results, SCOPAC Sediment Transport Study 2014 Update, additional information on coastal landsliding, new events, SMP2 units.

Acknowledgements:

Acknowledgement is given to the Isle of Wight Shoreline Management Plan 2010, Appendix C1 (Assessment of Shoreline Dynamics), the SCOPAC Sediment Transport Study (University of Portsmouth, 2004), and its subsequent literature review update for the North-west coast in July 2014 (Channel Coast Observatory), as key information sources used throughout this report, alongside Defra's Futurecoast Report (Halcrow, 2002), and the Channel Coast Observatory's Strategic Monitoring Programme Annual Report for the Isle of Wight 2013.

Photo credits:

Contents:

Glossary

Term	Definition
AONB	Area of Outstanding Natural Beauty: A statutory designation by the Countryside Commission. The purpose of the AONB designation is to identify areas of national importance and to promote the conservation and enhancement of natural beauty. This includes protecting its flora, fauna, geological and landscape features.
Accretion	Accumulation of sand or other beach material due to the natural action of waves, currents and wind.
Adaptation	Implies that there may be some actual change in the way a feature, such as a habitat or a community, functions. In supporting adaptation, management has to recognise certain principles: • That adaptation may take time and may evolve slowly so that change to the overall community does not happen immediately. • That management should not encourage a progressively more vulnerable situation to develop, where there is a sudden change from one condition to another. • That specific aspects of a feature, such as individual properties or elements of habitat may change or be lost, but without substantial loss to the value of the community or the overall ecological function of the feature.
Anthropogenic	Impacts that originate from humans.
Armour	Structural protection (rock or concrete) for the shoreline
AA/HRA	Appropriate Assessment. Also referred to as a Habitat Regulations Assessment (HRA). The AA is an independent check of the potential impacts of policies being put forward by the SMP with specific reference to designated European nature conservation sites (such as SACs, SPAs, etc.)
ATL	Advance the Line. Policy decision to build new defences seaward of the existing defence line where significant land reclamation is considered.
Back beach/back shore	The section of beach extending landwards from the high water mark to the point where there is an abrupt change in slope or material; also referred to as the backshore.
Bar	Fully or partially submerged elongated mound of sand, gravel or other unconsolidated material built on the sea-bottom in shallow water by waves and currents.
Beach face	Upper surface of the beach.
Beach nourishment	Artificial process of replenishing a beach with material from another source.
Beach profile	Side view of a beach which may extend from the top of the backshore, the face of a dune line, or a sea wall, into the sea.
Benefits (related to issue)	The service that a feature provides. In other words, why people value or use a feature. For example, a nature reserve, as well as helping to preserve biodiversity and meet national legislation, may also provide a recreation outlet much like a sports centre provides a recreation function.
Berm crest	Ridge of sand or gravel deposited by wave action on the shore just above the normal high water mark.
BAP	Biodiversity Action Plan. An element of UK environmental legislation, aimed at enhancing and protecting biodiversity within key habitat areas.
Brackish water	Freshwater mixed with seawater.
Breaker	
Breaker zone	Area in the sea where the waves break.
CSG	Client Steering Group. The CSG is comprised of representatives from the key operational bodies and statutory consultees involved with coastal and estuarine management within the SMP area. They provide an overseeing steer and guidance role to technical consultants and generally oversee the consultation and approvals activities required within the SMP2 programme.
Clastic	Pertaining to a sediment or rock composed chiefly of fragments derived from pre-existing rocks or minerals
Coastal defence	A term used to encompass both coastal protection against erosion and sea defence against flooding.
Coastal defence strategy plan	A detailed assessment of the strategic coastal defence option(s) for a management unit(s), based on Flood and Coastal Defence Project Appraisal Guidance 2.

Term	Definition
Coastal habitat management plan (CHaMP)	A non-statutory management plan which identifies potential future changes to coastal habitats and potential compensation measures for any losses to a European designated site or group of sites.
Coastal squeeze	The reduction in habitat area that can arise if the natural landward migration of a habitat under sea level rise is prevented by the fixing of the high water mark, e.g. a sea wall.
Coastal zone management plan	Plans through which local authorities and others implement planning objectives and policies for an area of the coast, which deal with a range of issues such as landscape management, development, recreation, conservation, etc.
Concern	This is a stated actual or perceived problem, raised by an individual or stakeholder. A concern can be strategic or local.
Consequence	An outcome or impact such as economic, social or environmental impact. It may be expressed as a quantity (e.g. monetary value), categorical (e.g. high, medium, low) or descriptive (see FCDPAG4).
Conservation	The political/social/economic process by which the environment is protected and resources are used wisely.
CV	Capital Value. The actual value of costs or benefits.
Deep water	Area where surface waves are not influenced by the sea-bottom.
Defra	Department for Food, Environment and Rural Affairs
Defra Procedural Guidance	The Shoreline Management Plan (SMP) Procedural Guidance produced by Defra to provide a nationally consistent structure for the production of future generation Shoreline Management Plans.
Downdrift	Direction of longshore movement of beach materials.
Downdrift effects	Impacts occurring in the lee of any coastal activity resulting from associated changes to the coastal processes, particularly sediment supply.
Dredging	Excavation, digging, scraping, draglining, suction dredging to remove sand, silt, rock or other underwater sea-bottom material.
Dune	Accumulations of wind-blown sand in ridges or mounds that lie landward of the beach and usually parallel to the shoreline.
Ebb-tide	The falling tide, part of the tidal cycle between high water and the next low water.
Economic appraisal	An appraisal which takes into account a wide range of costs and benefits, generally those that can be valued in money terms.
Ecosystem	Organisation of the biological community and the physical environment in a specific geographical area.
Enhance (improve)	The value of a feature increases.
Erosion	The loss of land or encroachment by the sea through a combination of natural forces e.g. wave attack, slope processes, high groundwater levels.
Estuary	Mouth of a river, where fresh river water mixes with the seawater.
European site	Any site that has been designated as a site of international nature conservation importance either as a Special Protection Area (SPA), a Special Area of Conservation (SAC) or a Ramsar Site. In regard to planning considerations it is Government policy to treat potential SPAs, candidate SACs and listed Ramsar Sites as if they were already designated.
EIA	Environmental Impact Assessment. Detailed studies that predict the effects of a development project on the environment. They also provide plans for mitigation of any significant adverse impacts.
EMF	Elected Members Forum. The EMF is comprised of elected council members from within the SMP area. They are consulted with at key stages of the SMP programme. Endorsement of the preferred plan is sought from the EMF prior to public consultation.
Epoch	The three periods of time in which the Shoreline Management Plan is reviewed in. The first epoch is 0-20 years, the second epoch is 20-50 years and the third epoch is 50-100 years.
ESA	Environmentally Sensitive Area. A non-statutory designation for an area where special land management payments are available through agreement with Defra to provide farming practices which are beneficial to the environment.
Feature	Something tangible that provides a service to society in one form or another or, more simply, benefits certain aspects of society by its very existence. Usually this will be of

Term	Definition
	a specific geographical location and specific to the SMP.
Fetch	The distance that the wind has passed across the water in one direction (the greater the fetch, the larger the wind-driven waves will be).
Flooding	Refers to inundation by water whether this is caused by breaches, overtopping of banks or defences, or by inadequate or slow drainage of rainfall or underlying ground water levels. Flooding due to blocked drains and sewers or the escape of water from a water supply service will usually be the responsibility of the local water company and does not fall within the scope of a Shoreline Management Plan.
Flood-tide	Rising tide, part of the tidal cycle between low water and the next high water.
Flood Zone	A geographical area officially designated subject to potential flood damage. The Environment Agency defines Flood Zone 2 and Flood Zone 3 (see below).
Flood zone 2	The area that could be affected by flooding from the sea, if there were no flood defences in place. Flood zone 2 shows the area that could be affected by an extreme flood from the sea, with up to a 0.1 per cent (1 in 1000) chance of occurring each year.
Flood zone 3	The area that could be affected by flooding from the sea, if there were no flood defences in place. Flood zone 3 shows the area that could be affected by a flood event that has a 0.5 per cent (1 in 200) or greater chance of happening each year.
Fluxes	The rate of flow of water, as the tide or current, through a defined area.
Foreshore	Zone between the high water and low water marks.
Gabions	Wire mesh rectangular containers filled with stones.
Geomorphology/ Morphology	The branch of physical geography/geology which deals with the form of the Earth, the general configuration of its surface, the distribution of the land, water, etc.
GIS	Geographic Information System. Software which allows the spatial display and interrogation of geographical information such as ordnance survey mapping and aerial photography.
Greenhouse effect	Heating of the earth's atmosphere due to a presence in gases like carbon dioxide.
Groyne	Shore protection structure built perpendicular to the shore; designed to trap sediment.
Groyne field	Series of groynes acting together to protect a section of beach.
Habitat action plan	A biodiversity action plan for a habitat.
Habitat directive	EC Directive 92/43 on the conservation of natural habitats and of wild fauna and flora.
Habitat regulations	The conservation (Natural Habitats & c.) Regulations 1994. This transposes the Habitats Directive into UK Law.
Hazard	A situation with the potential to result in harm. A hazard does not necessarily lead to harm.
HTL	Hold the Line. Policy decision to maintain or upgrade the level of protection provided by defences or natural coastline.
Heritage Coast	A non-statutory designation by the Countryside Commission for coasts of scenic quality, their largely undeveloped nature and their special wildlife and historic interest. Local authorities assist with the management of Heritage Coasts often with Heritage Coast officers.
Integrated	An approach that tries to take all issues and interests into account. In taking this approach, managing one issue adds value to the way another is dealt with.
Isobath	A line on a chart joining places of equal depth or height e.g. a contour
Issue	All issues and aspirations are related to flood and coastal defence and grouped or categorised under the three main themes: Technical; Environmental; or Socio-economic
Key stakeholder	A person or organisation with a major interest in the preparation of, and outcomes from, a shoreline management plan. This includes agencies, authorities, organisations and private bodies with responsibilities or ownerships that affect the overall management of the shoreline in a plan.
Land reclamation	Process of creating new, dry land on the seabed.
Landslide	A coastal landslide can be regarded as a transfer of sediment from an area of elevated topography to the foreshore. Slope instability and a semi-continuous sediment cascade is maintained by basal erosion which can act in two ways: (i)

Term	Definition
	degraded materials are removed from the base of the slope, which prevents a stable slope angle being achieved; (ii) basal erosion of in-situ strata can undercut the cliff toe so that the slope is steepened to a greater repose angle than would naturally be maintained by the ground-forming materials. From a coastal viewpoint the result is the same, in that sediment is supplied to the littoral zone, and, assuming it is removed thereafter, the coast retreats.
LDF	Local Development Framework. The Isle of Wight LDF is called the Island Plan.
Lithology	Mineralogy, grain size, texture, and other physical properties of granular soil, sediment, or rock.
Littoral	The littoral zone extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged. It always includes the intertidal zone and is often used to mean the same as the intertidal zone.
Longshore current	A movement of water parallel to the shore, caused by waves and tides.
Longshore transport	Movement of material parallel to the shore also referred to as longshore drift.
LNR	Local Nature Reserves. A statutory designation for sites established by local authorities in consultation with Natural England. These sites are generally of local significance and also provide important opportunities for public enjoyment, recreation and interpretation.
Maintain	That the value of a feature is not allowed to deteriorate.
Managed realignment	The reintroduction of tidal waters to previously enclosed or reclaimed land Defra definition - Allowing the shoreline to move backwards or forwards, with management control or limit movement (such as reducing erosion or building new defences on the landward side of the original defence).
Management Area (MA)	Management Area, defined by SMP2. A collection of Policy Units (PU) that are interdependent and should therefore be managed collectively.
MDSF	Modelling and Decision Support Framework. Mapping linked computer tool used in the evaluation of assets at risk from flooding or erosion.
Mean sea level	Average height of the sea surface.
MHW	Mean High Water. The average of all high waters observed over a sufficiently long period.
MLW	Mean Low Water. The average of all low waters observed over a sufficiently long period.
MR	Managed Realignment. Policy decision to manage the coastal processes to realign the 'natural' coastline configuration, either seaward or landward, in order to create a future sustainable shoreline position
Natura 2000	European network of protected sites which represent areas of the highest value for natural habitats and species of plants and animals which are rare, endangered or vulnerable in the European Community.
NAI	No Active Intervention. Policy decision to not to invest in providing or maintaining defences or natural coastline. NAI is also a scenario or prediction used in SMP2 to understand potential future coastal change. The scenario assesses the consequences of applying a NAI policy to the shoreline, allowing existing defences to fail and coastal change to occur.
Nearshore	The region of land extending from the backshore to the beginning of the offshore zone.
NNR	National Nature Reserves. A statutory designation by Natural England. These represent some of the most important natural and semi-natural ecosystems in Great Britain and are managed to protect the conservation value of the habitats that occur on these sites.
Objective	A desired state to be achieved in the future. An objective is set, through consultation with key parties, to encourage the resolution of the issue or range of issues.
Offshore breakwater	Structure parallel or angled to the shore, usually positioned in the sea, which protects the shore from waves.
Offshore zone	Extends from the low water mark to a water depth of about 15 m (49 ft.) and is permanently covered with water.
Operating authority	A body with statutory powers to undertake flood defence or coast protection activities, usually the Environment Agency or maritime District Council.

Term	Definition
Pile	Long heavy section of timber, concrete or metal, driven into the ground or seabed as support for another structure. Especially around/or at the toe of a shore protection structure.
Policy	In this context, “policy” refers to the generic shoreline management options (No Active Intervention, Hold the Existing Line of Defence, Managed Realignment, Retreat or Advance the Existing Line of Defence, and Hold the Retired Line).
PDZ	Policy Development Zone. A length of coastline defined for the purpose of assessing all issues and interactions to examine and develop management scenarios. These zones are only used in the procedure of developing policy. Policy Units and Management Areas are then used for the Final definition of the policies and the management of the coast.
Policy Scenario	A combination of policies selected against the various feature/benefit objectives for the whole SMP frontage.
Policy Unit (PU)	Policy Unit, defined by SMP2. A section of coastline for which a certain coastal defence management policy has been defined. These are then grouped into Management Areas (MA).
PV	Present Value. The value of a stream of benefits or costs when discounted back to the present day. For this SMP the discount factors used are the latest provided by Defra for assessment of schemes, i.e. 3.5% for years 0-30, 3.0% for years 31-75, and 2.5% thereafter.
Residual life	The time to when a defence is no longer able to achieve minimum acceptable performance criteria in terms of serviceability or structural strength.
Residual risk	The risk which remains after risk management and mitigation. It may include, for example, risk due to very severe storms (above design standard) or risks from unforeseen hazards.
Retaining wall	Wall built to hold back earth.
Revetment	Shore protection structure made with stones/ rock laid on a sloping face.
Risk assessment	Consideration of risks to people and the developed, historic and natural environment.
Risk management	The process of analysing exposure to risk and determining how to best handle such exposure.
Ramsar	Designated under the, “Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat” 1971. The objective of this designation is to prevent the progressive encroachment into, and the loss of wetlands.
RIGS	Regionally Important Geological/Geomorphological Sites. A non-statutory designation identified by locally developed criteria and are currently the most important places for geology and geomorphology outside statutorily protected land such as SSSI’s.
Schedule IV	'Waters excluded for purposes of definitions of 'sea' and 'seashore' (refer to Coast Protection Act, 1949).
Scour	Removal of underwater material by waves or currents, especially at the toe of a shore protection structure.
SAC	Special Area of Conservation. This designation aims to protect habitats or species of European importance and can include Marine Areas. SACs are designated under the EC Habitats Directive (92/43EEC) and will form part of the Natura 2000 site network. All SACs sites are also protected as SSSI, except those in the marine environment below the Mean Low Water (MLW).
SFRA	Strategic Flood Risk Assessment. The Isle of Wight SFRA assesses flood risks on the Isle of Wight, and in particular the flood risks associated with areas being considered for future development as part of the emerging Local Development Framework (LDF).
SM	Scheduled Monument. A statutory designation under the Ancient Monuments and Archaeological Areas Act 1979. This Act, building on legislation dating back to 1882, provides for nationally important archaeological sites to be statutorily protected as Scheduled Ancient Monuments.
SEA	Strategic Environmental Assessment. In SMP terms an SEA is an independent audit of the SMP process and the policies it puts forward. SEA assesses policies for potential impacts against a series of environmental themes.
Seawall	Massive structure built along the shore to prevent erosion and damage by wave action.

Term	Definition
Sediment	Particles of rock covering a size range from clay to boulders.
Sediment cell	A length of coastline and its associated near shore area within which the movement of coarse sediment (sand and shingle) is largely self-contained. Interruptions to the movement of sand and shingle within one cell should not affect beaches in an adjacent sediment cell.
Sediment sub-cell	A sub-set of a sediment cell within which the movement of coarse sediment (sand and shingle) is relatively self-contained.
Setback	Prescribed distance landward of a coastal feature (e.g. the line of existing defences).
Shore	Narrow strip of land in immediate contact with the sea.
Shoreline	Intersection of a specific water height with the shore or beach, e.g. the high water shoreline is the intersection of the high water mark with the shore or beach.
Significant effect	Where a plan or project is likely to affect a European Site it is necessary to decide whether or not it would have a significant effect. If there is any doubt, the operating authority must consult English Nature/Countryside Council for Wales. They will advise whether, in their view, the proposed scheme would be likely to have a significant effect.
Sink	Area at which beach material is irretrievably lost from a coastal cell, such as an estuary, or a deep channel in the seabed.
SLA	Special Landscape Area. A non-statutory designation for an area usually identified by local authorities as having a strategic landscape importance.
SMA	Sensitive Marine Area. A non-statutory designation for nationally important locations around the coast that require a cautious and detailed approach to management. They are identified by Natural England for their important benthic populations, spawning or nursery areas for fish, fragile intertidal communities, or breeding, feeding, and roosting areas for birds and sea mammals.
SMP	Shoreline Management Plan. A non-statutory plan, which provides a large-scale assessment of the risks associated with coastal processes and presents a policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner.
SNCI	Site of Nature Conservation Importance. A non-statutory designation defined by the Wildlife Trusts and Local Authorities as sites of local nature conservation interest. These form an integral part in the development of planning policies relating to nature conservations issues.
SPA	Special Protection Area. A statutory designation for internationally important sites, being set up to establish a network of protected areas of birds.
SSSi	Sites of Special Scientific Interest. A statutory designation notified by Natural England representing some of the best examples of Britain’s natural features including flora, fauna, and geology.
Stakeholder	A person or organisation with an interest in the preparation of a shoreline management plan or affected by the policies produced. This broad interpretation has been taken to include agencies, authorities, organisations and private persons. See "Key stakeholder".
Storm surge	A rise in the sea surface on an open coast, resulting from a storm.
Strategic	Used to describe the undertaking of any process in a holistic manner taking account of all associated impacts, interests of other parties and considering the widest possible set of potential options for the solution of a problem. In the context of this document, the word 'strategic' does not imply any particular level in the hierarchy of the planning process.
Sustain	Refers to some function of a feature. A feature may change, but the function is not allowed to fail.
Sustainable policies	Sustainable policies lead to coastal defence solutions that avoid tying future generations into inflexible and/or expensive options for defence. They will usually include consideration of interrelationships with other defences and likely developments and processes within a coastal cell or sub-cell. They will also take account of long-term demands for non-renewable materials.
Swell	Waves that have travelled out of the area in which they were generated.
Temporal	Referring to the passage or a measurement of time
Tidal current	Movement of water in a constant direction caused by the periodic rising and falling of

Term	Definition
	the tide. As the tide rises, a flood-tidal current moves in one direction and as the tide falls, the ebb-tidal current moves in the opposite direction.
Tidal inlet	A river mouth or narrow gap between islands, within which salt water moves landwards during a rising tide.
Tidal prism	The volume of water within an estuary between the level of high and low tide, typically taken for mean spring tides.
Tide	Periodic rising and falling of large bodies of water resulting from the gravitational attraction of the moon and sun acting on the rotating earth.
Toe protection	Material, usually large boulders, placed at the base of a sea defence structure like a seawall to prevent wave scour.
Topography	Configuration of a surface including its relief and the position of its natural and man-made features.
Transgression	The landward movement of the shoreline in response to a rise in relative sea level.
Updrift	Direction opposite to the predominant movement of longshore transport.
VMCA	Voluntary Marine Conservation Areas. A statutory designation to protect the marine conservation importance of a site and to provide a focus for liaison, co-operation and education for a sustainable marine environment.
Water table	The upper surface of groundwater; below this level, the soil is saturated with water.
WFD	Water Framework Directive. European legislation which seeks to improve the quality of both freshwater and coastal water bodies.
Wave direction	Direction from which a wave approaches.
Wave refraction	Process by which the direction of approach of a wave changes as it moves into shallow water.
Wetlands	Low-lying areas that are frequently flooded and which support vegetation adapted to saturated soils e.g. mangrove swamps.
WPM	With Present Management. WPM is a scenario or prediction used in SMP2 to understand potential future coastal change. The WPM scenario essentially describes the current regime of management which exists for a given frontage. WPM scenario assumes that defences will be maintained in their present position and other management practices, e.g. beach re-nourishment, will continue as at present.

Coastal Processes Report

1. Introduction

This report assesses the coastal processes shaping the evolution of the West Wight Isle of Wight coast, describing the character of different sections of the coastline in accordance with the Shoreline Behaviour Statements defined in the Futurecoast report (Futurecoast, 2002):

- South-west coast: Rocken End to the Needles
- Western coast: The Needles to Cliff End (Fort Albert, Colwell Bay)
- North-west coast: Cliff End to Old Castle Point

A map is provided below illustrating the large-scale and local-scale process unit boundaries used in each section of the report, as well as a map illustrating the West Wight Coastal Flood and Erosion Risk Management Strategy area.

The report also contains relevant information produced post-Futurecoast or at a level of detail not included within Futurecoast, e.g. longshore variations in sediment transport rates. The two can be read in conjunction with one another to provide a full understanding of coastal dynamics and behaviour across different spatial and temporal scales.

This report makes extensive use of the Sediment Transport Study 2004, which was produced by the Geography Department, University of Portsmouth for SCOPAC (Standing Conference on Problems Associated with the Coastline). Details relating to hydrodynamic regime and functional behaviour and organisation of landforms in this coastal processes report have largely been taken from the Sediment Transport Study which is currently the best available research for this area of the coast. The Sediment Transport Study is publicly available on the SCOPAC website - www.scopac.org.uk/sedimenttransport.htm.

The report also includes the updated literature review 2014 for the SCOPAC Sediment Transport Study, for the north-west coast of the Isle of Wight, supplied by the Channel Coast Observatory, July 2014 (to be incorporated into an update of the Sediment Transport Study).

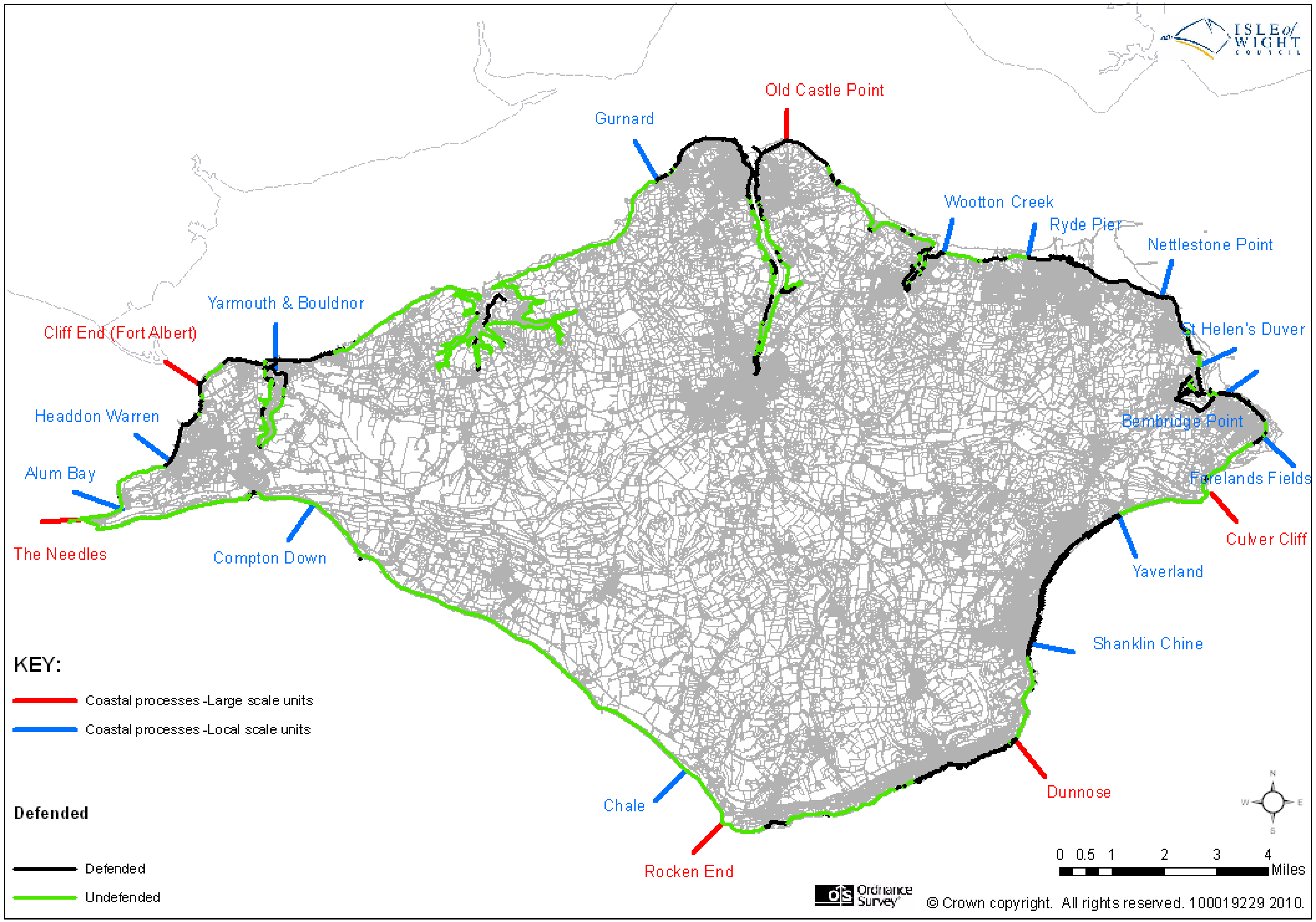
This report also includes the latest results of the Annual Strategic Coastal Monitoring programme, showing, firstly, change in beach profiles and volumes over the past year (2012-2013) and secondly, change over the ten year period since the baseline surveys were first conducted in 2003.

The Southeast Strategic Regional Coastal Monitoring Programme provides a consistent regional approach to coastal process monitoring, providing data on large number of beach profile lines around the Isle of Wight coast as well as data on wave and tide conditions. Some data predating the strategic monitoring programme exists for some areas of the coastline but data is not consistent. Baseline data was collected in winter 2003 onwards and a summary of the results from the monitoring programme since the programme started are presented in the local scale units below. This is a relatively short time base over which beach changes have been monitored, and detailed interpretation and decision-making is not advisable on the basis of these short-term changes, which may not be representative of longer-term trends. However, these results provide an indication of short-term trends and will be reviewed in future years as more data is collected. Further details are available in Annex B and in the Southeast Strategic Regional Coastal Monitoring Programme Isle of Wight Annual Report (Channel Coastal Observatory, 2014).

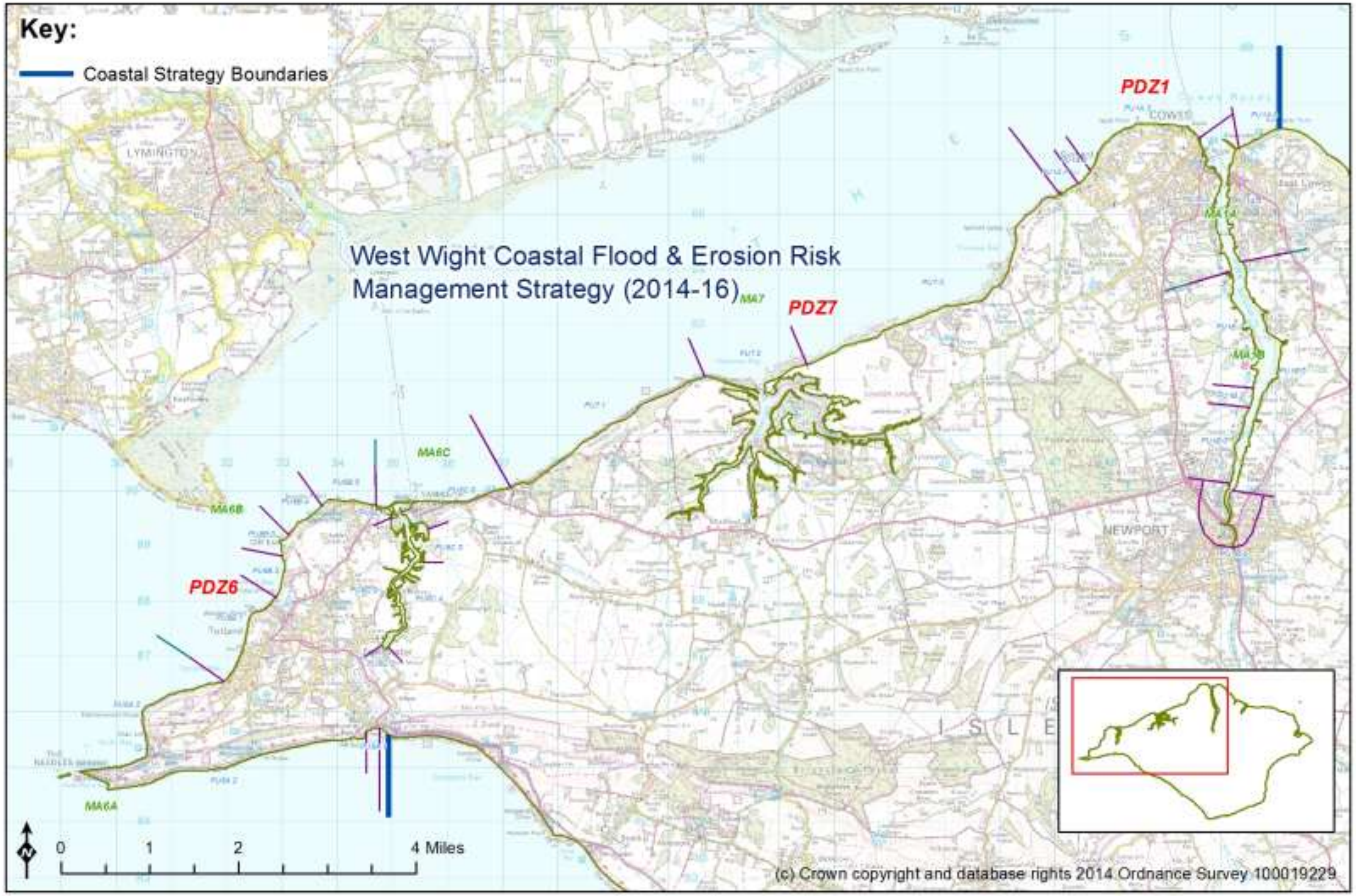
In summary, the results of the Coastal Monitoring programme are as follows:

- The 2012-2013 annual percentage change maps for the Isle of Wight (i.e. over the past year) suggest percentage change is greatest within Alum Bay, Totland Bay, Colwell Bay, Reeth Bay and Freshwater Bay.

- The percentage change maps from the 2003 baseline to 2013 (i.e. over a 10 year period) show the greatest changes over this time period to be occurring at Totland Bay, Colwell Bay, Seaview, Reeth Bay, Compton, Freshwater Bay and Sandown Bay.
- Generally, these maps show that the more exposed west and southwest coasts show erosion, while some accretion is more prevalent along the east and north coasts of the Isle of Wight.



Map showing the large-scale (red) and local-scale (blue) coastal process unit boundaries used in this report (derived from Futurecoast, 2002).



ISLE of WIGHT COUNCIL West Wight Coastal Strategy boundaries, Isle of Wight; and SMP2 Policy Units

Map showing the 'West Wight Coastal Flood & Erosion Risk Management Strategy' area, & Shoreline Management Plan 2 unit boundaries within it

2. General overview of Isle of Wight geology, geomorphology and coastal processes

The Isle of Wight Coast and estuaries form a dynamic coast approximately 168km in length, with a wide variety of coastal scenery in a relatively small area. Following this overview, this report concerns the western half of the Isle of Wight coastline.

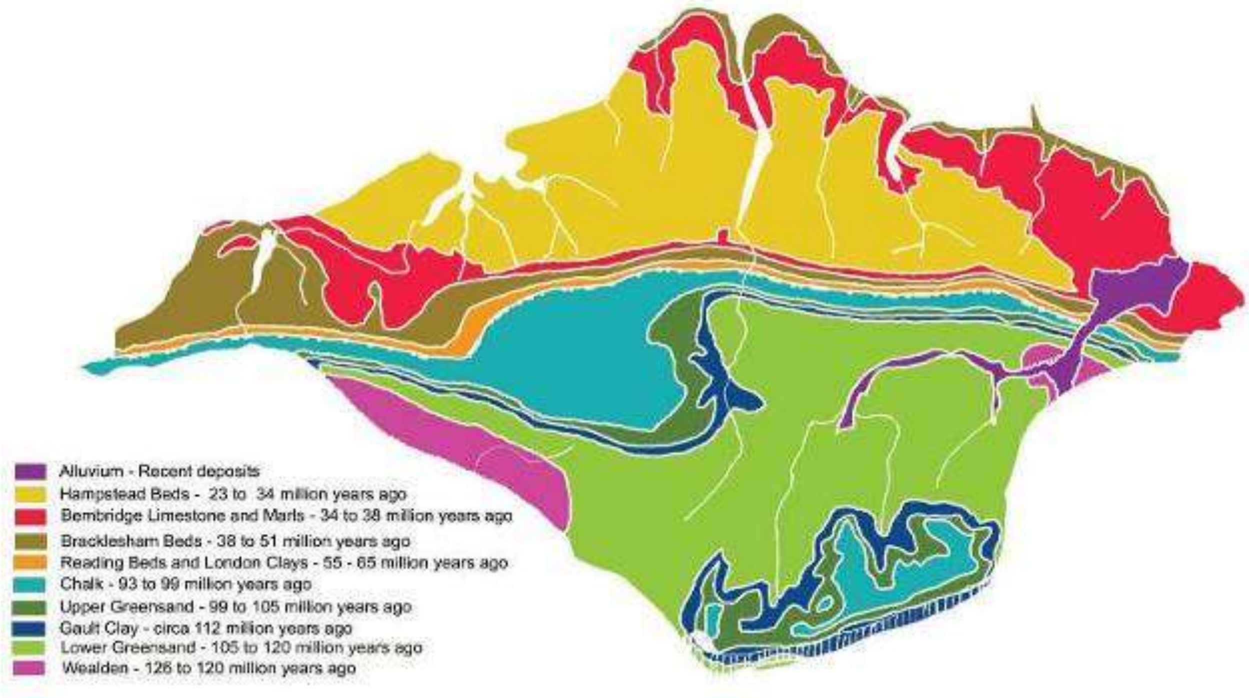
The northern coast of the Isle of Wight is generally characterised by relatively low-lying coastal slopes, with five estuaries and rivers draining north into the Solent. By contrast the southern coast is generally characterised by steep coastal cliffs and landslides.

The Isle of Wight coastline has been shaped by major sea level fluctuations which have occurred in response to periods of glaciation. During the last cold period of the Ice Age sea levels fell by up to 140 metres. At this time, the Island's Chalk ridge (its west-east spine) would have extended further westwards to the Isle of Purbeck in Dorset. As the ice sheets melted and sea levels rose over the period 15,000 to 5,000 years BP (before present), the Chalk ridge was eroded and the valley behind flooded, forming the Solent sea and separating the Isle of Wight from the mainland. During this period of fluctuating sea levels the Isle of Wight coastline was subject to rapid rates of erosion. The sediments resulting from the erosion of the Island's cliffs were transported to form various sand and gravel banks in the eastern Solent.

Aerial view of the Isle of Wight, viewed from the south (Isle of Wight Council)

The solid geology and structure of the Island is dominated by a strong east-west monocline – a Chalk ridge which cuts through the centre of the Island and is exposed at either end to form headlands at The Needles in the west and Culver Cliff in the east. This ridge is the result of tectonic activity 30 million years ago (the Cainozoic era) causing a folding of the Isle of Wight rocks.

A prominent feature of the south coast is The Undercliff - an ancient coastal landslide complex extending from Luccombe in the east to Blackgang in the west. The feature is approximately 12km in length and extends approximately 500m inland and nearly 2km seawards. A significant area of landsliding also underlies Cowes-Gurnard at the northern tip of the Isle of Wight, and weak cliffs prone to landsliding occur behind Totland Bay in the west of the Island.



Geological map of the Isle of Wight (Isle of Wight Council)

Within its relatively small area, the Island's coast is extremely varied and dynamic. Marine erosion has continued around most of the Island to produce a near-continuous cliff line that varies greatly in terms of morphology and rates and styles of weathering and landslide activity. The cliffs adopt characteristic forms according to topography, the properties of their ground forming materials and exposure of their toes to marine erosion. The south coast in particular is vulnerable to large storms crossing the Atlantic and rates of erosion are particularly rapid in the softer Wealden rocks along the south-west coast of the Island. The exposed (high energy) southern coasts also allow greater potential for shoreline sediment transport compared to those along the sheltered environments of the Solent to the north. Nevertheless, strong tidal currents are generated in the western Solent and these contribute additionally towards sediment mobility in specific areas.

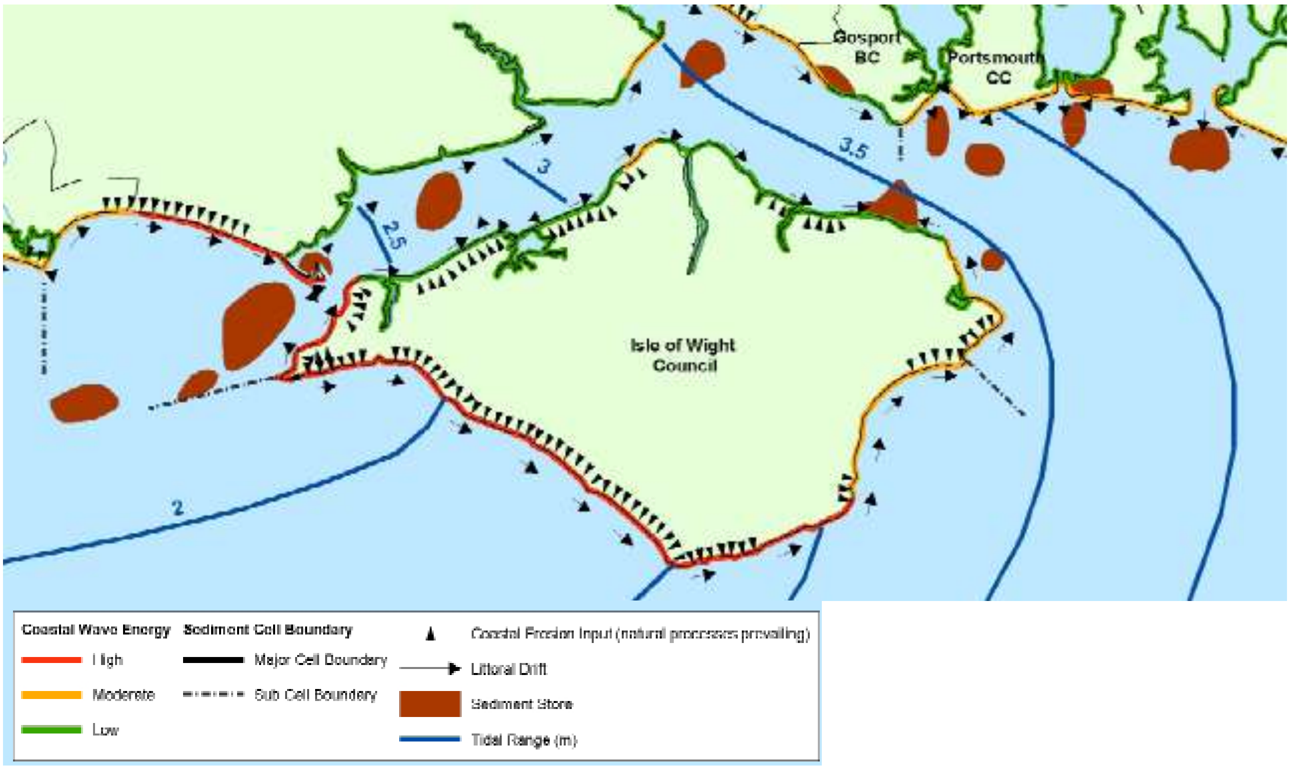
There are five estuaries located on the north and north-eastern coasts of the Island: the Western Yar; Newtown Estuary; Medina Estuary; Wootton Creek; and the Eastern Yar. The Island's estuaries have been internationally recognised as important for nature conservation and are included in the Solent European Marine Site. The nearshore and offshore zones are characterised by a thin layer of sand and gravel that form gravel banks at some locations. Sediment transport in the nearshore zone is complex around the Island's coastline, as movement of sediment is interrupted by estuaries, headlands and offshore features such as St. Catherine's Deep off the extreme south of the Island.

Sediment transport plays a central role in coastal processes and a study of the sedimentary system is essential to gaining a clear picture of coastal processes and assessing past, present and future coastal change. "The results of the EUROSION case studies and other Europe wide evidence, suggests that too often in the past insufficient attention has been paid to the functioning of the whole sedimentary system" (EUROSION, 2004).

There are distinct differences between the exposed southerly and westerly facing coasts (potentially rapid marine erosion) and the relatively sheltered north coast (toe erosion). Cliff erosion materials deposited on the foreshore are valuable inputs to the immediate littoral system and also contribute to beaches further downdrift. Cliff sediments provide more permanent protection of the cliff toe if they are sufficiently durable to remain on the local beach and are not removed by littoral drift. In spite of continued cliff erosion sediment inputs, local beaches are not large, suggesting that most materials continue to be removed and that the Island's beaches are open systems dependent upon continued inputs for their stability and even survival. Since sedimentation is generally confined to small spits at inlets, or within the estuaries themselves, the Island apparently functions as a sediment source or donor to other areas including the offshore zone.

The only significant area of accretion around the Isle of Wight coast is at Ryde Sands, on the north-east coast.

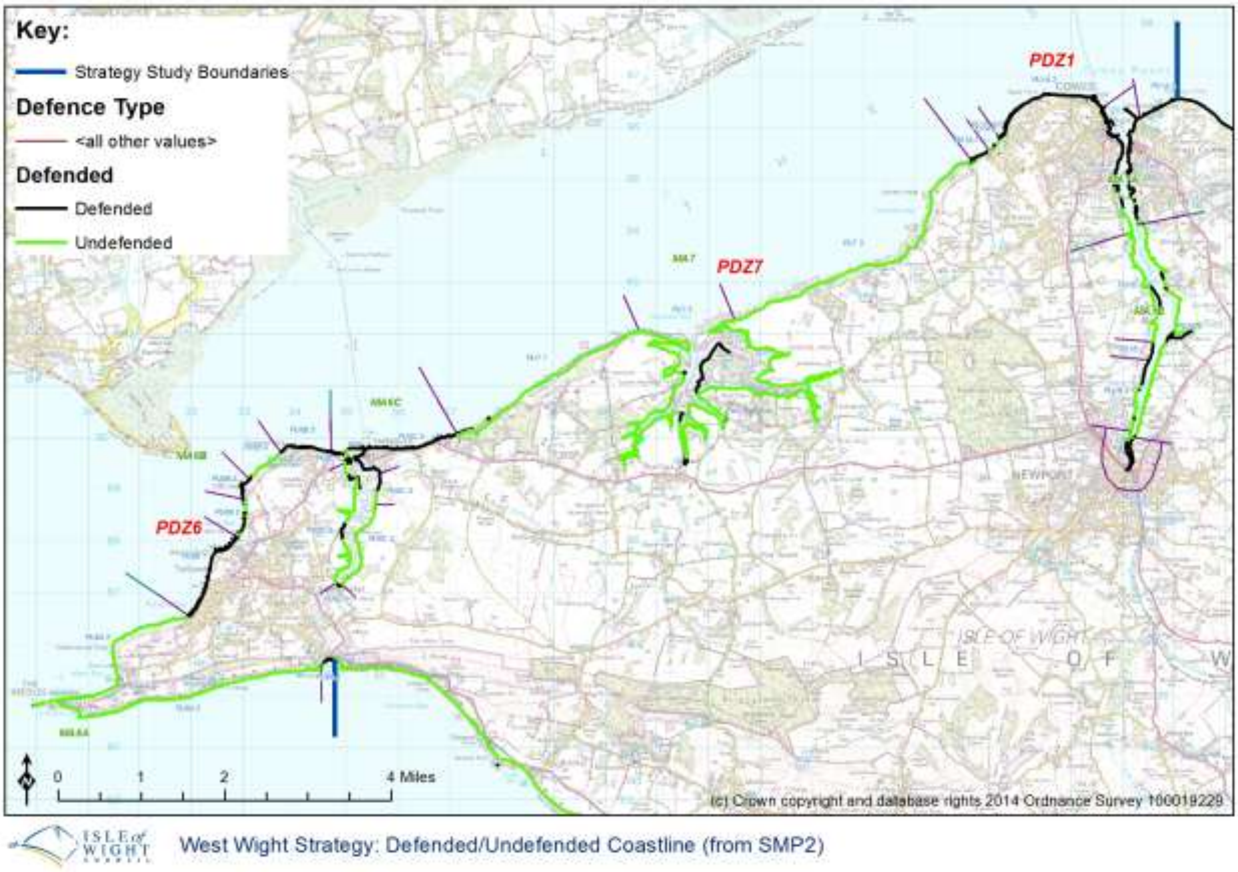
Around the coast of the Isle of Wight, seabed sands and gravels are highly mobile during peak flow conditions, with a general eastward transport of bedload sediment. In sites where this general trend is interrupted, for example at Thorness Bay and Hurst Narrows, sand and shingle banks have formed. A number of these shingle banks have been extensively dredged in the past, including Pot Bank, off the Needles, and Solent Bank off Newtown.



Sediment budget around the Isle of Wight coast

A number of sections of the Islands coastline have been modified by the construction and maintenance of hard coastal defences; namely Cowes, Ryde, Ventnor, Sandown Bay and in the extreme north-west. This means that in some areas natural shoreline dynamics may be altered, which has implications for future shoreline management.

The following map shows a summary of the defended and undefended (naturally evolving) coastlines in the West Wight area, which have an influence of coastal processes.



Map showing the distribution of defended (black) and undefended (green) coastline in the West Wight area (Isle of Wight Council, 2010).

Key towns and transport links on the Isle of Wight, with the majority of large settlements located along the coast (Isle of Wight Council, 2009).

3. Summary and context of coastal change along the *West Wight Coastal Flood and Erosion Risk Management Strategy* Area

The following summary provides an overview of the coastal evolution, topography and influences controlling coastal processes in the Strategy area.

The north-west coast of the Isle of Wight forms the southern margin of the Solent channel. The Solent occupies the valley of a formerly more extensive Pleistocene river system (the Solent River), which has experienced a complex history of change. Three key stages can be recognised in its evolution, in a summary drawn from the SCOPAC sediment transport study, north-west Isle of Wight coast update 2014:

1. *'Breaching of the Chalk ridge previously existing between the Needles and Isle of Purbeck (Everard, 1954) and subsequent rapid marine erosion of soft Tertiary strata in the early to mid-Holocene created Christchurch Bay as a result of rapid sea-level rise. This in turn allowed refraction of dominant southwest waves around remnants of the protective ridge to attack the northwest coast of the Isle of Wight.*

2. *Linkage between the Western Solent and Christchurch Bay was probably initiated between 8,000 and 7,500 years BP (Nicholls and Webber, 1987; Dean, 1995; Velegrakis et al., 1999; 2000). This interpretation is corroborated by dating of organic horizons in Holocene sediments that accumulated in the Western Yar estuary (Devoy, 1987). The isthmus of land connecting the shorelines of the northwest Isle of Wight and Hampshire may not have been finally removed until approximately 4,500 years BP* (SCOPAC, 2014).

3. *Eastward littoral drift of coarse sediments in Christchurch Bay created Hurst Spit, a transgressive coarse clastic barrier spit built on a basement of late Pleistocene gravel terraces and extending south-east from the mainland (Nicholls, 1987; Nicholls and Webber 1987). This spit has several effects on hydraulic conditions in the Western Solent. It provides shelter from dominant southwest waves and its progressive growth has constricted the channel at Hurst Narrows, thus deflecting tidal currents towards the northwest Wight coast (Brampton et.al, 1998). Coarse sediment is lost from the distal part of the spit and is transported offshore by high velocity dominant ebb currents to feed the Shingles Bank (Nicholls and Webber, 1987; Velegrakis and Collins, 1992). This bank interferes with west and south-west waves approaching the open north-west Wight coast between the Needles and Fort Albert, and thus provides an additional element of dampening of the wave regime.'*

In the west of the Strategy area, from Alum Bay to Fort Albert, the coast is exposed both to tidal currents and the modified open sea, including swell waves. Maximum significant wave heights of up to 2.36m (Webber, 1969; Posford Duvivier, 1990, 2000; HR Wallingford, 1999) might occur at a 1 in 50 to 1 in 100 year frequency south of Fort Albert.

In the east of the Strategy area, from Fort Albert to Cowes, the coast is sheltered from the open sea and incident waves generated in the West Solent are fetch-limited and generally are less than 1m in height. However, exceptional storm and tidal surge events, such as occurred in March 2008, can raise water levels in excess of 1m above those predicted (Yarmouth Coastal Defence Working Group, 2010).

Locally strong currents are generated by exchange of tidal waters at the mouths of the Western Yar, Newtown Harbour and Medina Estuaries.

Alongside these hydraulic influences, the major factors influencing coastal morphology are geology and topography (Isle of Wight SMP2, 2010), as follows:

- At the westernmost point, relatively resistant Chalk forms the Needles and Tennyson Down ridge, with high Chalk cliffs and the headland rising to 147m in height.

- Moving north-west, the remainder of the coast comprises Eocene and Oligocene (Tertiary) strata, a sequence of poorly consolidated sands, silts and clays inter-bedded with thin and mostly soft limestones. The strata immediately succeeding the Chalk to the north dip almost vertically, so that the Reading Clay and Thames Group formations have extremely limited outcrops in Alum Bay. Younger Palaeogene strata dip more gently towards the northeast and these comprise the main geological formations outcropping on this coast between Headon Hill and Old Castle Point, East Cowes.

- The coastal topography is undulating with high points at Headon Hill (120m), Bouldnor Cliff (61m), Burnt Wood (57m) and Gurnard Cliff (45m).

- Small estuaries are developed in former tributaries of the Solent River that have been inundated by the Holocene transgression. These comprise the Western Yar, Newtown Harbour and the Medina, all of which have sediment-filled palaeovalleys between 14 and 22m in depth. Other minor tributaries have been truncated by post mid-Holocene recession of the coast and form short, steep gradient coastal valleys e.g. Alum, Brambles and Widdick Chines, or the marshy valleys of the Gurnard and Thorness. The latter have been partly blocked, or deflected, by the eastward growth of small gravel spits.

The combination of relatively non-resistant rock material and a spatially varied exposure to waves and currents has resulted in the formation of a predominantly eroding coastline characterised at several locations by well-developed cliffs and landslides. Headlands occur on more resistant strata that also outcrop on the foreshore to form protective ledges or platforms. In places the prominence of headlands has been accentuated by the nineteenth century construction of forts and associated coast protection structures e.g. Fort Victoria, Fort Albert and Warden Point (McInnes, 2008). The shoreline exhibits a varied sediment transport pattern due to both coastal configuration and hydraulic regime. The general drift direction is to the north-east. Transport sub-cells on the open coast are separated by headlands, and each of the three estuaries has distinct, albeit small scale, circulation patterns (Halcrow, 1997).

Reference: SCOPAC Sediment Transport Study (2014 update). In progress. Literature review update for the north-west coast of the Isle of Wight, supplied by Channel Coast Observatory, July 2014.

4 A summary of sediment pathways along the north-west coast of the Isle of Wight

The following summary of sediment pathways along the north-west coast of the Isle of Wight (the Strategy area) is an extract of the SCOPAC Sediment Transport Study updated literature review for the north-west IOW coast, July 2014.

2. *'This unit comprises the north facing valley side of the former Solent River that became occupied/re-occupied by marine inundation some 7,000 to 8,000 years before present. It is considerably more exposed than the corresponding mainland shore to the combination of waves and tidal currents. Erosion has therefore prevailed at the toes of coastal slopes formed in soft Tertiary clays and mantled by relict landslides. In this situation the slopes and cliffs are inherently sensitive to erosion and renewed landslide activity, even when the driving marine forces are relatively weak.*

3. *Cliffs to the west of Fort Albert are exposed to open coast wave action and undergo relatively rapid rates of recession. Between Yarmouth and Gurnard, recession is also locally rapid despite their more sheltered location within the West Solent. This is due to the soft predominantly clayey lithology and the combination of wave action with rapid tidal currents that removes stabilising (protective) debris from the cliff toe. Some coastal slopes in the east remain intact and mantled by relic landslides, although there is evidence at many locations that reactivations are in progress or imminent.*

4. *Substantial quantities of sediment are yielded by cliff erosion, but most are fine grained and are transported offshore so that they do not contribute to protective local beaches. Instead, it is likely that they are deposited within more sheltered regions such as the local estuaries, Southampton Water and the mainland shore of the West Solent. Significant quantities of sand are contributed in Alum Bay and small quantities of gravel are contributed from thin superficial deposits along much of the summit of the cliffline, especially Headon Hill, Bouldnor Cliff, Burnt Hill and Thorness cliffs.*

5. *Two distinct shoreline drift pathways appear to operate as follows: (i) From Alum Bay to Fort Albert and (ii) from Fort Victoria to Egypt Point. The linkages between the two are uncertain for their interface flanks Hurst Narrows and it is thought that ebb-dominated tidal transport dominates over shoreline drift, imposing a significant discontinuity.*

   Between Alum Bay and Fort Albert drift is north-eastward within a series of partly connected bays. It is thought that sand can move from bay to bay, although gravel generally cannot in any significant quantity. Intervening headlands between the bays inhibit transport. A potential uncertainty relates to the fate of the quantities of sand and gravel yielded from between the Needles and Fort Albert because there are no significant shoreline accumulations. In the absence of firm evidence the most likely explanation is that material is lost seaward entrained by the strong ebb tidal flows that exit Hurst Narrows. Losses would be most likely to occur at headlands such as Hatherwood Point, Warden Point and Fort Albert.

   Between Fort Victoria and Egypt Point, coarse sediments drift eastwards and appear to be retained in spits at the mouths of the Western Yar and Newtown Harbour estuaries, with some material moving onward to collect within Thorness Bay. Very little exits Thorness Bay to continue to Egypt Point. The quantities of drift involved are small so that the spits and barriers are sensitive to morphodynamic change.

6. *Exchanges of sand and gravel between the West Solent Channel and the shoreline are poorly understood. Some foreshore gravel bars would appear to be indicative of onshore supply between Thorness Bay and Bouldnor, but this has yet to be proven. Exchanges are indicated at the entrance to Newtown Harbour where gravels drifting along the convergent*

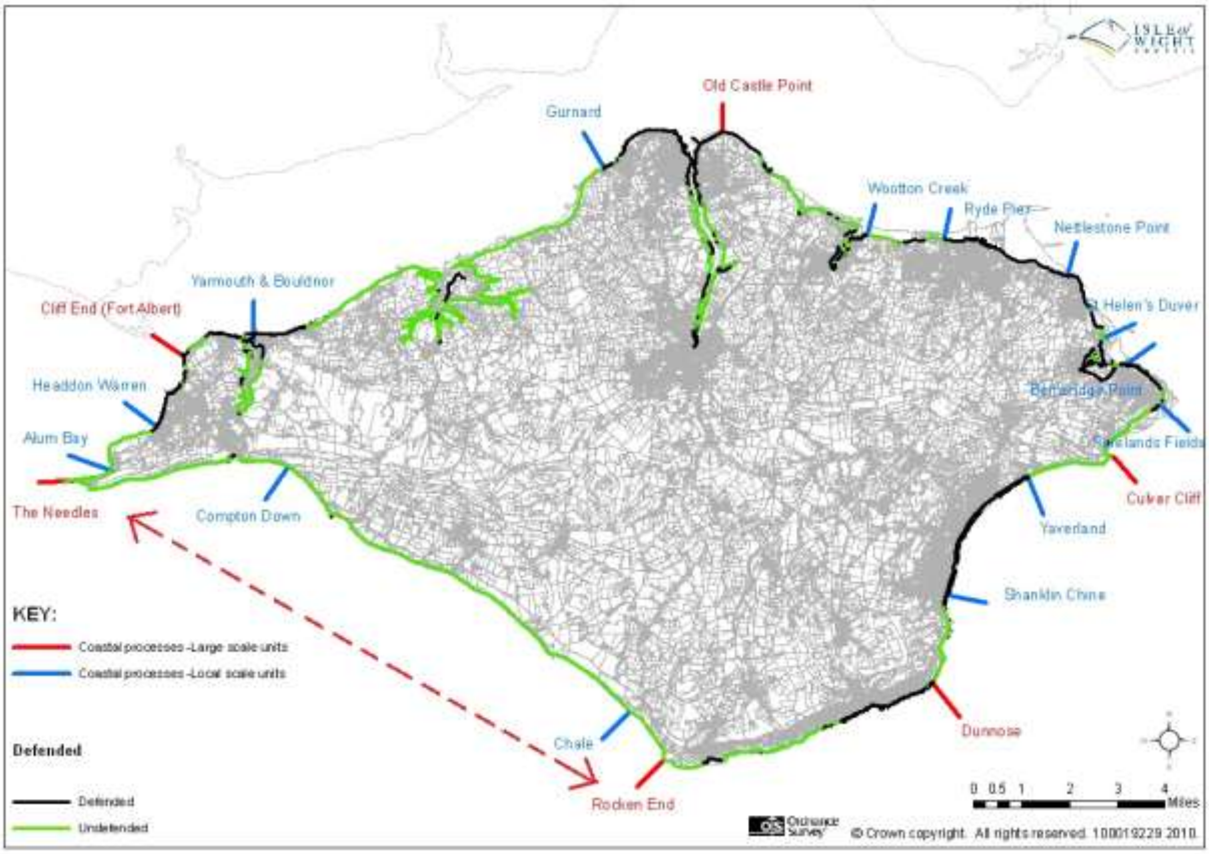
spits are flushed seaward and some return onshore directed transport back to the spits is indicated by foreshore morphology. It is uncertain whether this constitutes a closed circulation, or whether "new" material could be contributed from the West Solent channel e.g. Solent Bank.

7. *Future increases in rates of sea-level rise and winter rainfall would have a clear potential to accelerate processes of landslide re-activation on the historically stable coastal slopes between Gurnard and Cowes. It would also accelerate the landsliding of currently active cliffs between Alum Bay and Fort Victoria and between Bouldnor and Gurnard (Halcrow Maritime et al, 2001). Increased supply of sediments to the shore would be likely to occur as a result.*

8. *The Western Yar Newtown and Medina estuaries appear to be capable of continuing to accrete fine sediments and their saltmarshes have been relatively stable, although trends for slow to moderate saltmarsh erosion have become apparent recently in the Western Yar and Medina. Since these are all valley type estuaries with relatively steeply sloping margins their saltmarshes are likely to be sensitive to future climate change and sea-level rise unless vertical accretion can compensate (Halcrow Maritime et al, 2001).'*

5. Process units and coastal processes

5.1 Large Scale process unit: Rocken End to The Needles (western end)



Map showing the boundaries of this large-scale process unit (see red arrow).

Interactions:

Along the south-west coast of the Isle of Wight, rising sea-levels of the mid to late Holocene re-occupied former degraded cliffs initiating renewed erosion of its soft Cretaceous sands and clays to form a rapidly retreating linear or slightly embayed cliff coastline some 15km in length. As the coast retreated it has produced a shallow nearshore shelf, or shore platform extending seaward for some 4km which is thought to indicate the extent of late Holocene coastal recession.

Recession has been controlled partly by the occurrence of more resistant strata forming the northwest (Chalk) and southeast (the Undercliff boulder aprons) extremities of this segment.

The eroding coastline has truncated the northward flowing Western Yar River. Much of the land lost to erosion is therefore thought to be part of the drainage basin of the Western Yar.


View along the eroding south-west coast of the Isle of Wight, to the West Wight, from near Blackgang in 2009 (N.Dix).

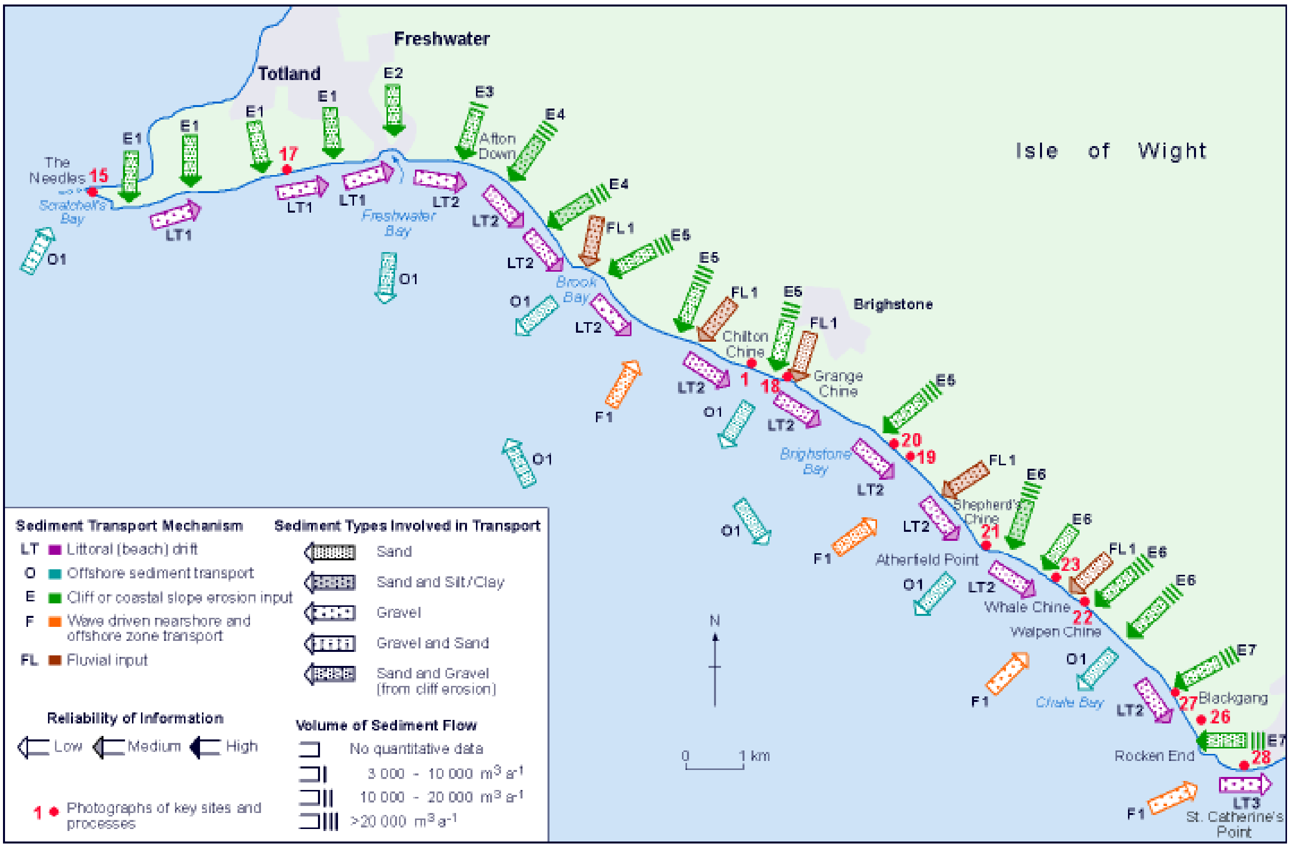
Although significant volumes of material would have been released as a result of such rapid recession along a wide front, the majority of sediment yielded would have been clays and sands that were rapidly removed offshore by wave action.

Variations in the cliff morphology and style of recession would have developed along this unit as a result of variations in ground elevation, lithology, stratigraphy and geological structure revealed as the cliffs retreated. Minor headlands have developed at Hanover and Atherfield points due to local occurrences of harder lithologic units that have formed protective foreshore reefs. However, the rates of retreat are such that headlands of this type would have had limited longevity. A highly distinctive feature of the West Wight coastline is the presence of a number of deeply-incised coastal valleys, or chines, that interrupt the continuity of the cliffs. Their origin is uncertain, but they might represent the remnants of tributaries of a previous Western Yar river system that has been destroyed by rapid coastal erosion.

This frontage occupies one of the most exposed locations on the south coast of England with long fetches in excess of 4,000km to the south-west extending directly into the north-east Atlantic as well as shorter fetches to the south across the English Channel. It is exposed to significant swell wave activity as well as to energetic locally-generated wind waves. The well-documented history of shipwrecks along this largely unprotected rugged coast is a testimony to this fact. HR Wallingford (1999) calculated, using numerical modelling of synthetic data for wave climate that the range of maximum wave height, for a 1 in 1 year recurrence, is up to 5m for the coastline between Freshwater Bay and the Needles. For example, at Compton Bay, it extends up to 4.26m. Estimations for longer recurrence intervals are also given. Variation is due to the range of different wave types and approaches.

Tidal range is small so that wave energy is concentrated over a limited vertical range. However, the shallow nearshore and shore platform provides for some dissipation and breaking of very large waves a distance offshore. Wave exposure and the steepness of the nearshore profile are greatest towards the south-east so that Chale Bay experiences the most energetic shoreline wave conditions. Tidal currents generally are weak at the shoreline, except at the headland extremities of The Needles and Rocken End.

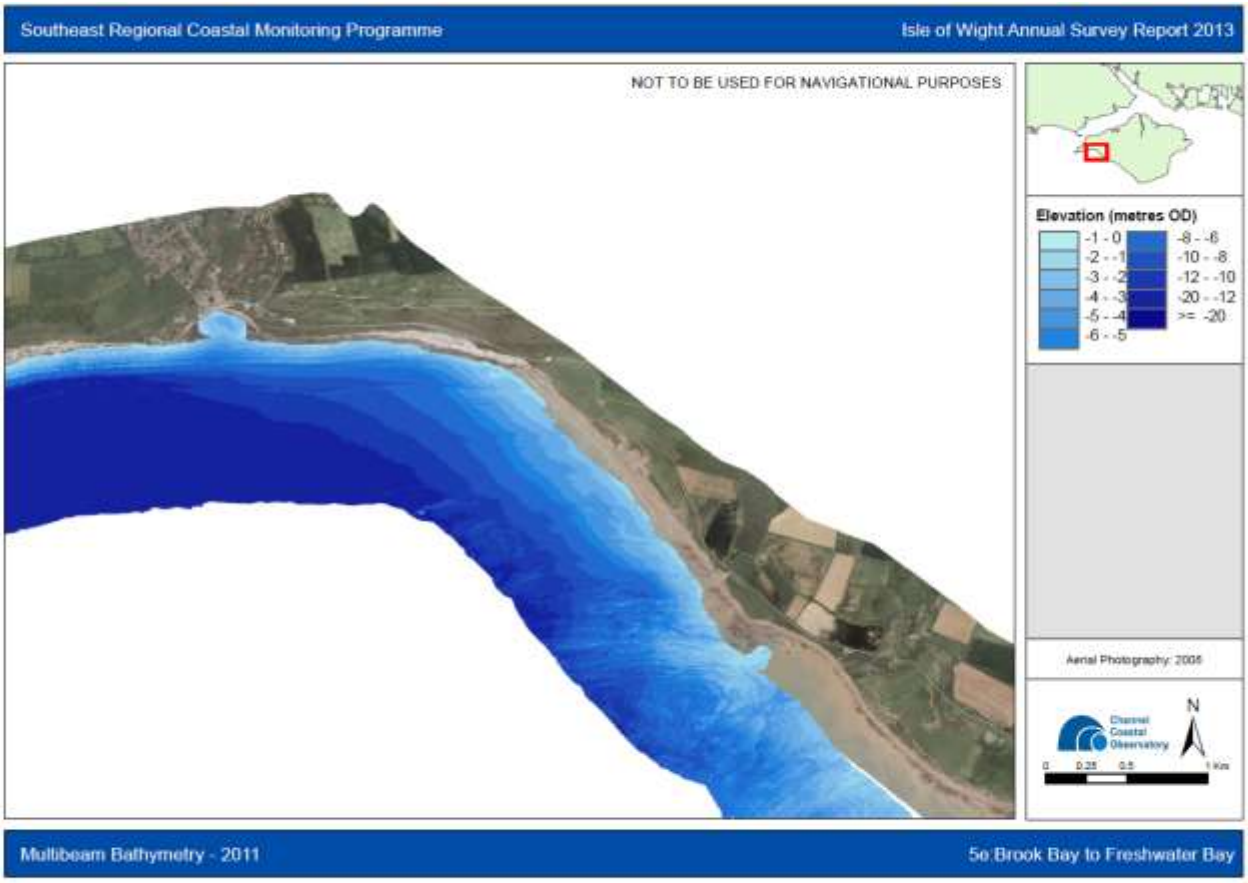
West and South Isle of Wight (The Needles to St Catherine's Point): Sediment Transport



Sediment transport sources, pathways and sinks on the south west coast, from SCOPAC Sediment Transport Study, 2004.

The offshore to onshore supply of sediment by wave-induced or tidal currents may account for a proportion of beach stores at certain locations. However, knowledge of nearshore sediments and possible pathways of transfer to littoral transport is very limited and is largely a matter of conjecture (Brampton et al, 1998). It is known that parts of the shoreface between The Needles and St Catherine's Point are current-swept bedrock surfaces (Posford Duvivier and British Geological Survey, 1999), thus implying limited supply potential. Tidal currents achieve relatively high velocities of 1.5 to 2.1 ms^{-1}, and flow sub-parallel to the coastline. They may effect scour around large boulder accumulations and gravel patches. Sand and sandy gravels occur as large lobate accumulations seawards of the inshore rock platform and reefs, especially south of Freshwater Bay and between Atherfield and Walpen Chine. This may represent a sediment sink that could supply some net onshore feed (Brampton et.al, 1998). However, echo-sounder survey data, commissioned by English Nature (1995, unpublished) did not reveal evidence of sediment mobility in these areas.

Along the south-west coast, a concrete sea wall with concrete apron and sheet steel toe piling defends the small settlement of Freshwater in Freshwater Bay. The remainder of the coast consists of agricultural land with isolated settlements and is unprotected. The theme park of Blackgang Chine is the main tourist development along the coast, along with the Needles Battery.



Bathymetry in Freshwater Bay and along the Tennyson Down headland to the west (CCO, 2013)

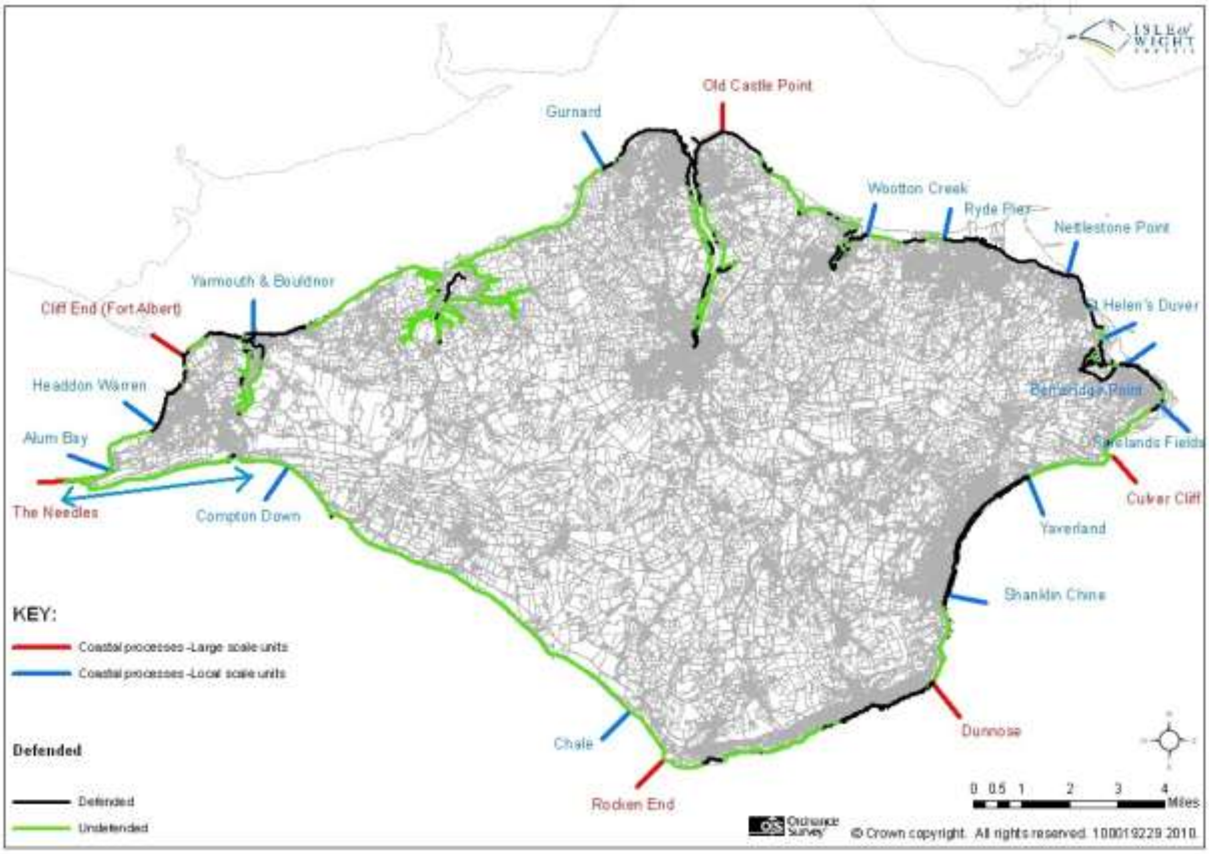
Bathymetry around the Needles, Tennyson Down and Alum Bay (CCO, 2013).

Shoreline Movement:
Extrapolation of measurements of coastal recession for the past 150 years (e.g. Posford Duvivier, 1989a, 1999; Halcrow, 1997; Tomalin, 1977 –in SCOPAC, 2004) supports the conclusion that there has been up to 6km of retreat of the western coast since the start of Holocene sea level recovery between 12,000 and 11,000 years BP. This estimate can be applied with most confidence to those sectors where there are outcrops of comparatively weak, erodible sandstones, clays, marls and interbedded limestones.

The Chalk of Tennyson and Afton Downs forms high, steep rockfall-dominated cliffs that retreat at slow to modest rates. To the west, the main central portion of the frontage, formed in soft Lower Greensand and Wealden clays and sands, forms rapidly eroding cliffs typically adopting simple landslide morphology. Local transitions to complex landslides and rockfall-dominated forms do, however, exist. In the south-east, Upper Greensand and Gault Clay overlie interbedded sandy and clayey strata in a major landsliding-generating sequence, resulting in a complex landslide behaviour characterised by periodic high magnitude cliff top recession events.

It is known that the erosion of this coast yields substantial quantities of sediments making it an important regional source. However, there is a major uncertainty relating to the fate of these inputs, especially their relation to depositional environments such as the Solent and its estuaries. Cliff recession may accelerate in future because all cliffs along this frontage are sensitive to heavy winter rainfall promoting higher pore water pressures within permeable strata, potentially triggering failures. The cliffs are also sensitive to sea-level rise that could increase toe erosion and result in increased landsliding and retreat of the cliff top.

5.1.1 Local Scale process unit: Compton Down to The Needles



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Area: 6A - Freshwater and the Tennyson Headland -including Alum Bay and Headon Warren).* Policy Units:

- 6A.1 Freshwater Bay (286m);
- 6A.2 Tennyson Down, Alum Bay and Headon Warren (9,764 metres) -part 1 of 3.

Interactions:
This coastline is characterised by high (80-130m) steep to vertical cliffs comprise mostly free face segments that are the product of basal undercutting by waves separated at Freshwater by a small low-lying embayment formed where coastal recession has truncated a narrow valley and cliff height is reduced to a mean of 25m, with a seawall in the centre of the bay protecting the flat land of the Western Yar Estuary behind. The main landforms are very steeply northward dipping Chalk sea cliffs developed by erosion of a southward-facing portion of the Purbeck – Needles – Culver Chalk ridge. The cliffs are fronted by variable accumulations of Chalk debris according to recent cliff-falls. A dissipative shore platform is present between Compton Down and Freshwater Bay, but further to the west the cliffs descend directly to deep water. Shingle beaches have accumulated within Scratchells and Freshwater Bays.

View from Compton Bay Car Park north-west towards the Chalk ridge and the start of the Strategy area, 2014. Note: the settlement of Freshwater Bay is located at the low point in the Chalk cliff (J.Jakeways).


Freshwater Bay, at a low point along the high Chalk coastal cliffs of Afton Down to the east and Tennyson Down to the west (Isle of Wight Council).

Freshwater Bay, with the low lying Western Yar Estuary to the north (Isle of Wight Council).

The cliffs adopt a simple linear form and fail mainly by rock falls of variable magnitude. Flint nodules within the cliffs are released by erosion, but otherwise most cliff erosion products are removed in suspension by wave action. Flints released from the erosion of cliffs between Freshwater Bay and Compton Down are supplied to beaches downdrift to the south-east. Defences in Freshwater Bay prevent breaching of the beach and avert risk of a tidal connection developing between the West Yar estuary and Freshwater Bay.

Beach material is presumed to derive directly from the release of flint nodules from the steeply-dipping bedding planes of the Upper Chalk at a rate of 1500m^3/yr (Posford Duvivier, 1997, 1999) from a total yield of 15,000m^3/yr of Chalk debris. Recession of this cliff line is relatively slow, with intermittent rockfalls. A rate of shoreline recession of 0.14m/yr is suggested by Posford Duvivier (1991a) and 0.15m/yr was calculated by Halcrow, (1997) covering the period 1866-1995. The shoreface is relatively steep, with the 10m isobath between 200 and 300m from the shoreface. This limits capacity for debris storage.

The Needles headland is an important control affording shelter from dominant south-westerly waves to central and eastern parts of Christchurch Bay and the extreme north-west Isle of Wight coast.

The instability of the cliff top free face at neighbouring Afton Down (to the east of Freshwater), which has created a problem for the A3055 at this point, has revealed spalling (rockfalls in weathered material) and other weathering losses along widened joins trending parallel to the coastline. Cliff top recession is probably promoted by physio-chemical weathering of joint-directed fissures opened up by pressure release; the superficial slippage of unconsolidated "head" accentuates free face recession (Barton and McInnes, 1988; McInnes, 1994). As similar structural conditions prevail throughout this unit, the Afton Down situation is probably reproduced elsewhere, although the largest of the recent rockfalls has features diagnostic of toppling and block failures.

The pocket beach of Freshwater Bay is composed wholly of well-rounded and abraded flint cobbles, suggesting that the bay is a re-entrant trap receiving sediment from both east and west. The lack of in situ flints in the Chalk cliffs in the eastern part of the Bay suggests their movement by littoral transport from the west, but there may be an input from the mass wasting and marine erosion of the soliflucted Chalky-flint deposits infilling the truncated valley profile of the Yar. This would have been more significant before the completion of the first generation of sea defences in the late nineteenth century. Severe damage sustained by the sea wall esplanade and groynes, necessitating extensive repairs and reconstruction in the 1900s, 1953 and 1966, indicate the effectiveness of both abrasion and scour (Posford Duvivier, 1989b).Swell waves approach this coastline with minimal refraction, creating a substantial reflective beach that affords significant cliff toe erosion within the perimeter of the bay. However, a near-vertical cliff profile is retained, suggesting a low-order dynamic equilibrium between supply and removal of debris (Geodata Institute, 1989). Changes in the stability of this beach were induced by beach mining in the early part of this century (Colenutt, 1904); the refurbishment of the seawall and slipway are largely to offset the effects of abrasion (Lewis and Duvivier, 1981; Posford Duvivier, 1989b).

Seawall stabilisation of the beach in Freshwater Bay prevents breaching and averts risk of a tidal connection developing between the West Yar estuary and Freshwater Bay.

View of Scratchells Bay, looking west towards the Needles, 2014, showing the cliff morphology and an example of a debris lobe from the periodic Chalk cliff failures (J.Jakeways)

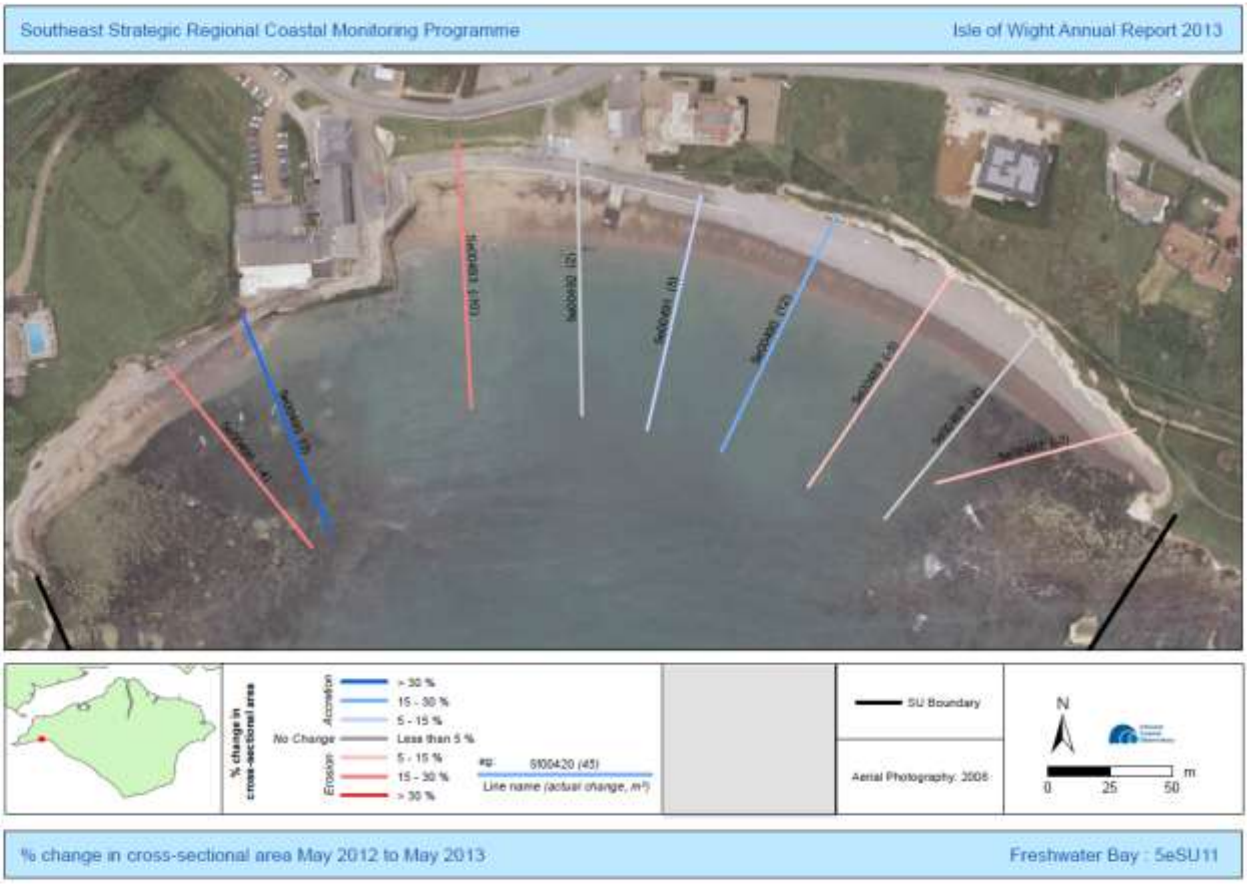
Results of the Strategic Regional Coastal Monitoring Programme:

(Maps and text ref. Channel Coast Observatory, 2013, Isle of Wight Annual Report):
The only monitored section in this area is in Freshwater Bay.
5eSU11 (FRE 4): Freshwater Bay

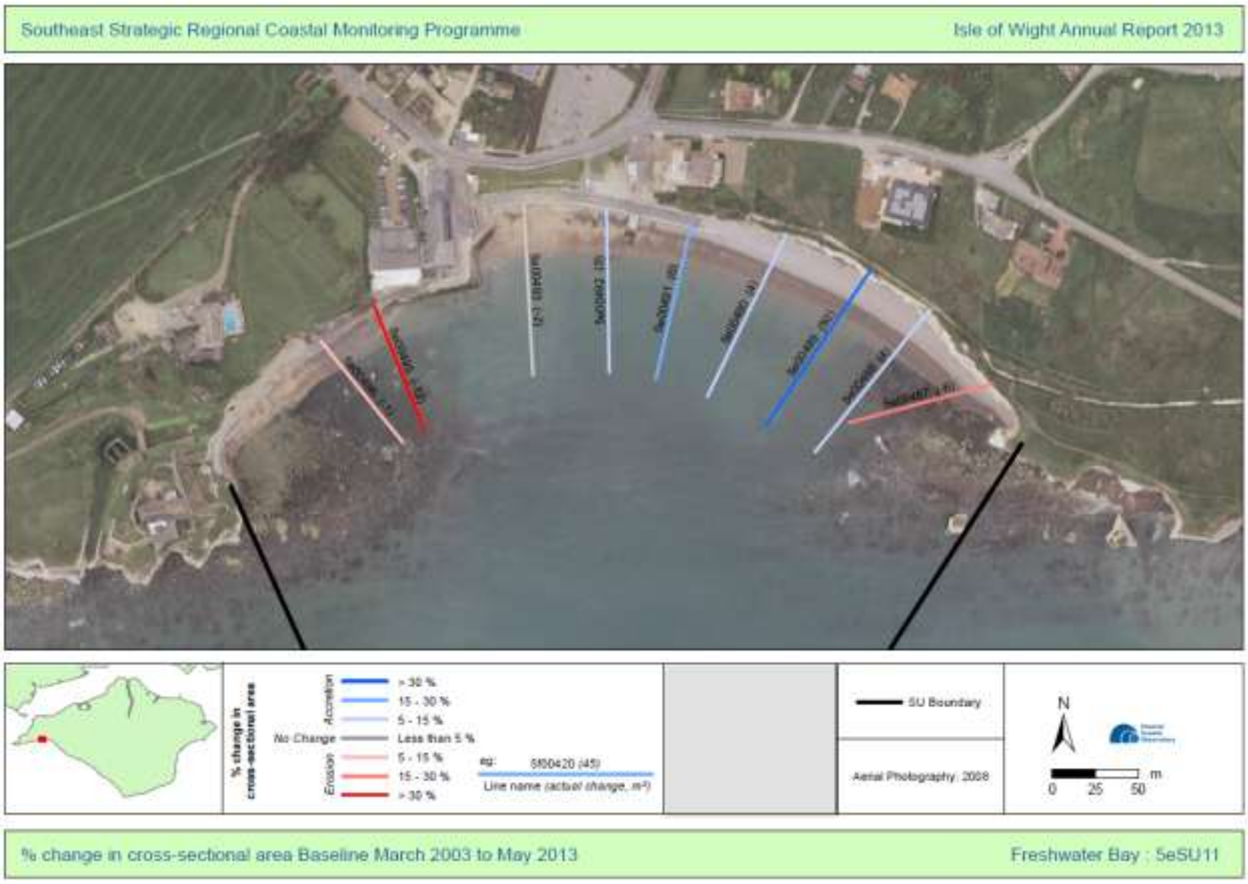
- *Following a survey review, the biannual interim profile surveys now include a full baseline survey for this unit. As 2011 is the first year of this revised program there is nothing to compare the baseline data with. Future annual reports will show full ground and difference models for this unit. Profiles 5e00487 to 5e00490, 5e00492 and 5e00493 were first surveyed on 05/11/2010; Profile 5e00496 was first surveyed on 19/5/2011.*
- *Spring 2012 to Spring 2013: The profiles to the east of this unit are stable or eroding slightly, to the west of the unit larger changes in accretion and erosion are observed.*

5e00495 has shown accretion to the entire profile, whereas profiles 5e00496 and 5e00493 show erosion across the entire profile.

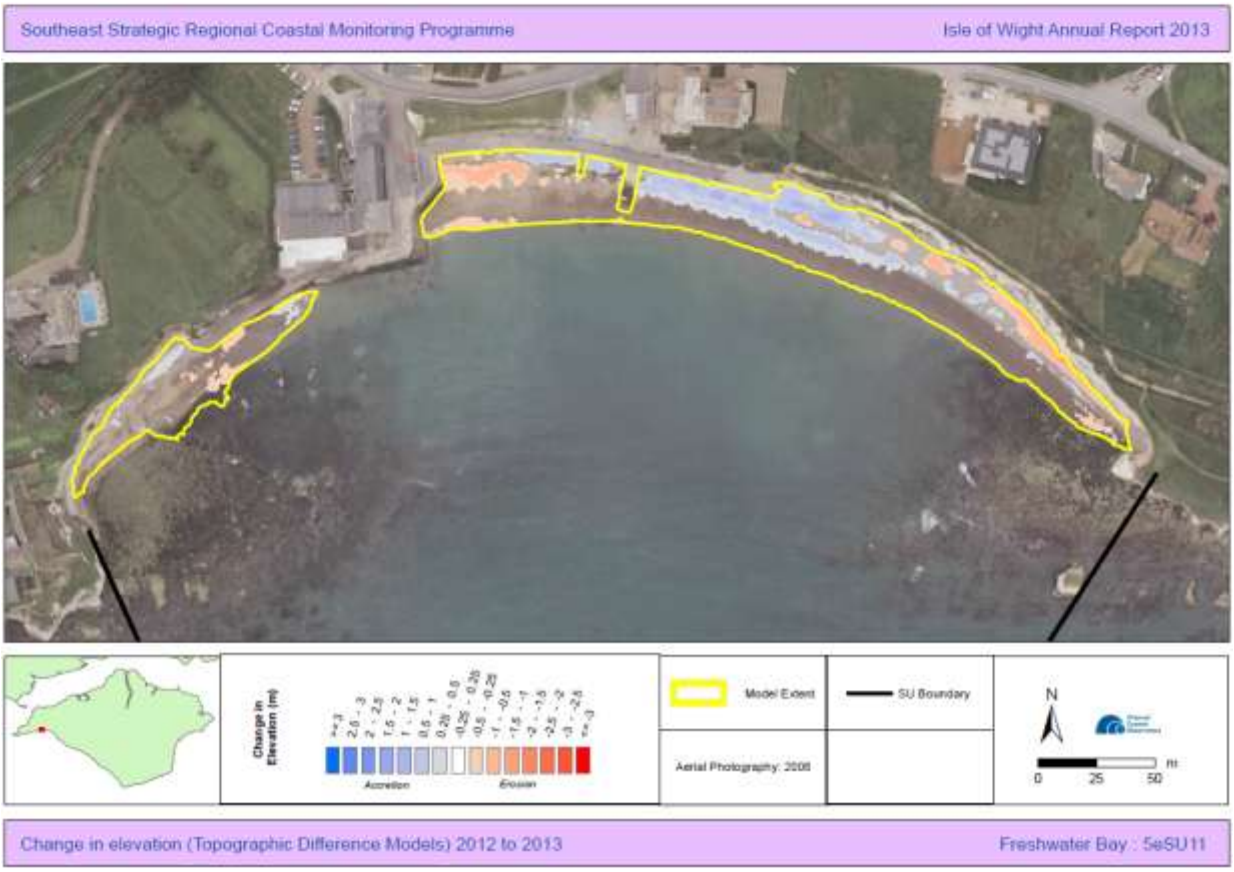
- *Baseline Spring 2003 to Spring 2013:* *From 2003 to present, 5e00495 has experienced the most erosion. The 2013 profile is 1m lower along its extent from the seawall and shorter with MLWS (-1.13mOD) being 6m landward of the 2003 profile. Profile 5e00489 has shown ~4m accretion along the entire profile length over this time period. The majority of the rest of the profiles in this management unit are stable over the longer term.*



Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



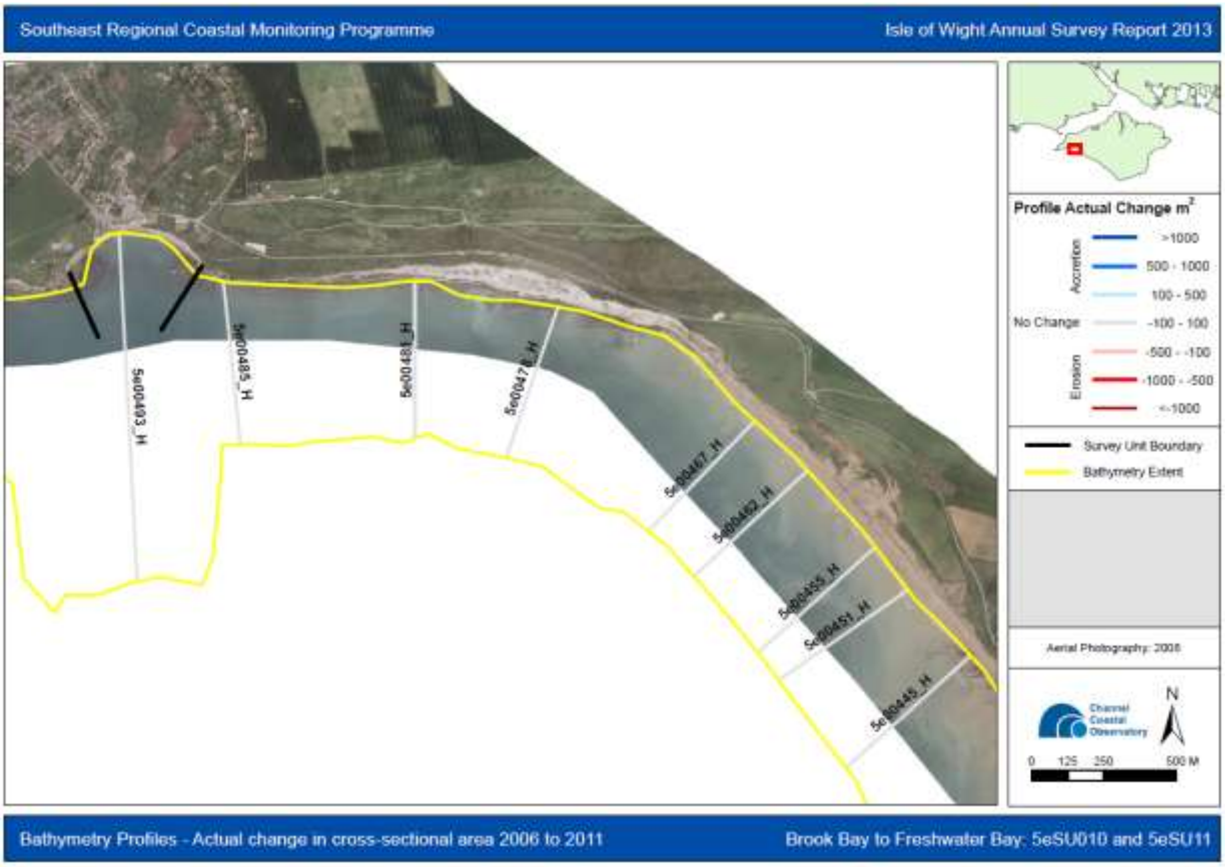
10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



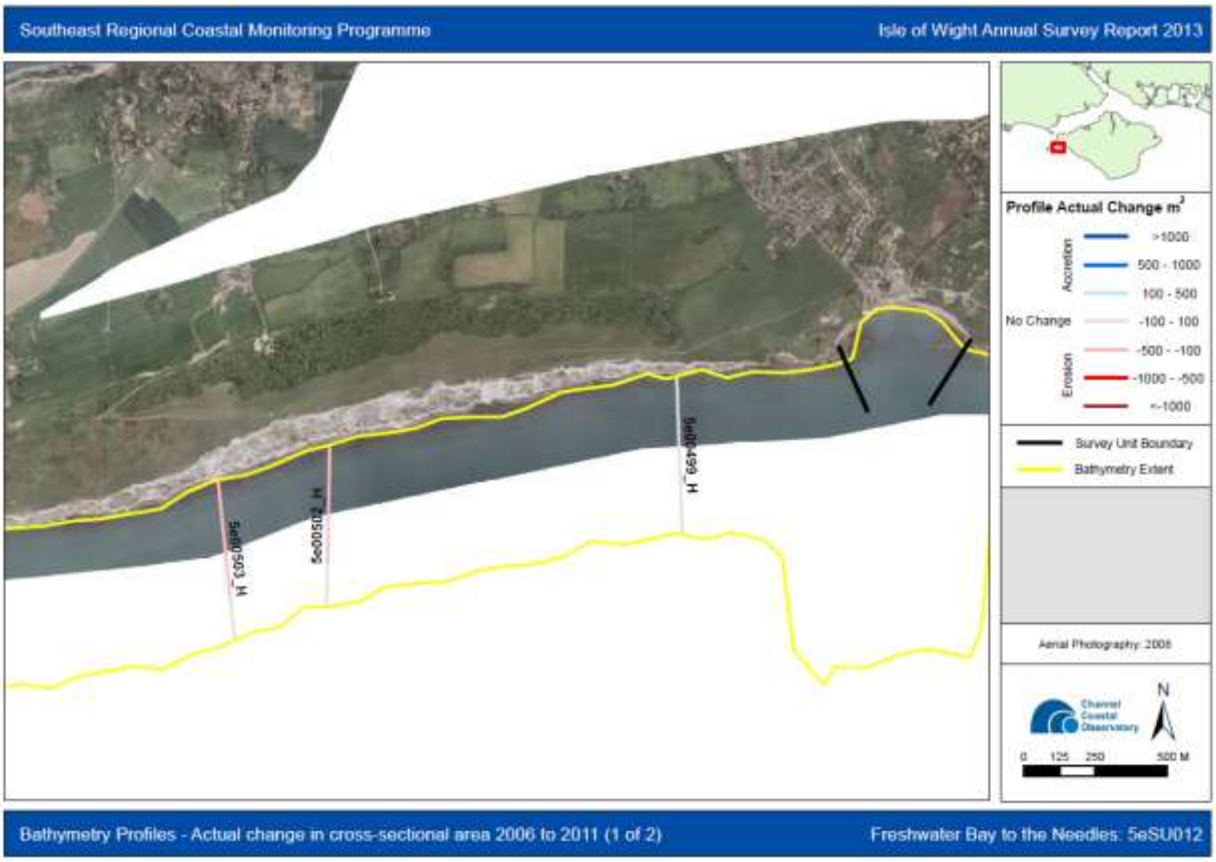
1-year topographic difference model, showing change in beach elevation, 2012-13 (CCO, 2013)

2-year topographic difference model, showing change in beach elevation, 2011-13 (CCO, 2013)

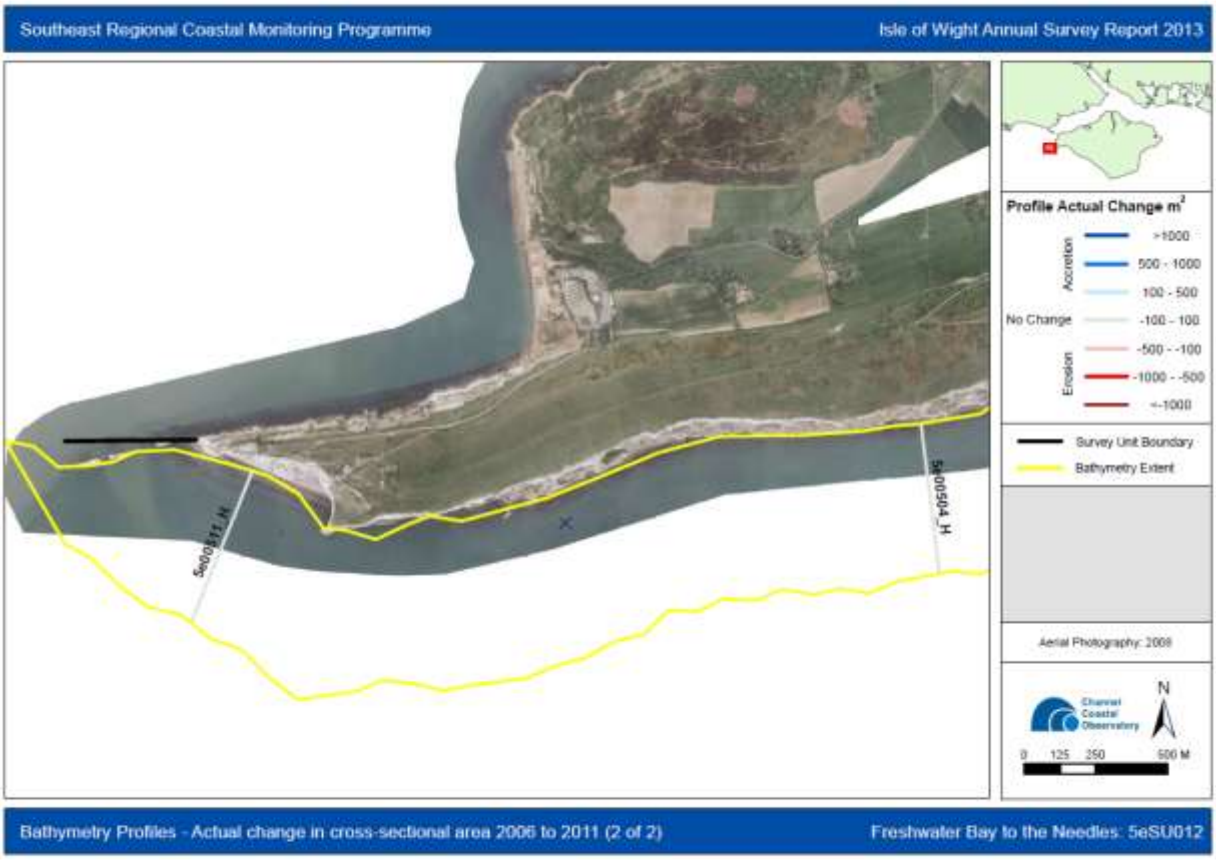
10-year topographic difference model, showing change in beach elevation, 2003-13 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

Shoreline Movement:

Measurements of rates of recession for this unit are sparse; May and Heeps (1985) suggested 0.08m/yr, whilst Barton and McInnes (1988) derive a figure of 0.05m/yr for the Afton Down cliff face (just to the east of the Strategy area, with similar geology & geomorphology to the Tennyson Down cliffline to the west). Localised free face recession might be as high as 0.3m/yr, but much of the movement is episodic rather than continuous. Between Freshwater Bay and Compton Down, May (1966) calculated a rate of shoreline recession of 0.01m/yr, which is significantly less than for Chalk cliffs of similar exposure and dimensions at other south coast locations. Posford Duvivier (1981, 1989b, 1997, 1999) propose an average long-term rate of 0.15-0.6m/yr, yielding some 15,000m^3/yr of Chalk and 500m^3/yr of flint gravel. Halcrow (1997) calculated a long-term recession of around 0.1m/yr from 1886 to 1975, but with an increase to 0.42m/yr for 1975-1995 attributable to failures in superficial deposits at the cliff top.

Recession of the cliff top at Afton Down has posed a particular threat to the A3055 road leading westwards into Freshwater Bay since 1981. The cliff slope hereabouts is partly defined by east-to-west trending joints, but is mantled by slip debris derived from Chalky Head materials above. Detailed geotechnical surveys and sophisticated monitoring have been undertaken because of the threat to public safety and in 2003 a road stabilisation scheme was completed.

The overall erosion rate along this sector of the coastline is comparatively slow, and may be partially explained by the exceptional width of the offshore zone. The 10m depth contour in the north of Compton Bay indicates a 1300m wide offshore platform so that incident wave energy is strongly dissipated. However, the Chalk yields very little sediment suitable for beach building, so that protection against breaking waves is slight.

Prior to the provision of coastal defences within Freshwater Bay, recession occurred at a mean rate of around 0.5m/yr for the period 1866-1909 (Halcrow 1997). Occasional rockfalls yield a small quantity of clastic material, but in the western part of the bay the cliffs support an overburden of loosely consolidated Chalk and flint fragments (Coombe Rock) that is subject to mass wasting and gullying. Posford Duvivier (1999) calculate an erosion loss of approximately 2000m^3/yr of mixed sediment sizes, of which less than 100m^3/yr is flint gravel that is retained on the local beach.

Predictions of Shoreline Evolution:
Futurecoast (2002) estimated that without defences cliff recession is likely to continue at, or close to, recent historical rates. Since many of the cliffs are cut into the southern flanks of the Chalk ridge, cliff height will increase as recession progresses. The cliffs would continue to supply small quantities of flints to the foreshore some of which may enter Freshwater Bay and some may drift south-east into Compton Bay.

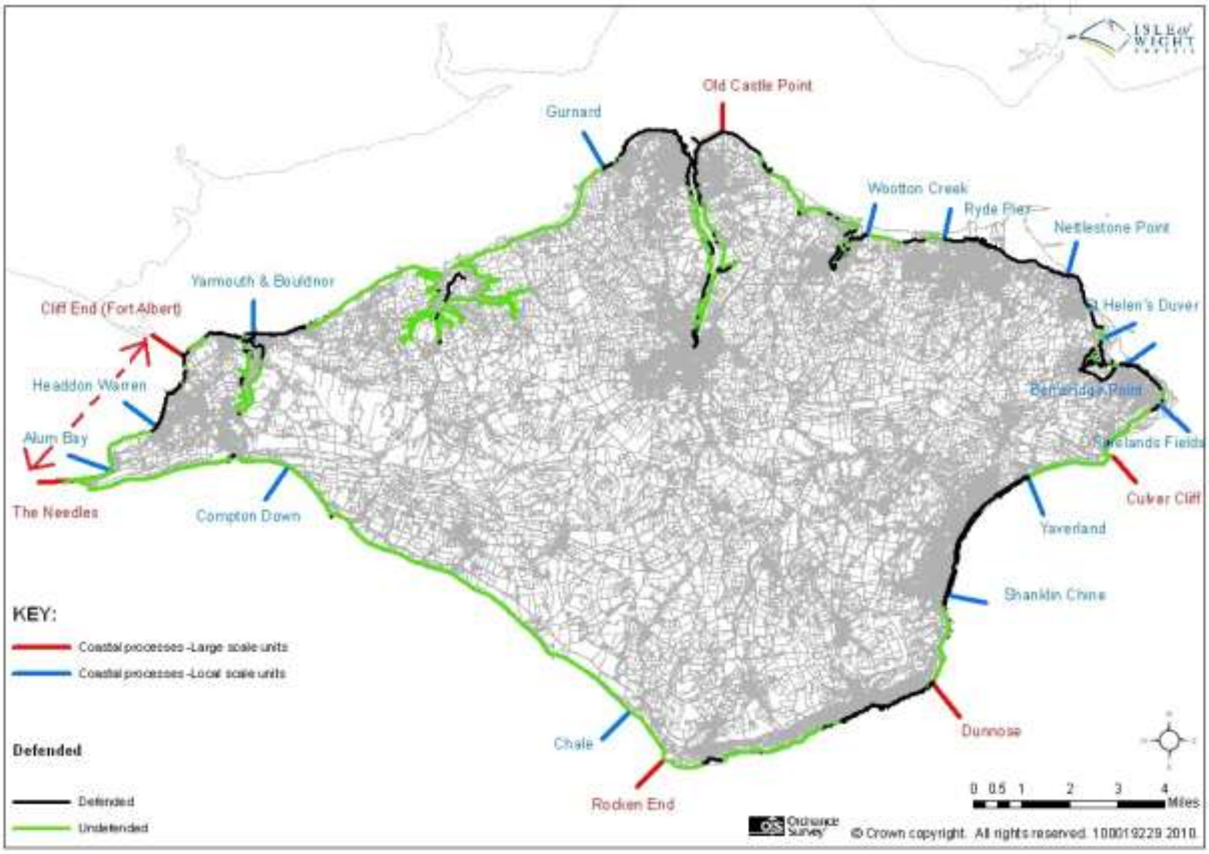
At Afton Down, it is likely that continued cliff recession would induce shallow slides within upslope head deposits that could affect sections of the main road. Furthermore, there are several large tension cracks that have appeared landward of the cliff top that are indicative of incipient large-scale toppling failures perhaps involving cliff top losses of 5-15m within single events. It is likely that similar processes would operate on the seaward sloping cliff tops of Tennyson Down.

The Western Yar valley is vulnerable to marine inundation if the beach in Freshwater Bay is overwashed and breaches. It is uncertain whether a breach would seal naturally, or whether the whole Western Yar valley could flood such that the land to the west would become an island and tidal flows could occur between the West Solent and Freshwater Bay.

With maintenance of the current defences at Freshwater Bay, the present beach configuration would be maintained and flooding of the Western Yar valley from the south would be prevented.

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report –please see below (re. units IW41 & IW42).

5.2 Large Scale process unit: The Needles to Cliff End (Fort Albert)



Map showing the boundaries of this large-scale process unit (see red arrow).

Interactions:

This unit comprises the north facing valley side of the former Solent River that became occupied/re-occupied by marine inundation some 7,000 to 8,000 years before present. It is considerably more exposed than the corresponding mainland shore to waves and tidal currents. Erosion has therefore prevailed of the toes of coastal slopes formed in soft Palaeocene, Eocene and Oligocene clays and mantled by relict landslides. In this situation the slopes and cliffs are inherently sensitive to erosion and renewed landslide activity, even when the driving marine forces are relatively weak.

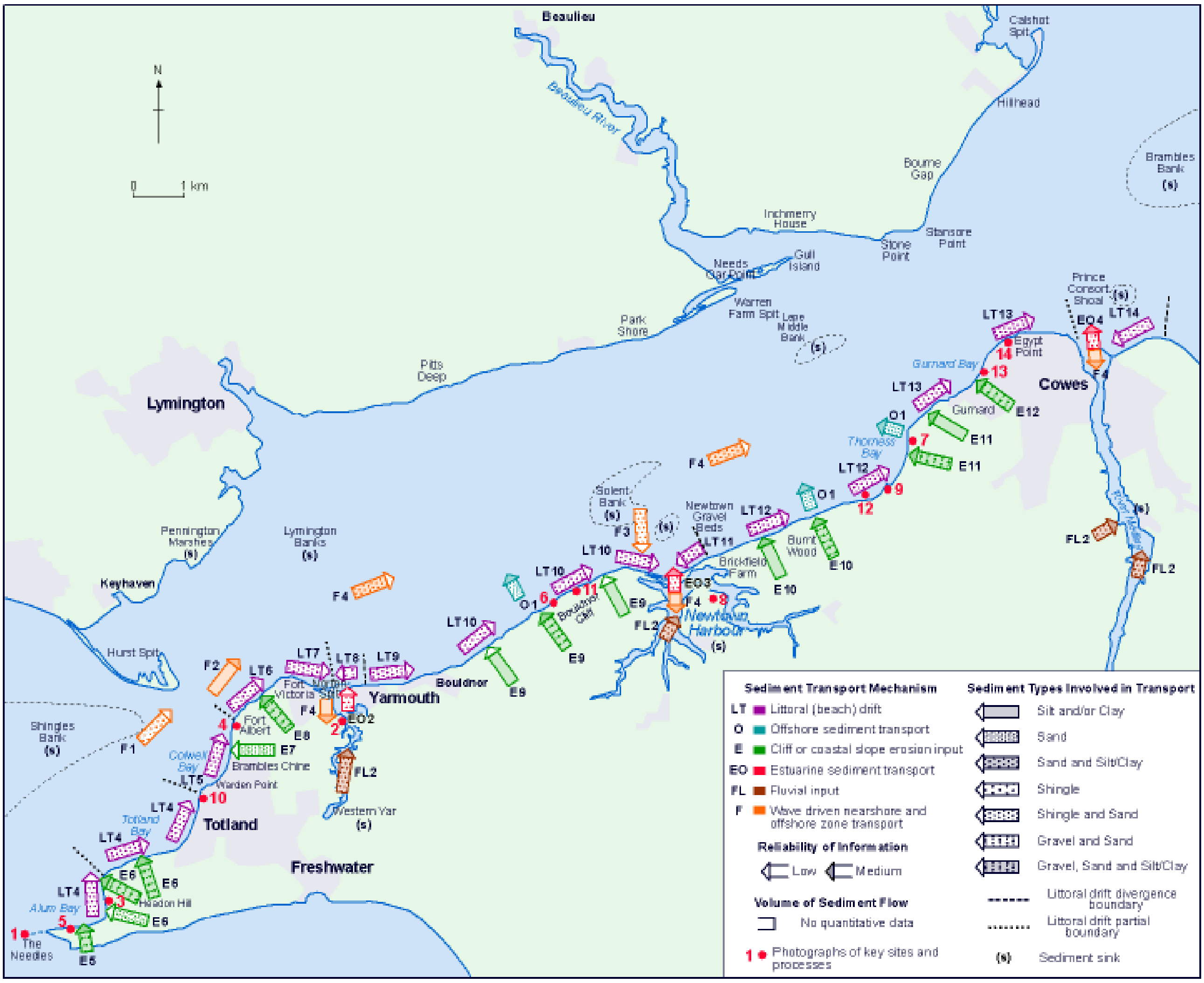
Spatial variation in sediment yield from eroding cliffs is, in part, a function of the contrast in hydraulic regime east and west of Fort Albert. To the east, dominant waves are fetch-limited, whilst westwards the more open coast receives attenuated and refracted swell as well as locally propagated waves. There is no routinely monitored data on incident wave heights and periods (New Forest District Council, 1998-2000) on which to base any quantitative comparisons. H.R. Wallingford (1999) undertook numerical modelling of modified swell waves for Totland Bay, using HINDWAVE applied to synthetic data. For an annual return period, Hs (mean) was computed to be between 0.22 and 1.71m, depending on wave approach. For a 1 in 10 year frequency values are between 0.33 and 2.05m.

The Needles headland provides shelter to this frontage from waves approaching from the south and south-east. Despite this, this frontage is potentially exposed to dominant waves approaching from the north-west, west and south-west.

View of the Needles headland at the western tip of the Isle of Wight: From left to right: Tennyson Down (Chalk ridge), The Needles, Alum Bay (coloured sands), Headon Warren and view towards Totland (far left) (Isle of Wight Council, Coastal Management).

The narrow Chalk ridge exposed along the south of Alum Bay is relatively resistant to erosion and forms high cliffs, rising to 100m. The remainder of the coast comprises Eocene and Oligocene strata, a sequence of poorly consolidated sands, silts and clays interbedded with thin and mostly soft limestones. Strata immediately succeeding the Chalk to the north dip almost vertically so that the Reading Clay and Thames Group formations have extremely limited outcrops in Alum Bay.

NW Wight (Needles to Old Castle Point): Sediment Transport



Sediment transport sources, pathways and sinks on the north west coast, from SCOPAC Sediment Transport Study, 2004.

Rapid erosion of high cliffs along much of this shoreline yields large quantities of predominantly fine sediments. These materials are not usually stable on the foreshore, thus widespread offshore transport of fine sediments can be inferred. Little direct evidence of this process is available although the relatively rapid removal of landslide debris on the foreshore is well documented (Hydraulics Research, 1977b; Moorman 1939; Posford Duvivier, 1989a; Halcrow, 1997). The majority of sediments are probably transported offshore in suspension, but no precise information on pathways, quantities and ultimate 'sink' areas is available. Estimates of quantities removed annually, based on approximate measurements of shoreface width and depth and cliff recession rates, are given in Posford Duvivier (1999).

Regarding coarse marine sediment input, the entry of coarse sediments into the West Solent from Christchurch Bay is normally restricted by tidal conditions at Hurst Narrows. Examination of tidal curves for Lymington, Yarmouth (Isle of Wight) and Totland reveal marked asymmetry, because the ebb flow is concentrated into a shorter time period than the flood (Webber 1980). The ebb flow is therefore considerably more rapid than the flood and transport of coarse bedload sediments (sand and gravel) is therefore likely to be in a net south-eastward direction, parallel to the shoreline between Fort Albert and the Needles, determined by peak current velocities. Coarse sediments may enter the Solent via Hurst Narrows during exceptional conditions. A combination of high wave energy and a storm surge from the southwest coincident with peak flood tide velocities can be sufficient to transport pulses of coarse sediment into the West Solent against the prevailing net transport direction. This would certainly explain the growth of re-curves and the extension of Hurst Point and may also supply materials to the main channel. Such a process is unlikely to operate on the Isle of Wight shores of Hurst Narrows due to shortage of mobile gravel. (SCOPAC Sediment Transport Study, 2014).

The extent to which these transport pathways are significant sources of supply of sediment to beaches between Fort Albert and Alum Bay remains uncertain. Studies of the Pot Bank dredging area by Hydraulics Research (1977a) identified significant coarse sediment circulation from Hurst Narrows offshore to feed Shingles Bank and Dolphin Sand in Christchurch Bay and, to a lesser extent, Pot Bank. Although much of the analysis, involving comparison of successive editions of Admiralty hydrographic charts, concentrated on Pot Bank (located south-west of the Needles) it was concluded that sediments from this offshore directed pathway from Hurst Narrows did not directly feed the beaches of the north-west Wight coast. Evidence is not conclusive because sediment throughputs may occur with no net alteration in seabed levels. A general survey of the Isle of Wight coast revealed that in this sector beaches were generally depleted, and thus concluded that there was little supply of coarse material from offshore (Barrett, 1985). A study of the potential effect on beach morphology of dredging of the Shingles Bank (Bradbury et al. 2003) also did not identify any onshore supply of sediments to these beaches, although it did highlight the important function of the Shingles Bank in providing shelter against waves approaching from the west.

Regarding suspended marine sediment input, net suspended sediment transport is likely to be into the West Solent at Hurst Narrows due to the greater duration of the flood current. Thus, it is likely that fine marine sediments and suspended clay sediments derived from cliff erosion of the west Isle of Wight and Christchurch Bay coasts become drawn into the West Solent. Remote sensing studies of suspended sediments within Christchurch Bay and the Western Solent support these conclusions (Strisaenthong, 1982; McFarlane, 1984, in SCOPAC, 2004).

Both the potential for, and actual rates of, *littoral drift* vary along the north-west Wight coast due to spatial changes in wave climate and the role of tidal currents. Between the Needles and Fort Albert, the coast is subject to obliquely approaching refracted Atlantic swell waves, modified by the shallow water of the western English Channel and Christchurch Bay, especially the Shingles Bank. Drift potential is therefore high (New Forest DC, 1998, in SCOPAC, 2004). Beach monitoring at Alum, Colwell and Totland Bays from 1997 to the present (this programme is ongoing), has revealed considerable seasonal fluctuation of profile form and volume, but relatively modest net morphological changes (from Channel Coast Observatory, in SCOPAC 2014).

Although medium- to high-energy wave conditions might be expected due to the exposure of this coastline, this frontage benefits from the presence, 1 to 2km offshore, of the Shingles Bank. This is a major accumulation feature containing between 25 and 50 million m^3 of sand and gravel, which refracts and dissipates incoming waves from the south-west, west and north-west that otherwise would directly strike the shore. Resultant wave energy is therefore medium to low, decreasing from Alum Bay towards Cliff End.

It is thought that Alum, Totland and Colwell Bays were once more strongly linked by shoreline drift, but headlands have increased in prominence as the Bays have become more deeply eroded so that each of the three Bays now generally behaves independently of the others. As the Bays are relatively closed systems, they receive sediment inputs only from erosion of local cliffs. Much of the material yielded is too fine to remain on beaches and is transported seaward, where tidal currents may transport it south-westward of the Needles or north-eastwards into the Western Solent. Although some sands and thin superficial deposits of gravels are available throughout the cliff coast of this frontage, the major sources of shoreline sediments have been the flints from the Needles Chalk and sands and some gravels and limestones from Alum Bay and Headon Warren. Segmentation of the bays has tended to isolate Colwell and latterly Totland Bays from these sources. Remaining shore sediments tend to drift northward at low rates within each Bay towards the local headland, whereupon they are entrained and removed by strong tidal currents generated within Hurst Narrows.

The Shingles Bank was dredged in 1996 to provide recharge material for Hurst Spit. If such operations were to significantly reduce crest levels of Shingles Bank, they could adversely affect its wave refraction and dissipation function, such that this frontage would experience increasing wave energy. Shingles Bank is believed to be fed by sediments drifting from Christchurch Bay and along Hurst Spit and into Hurst Narrows. It therefore could be sensitive to the management practices in Christchurch Bay that have significantly reduced drift inputs to Hurst Spit. Although there is some evidence of historical crest lowering, a clear trend has yet to be established.

Seawalls, promenades and cliff drainage schemes have been constructed to stabilise the shoreline in Totland Bay and southern Colwell Bay. The prevention of local sediment inputs from the formerly eroding local cliffs is thought to have contributed to the falling beach levels observed over the past century.

Bathymetry from the Needles headland to Fort Albert (Channel Coastal Observatory, 2013).

Shoreline Movement:

Much of the north-west Wight coast is subject to active erosion, but its morphology varies spatially from simple high-angle cliffs, as at Colwell Bay, to compound slopes with multiple scarps and intervening degradation zones, e.g. Headon Hill (Bird 1997). This is principally related to the mechanisms of mass movement and slope failure.

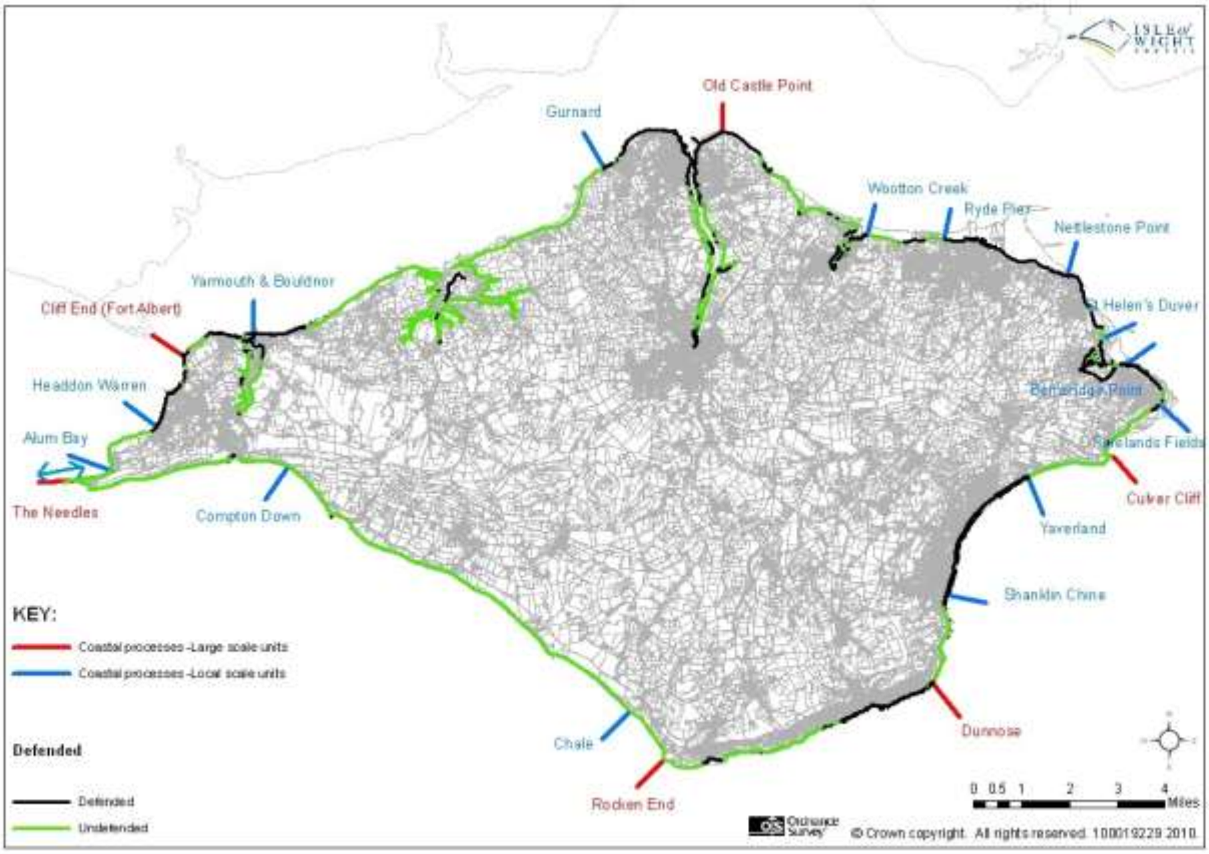
The type and rate of coastal slope retreat is controlled by the geology and hydrogeology of outcropping strata, and antecedent topography (height of the coastal slope), thus promoting slope failure through various slide and slip mechanisms (Hutchinson and Bromhead, 2002). All these factors vary spatially, so rates of retreat and volumes and grades of sediment input are also non-constant. Reports of past coastal erosion and landsliding reveal similar rates of activity and landform development to the present day situation (Norman, 1887; White, 1921; Colenutt, 1938; Moorman, 1939). Thus, it is likely that this coast has retreated throughout much of the late-Holocene period following the establishment of interconnection between the West Solent and Christchurch Bay. Evidence of this is provided by recognition of an ancient landslide deposit, extending up to 100m offshore, from a foreshore lobe of boulders off Brickfield Farm (Munt and Burke, 1987).

Overall, the longer-term retreat of this cliffed coastline has widened the West Solent estuarine channel and contributed a substantial input of fine sediment to its tributary estuaries. It is probable that much of the finer grained sediment stored in the West Solent itself comes from the same source, but nothing is currently known about residence times and supply pathways.

This frontage is still adjusting in response to: (i) breaching of the former Chalk ridge extending between the Isle of Wight and Purbeck; and (ii) breaching of the West Solent that resulted in generation of strong tidal currents close inshore. Consequently, a tendency is likely for continued erosion.

Future increases in rates of sea-level rise and winter rainfall would accelerate the landsliding of currently active cliffs between Alum Bay and Fort Victoria (Halcrow Maritime et al, 2001). Increased supply of sediments to the shore would be likely to occur as a result.

5.2.1 Local Scale process unit: The Needles to Alum Bay



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Area: 6A - Freshwater and the Tennyson Headland -including Alum Bay and Headon Warren).* Policy Unit:

- 6A.2 Tennyson Down, Alum Bay and Headon Warren (9,764 metres) -part 2 of 3.

Interactions:

North-facing, near-vertical Chalk sea cliffs developed by erosion of the mainland-facing extremity of the Purbeck–Needles–Culver Chalk ridge. The cliffs are fronted by variable accumulations of Chalk debris according to recent cliff-falls, but otherwise descend directly to deep water. The cliffs adopt a simple linear form and fail mainly by rock falls following oversteepening of the profile by toe erosion. Infrequent larger failures can result in several metres of retreat within single events. Flint nodules within the cliffs are released by erosion and supplied to the beach in Alum Bay, but otherwise most cliff erosion products are removed in suspension by wave action.

The Needles headland exerts an important control on wider shoreline evolution, affording shelter from dominant south-westerly waves to the frontage between the Needles and Cliff End, and also to Hurst Spit on the mainland. This headland also controls the direction of tidal flows exiting from Hurst Narrows such that it influences the configuration of seaward parts of the Shingles Bank.


View looking east, from the top of the high Chalk cliff forming the Needles ridge, towards Alum Bay, 2014 (J.Jakeways)


View looking west, from Alum Bay towards the Needles Chalk ridge, 2014 (J.Jakeways)

The northern face of the Chalk ridge runs from the Needles to Alum Bay The Chalk is significantly more resistant than other geological units outcropping further northeast having been 'hardened' by tectonic forces but is nevertheless subject to erosion, albeit at slow mean rates in the order of 0.1 to 0.3m/yr (May, 1966; Halcrow, 1997; Posford Duvivier, 1999), although rates at the lower end of the spectrum are likely to increase in the future due to sea level rise and the extreme exposure of the headland. The Needles stacks have been isolated by the assailing forces of breaking waves exploiting near vertical joint and other fracture planes. It should be noted that recession is episodic with major cliff falls and intervening periods of little activity. Erosion takes place by basal undercutting followed by periodic localised falls that generate temporary accumulations of scree at the cliff toe. The cliff face then retreats slowly by sub-aerial processes until marine erosion removes the debris at the toe and another cycle of undercutting can begin. Several large falls have occurred in recent decades causing subsequent localised recession of up to 10m. The significance of the Chalk is that it contains in-situ flint nodule bands, which are released as angular gravels that become abraded to form beach pebbles. However due to the short frontage and modest retreat rate the overall supply is quite small. An estimated shoreface erosion rate of 3mm/yr, combined with the above recession value, would yield approximately $100m^3$/yr of coarse flint debris (Posford Duvivier, 1999). The relative absence of other durable lithologies in the cliffs between the Needles and Warden Point make the Chalk cliffs the only significant gravel source for local beaches (Lewis and Duvivier 1962, 1973, Bird 1997), especially in Alum Bay.

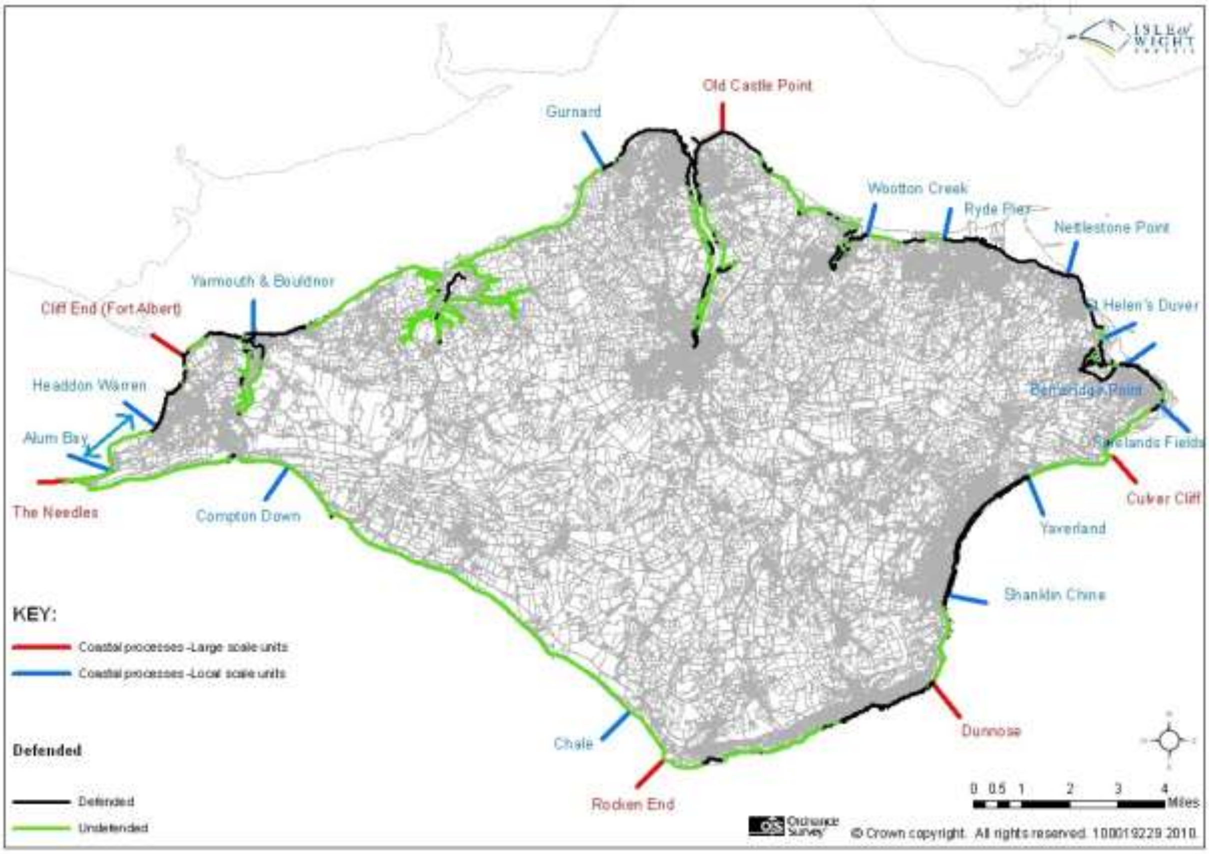
Results of the Strategic Regional Coastal Monitoring Programme:
The Southeast Strategic Regional Coastal Monitoring Programme does not monitor beach profiles along this stretch of coastline.

Shoreline Movement:
Relatively low recession rates of the cliffs are typical due to their sheltered north-facing orientation. It means that fallen debris can persist for a relatively long period as a protective apron thereby reducing opportunities for basal erosion of in situ strata.

Predictions of Shoreline Evolution:
Futurecoast (2002) estimated that without defence cliff recession would be likely to continue at, or close to, historical rates with the small quantities of flints eroded from these cliffs comprising the main inputs of fresh gravels to the Alum Bay beach.

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report (re. unit IW42).

5.2.2 Local Scale process unit: Alum Bay to Headon Warren



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Area: 6A - Freshwater and the Tennyson Headland -including Alum Bay and Headon Warren).* Policy Unit:

- 6A.2 Tennyson Down, Alum Bay and Headon Warren (9,764 metres) -part 3 of 3.

Interactions:

Alum Bay is a west-facing bay cut into soft Eocene sand and clay sediments. The geological strata dip steeply northward and rest against the Chalk. Composed of interbedded cycles of clay, silt and sand the cliffs form generally steep profiles that erode readily by rock fall, gullying, translational slides and mudsliding (within the clayey areas, especially the Reading Clay). A steep and relatively narrow shingle beach provides partial protection at the cliff toe.

In the south of Alum Bay, Reading Beds and London Clay (Thames Group) dip steeply (75 degrees to 85 degrees), but the outcrops of the Bracklesham and Barton Groups are wider because of a rapid reduction in dip angles as the Isle of Wight monocline fold levels out northwards. All strata in Alum Bay are easily eroded, comprising clays, sandstones and occasional grit and pebble horizons. The near vertically inclined strata in the south of the bay are primarily sandy and form relatively steep simple cliffs that fail by rockfall. Exceptions are the Reading and London Clay outcrops immediately north of the Chalk where mudslides and slumps have created a less steep, but dynamic degrading coastal slope. These materials are supplied to the foreshore by cliff falls, flows and mudslides (Hutchinson, 1965; Hydraulics Research, 1977b) and gullying (Gifford and Partners, 1994).


Alum Bay cliffs (the strata adjacent to the more-resistant Chalk, in the south of the bay), view looking north, 2014 (J.Jakeways)

Northward of Alum Bay, at Headon Warren, the topography rises considerably and a series of complex landslides and partially active scarps has formed on the coastal slopes. Cliffs are composed of gently northward dipping strata outcropping on the north-facing coast in a near-horizontal interbedded sequence of clays, sands and thin limestones. Weakly resistant Barton Clay and Sands outcrop at beach level so that the cliff toe is sensitive to marine erosion and overall recession rates are rapid. A wide multiple bench and scarp morphology has developed in which thin limestones define the in situ surfaces of benches that are covered by overburdens of landslide debris derived from degradation upslope. Failures occur both by mudsliding over the benches and periodic deep-seated failures of backing scarps. The soft limestones are of significance as they break down into boulders that afford some short-term protection to the cliff toes and have resulted in emergence of Hatherwood Point as a local headland.

Recession of these high cliffs provides considerable quantities of sand and clay to the shoreline, the majority of which is removed seaward by waves and tidal currents. The limestone boulder aprons at the shoreline significantly interfere with drift, although it is thought that some sands and gravels drift north-eastwards into Totland Bay.

Flints released from the Chalk of the Needles headland, sand and limited quantities of gravel from Eocene rocks and cliff top Quaternary sediments within Alum Bay are transported from Alum Bay and Headon Hill towards Totland Bay (Lewis and Duvivier, 1962, 1973, 1981; Hydraulics Research, 1977; Barrett, 1985; Posford Duvivier, 1989; Halcrow, 1997; Bradbury, et al, 2003). Boulder aprons on the foreshore at Hatherwood Point and beneath Headon Hill appear to intercept drift significantly so that only relatively small quantities of coarser materials appear to reach

Totland Bay (where groynes were installed in 1993). The transport discontinuity at Hatherwood Point appears to confine the well-defined gravel upper beach in Alum Bay whereas predominantly sandy beaches occur in Totland Bay. Study of nineteenth century engravings and paintings suggest that this distinction has been sustained for more than a century (McInnes, 2008). Net offshore loss of fine sand in Alum Bay is suggested by Brampton et.al, (1998) and beach profile monitoring revealed an overall but relatively modest loss of beach material over the period 1996 to 2002 (Bradbury et al, 2003). Possible causes are not given; historically this has been a narrow beach. (In SCOPAC, 2014).

Northwards, alternating sands clays and limestones form units of differing resistance and permeability generating deeper seated landslides and giving rise to a wide degradation zone incorporating benches and scarps towards and around Hatherwood Point on the western flanks of Headon Hill. Headon Hill rises to 120m and is underlain by Oligocene age Headon Beds, Osborne Beds, Bembridge Limestone, Bembridge Marls and a thin cap of Pleistocene Plateau Gravels. The varying resistance and permeability of these strata have led to the development of a complex coastal slope, with mudsliding over a series of partially concealed scarps and both translational and deep seated failures, especially towards the cliff top (Hutchinson, 1965, 1983, Hutchinson and Bromhead, 2002). The cliff top and toe environments are partially 'decoupled' by the interposition of the degradation zone.

A wide range of sediment grades is supplied to the shore by these processes. Little quantitative work has been undertaken, but analysis of the lithology of Headon Beds yielded a composition of 20% sand, 20% limestone and 60% clay (Lewis and Duvivier 1973). The other beds are predominantly clays and sands with a major limestone unit and small quantities of gravel from the superficial drift deposits. The limestones are of significance for they break down into joint-controlled boulders and thus provide some protection to the toe of the coastal slope (Hydraulics Research 1977b). There has been no quantitative estimation of their residence time, but this is probably limited due to the relatively low durability of these limestones.

The remainder of the cliff input comprises fine sands, silts and clays that are susceptible to rapid suspended transport offshore. Only coarse sands, gravel and limestones can contribute to beach volume in the long-term and the potential availability of these materials in the cliffs is limited. Posford Duvivier (1999) conclude that the 250m wide and 10m deep shoreface is scoured to a depth of between 14 and 44mm/yr, yielding 15,800m^3/yr of fine sediment. Most of this is removed offshore by suspended transport.

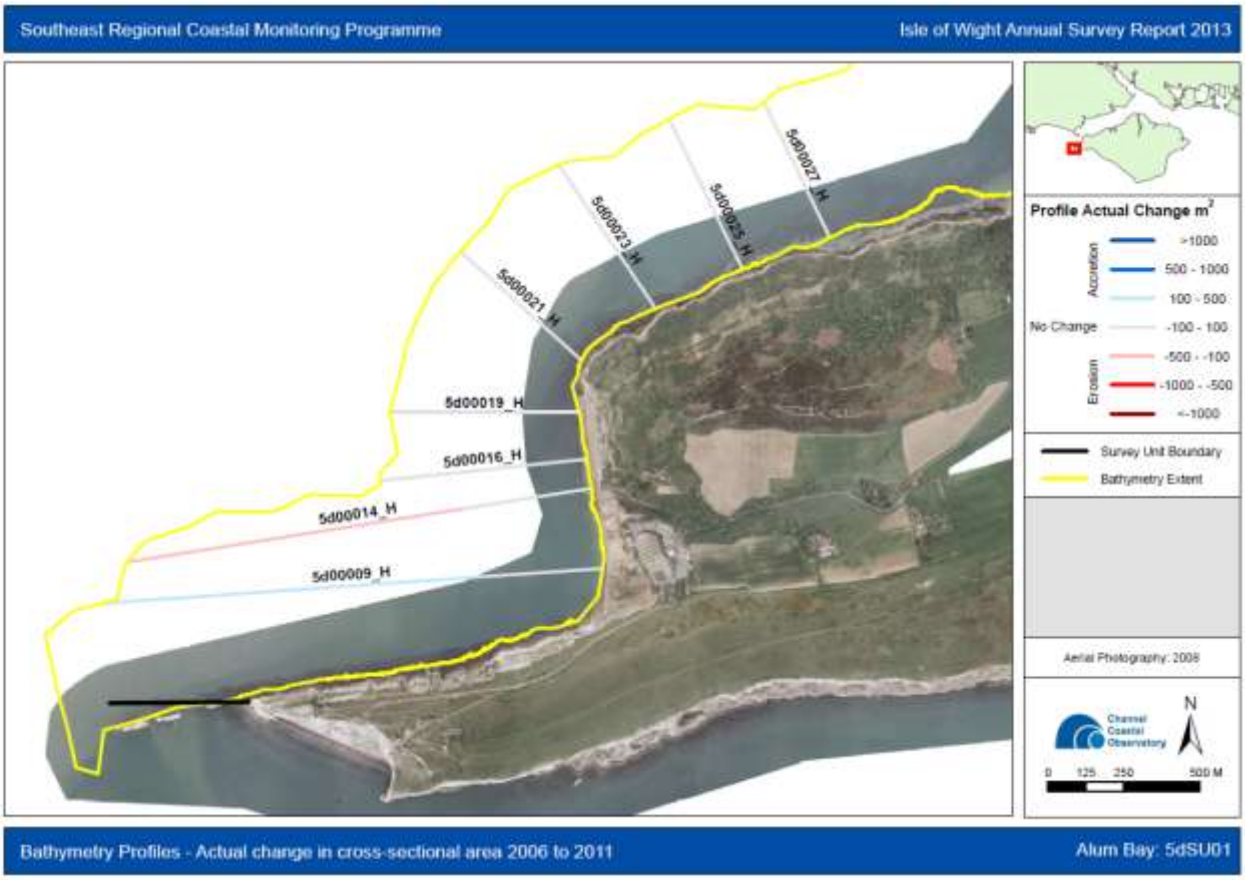
Results of the Strategic Regional Coastal Monitoring Programme:
(Maps and text ref. Channel Coast Observatory, 2013, Isle of Wight Annual Report):

5dSU01 (TOT 2): Alum Bay

- *Spring 2012 to Spring 2013: There has been some erosion towards the landward end of profiles 5d00007 and 5d00010 while the rest of the unit shows minor change.*
- *Baseline Spring 2003 to Spring 2013: This management unit shows erosion over the longer timescale, with more material lost to the north of the unit.*

Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)

10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

Shoreline Movement:

A major phase of landslide activity produced rapid cliff top or scarp recession over the period 1909-75 at Headon Warren, thereafter the cliff top remained relatively static. Such events are episodic and are interspersed between prolonged inactive periods at the cliff top. During such periods activity is concentrated in lower parts of the coastal slope involving degradation of detached blocks as they are transported down to the shore. The overall result has been mean recession at relatively high rates over the last century: this is thought to be representative of the long term recession rate. It should be noted that although the cliff toe has fluctuated in position, there has been little net retreat due to episodic seaward movement of landslide lobes.

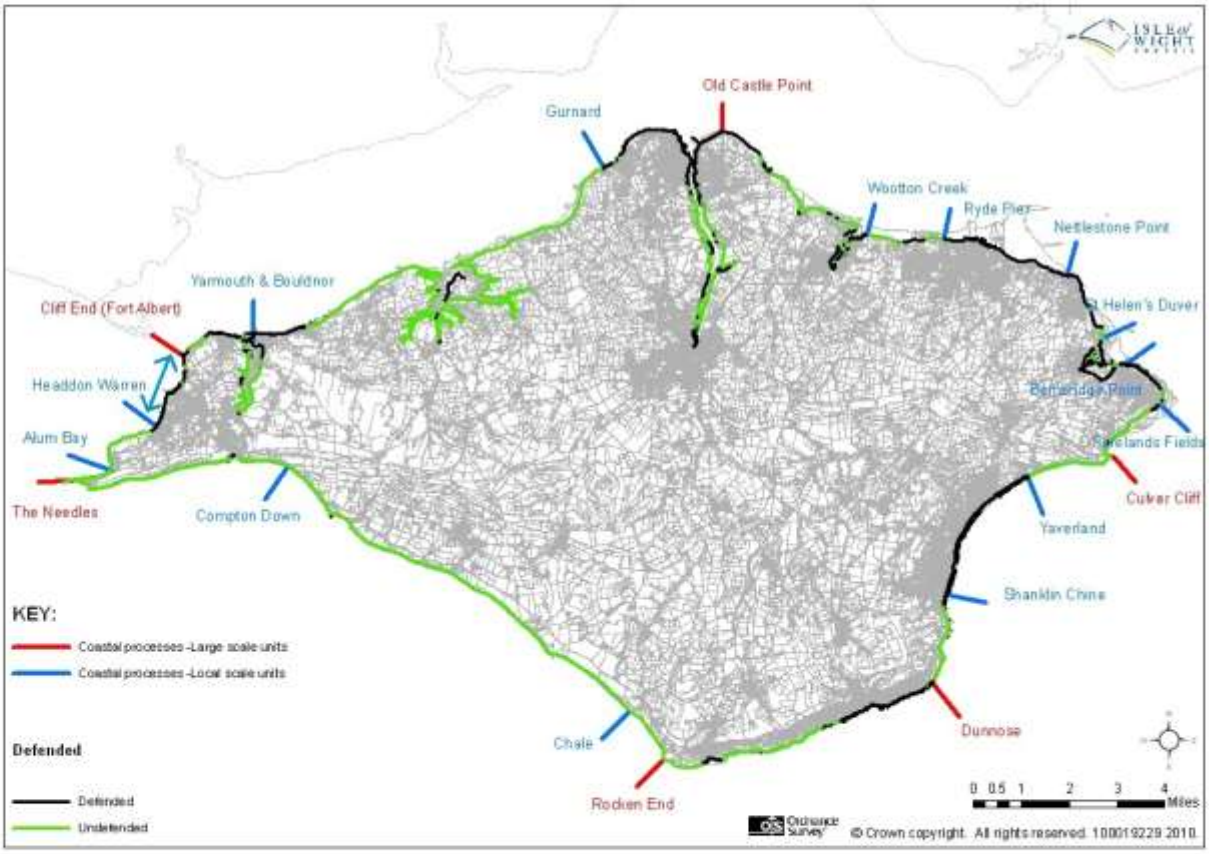
Map comparisons covering the period 1868-1963 revealed long-term cliff retreat at Alum Bay and Headon Hill of between 0.2-0.5m/yr (May, 1966). Corresponding estimates by Halcrow (1997) for 1909-95 are 0.24m/yr for Alum Bay and 0.69m/yr for Headon Hill. Posford Duvivier (1997; 1999) gives a rate of between 0.35 and 1.1m/yr for the sector between Widdick and Alum Bay Chines. Total erosion yield is calculated at 110,000m^3/yr of which 22,500m^3/yr is estimated to be sand, gravel and limestone boulders. It should be noted that the value for coarse materials is not based on field sampling and is rather uncertain, although 500m^3/yr is estimated for flint gravel from superficial deposits that cap the hill.

Predictions of Shoreline Evolution:

Futurecoast (2002) estimated that without defences the sea cliffs would continue to experience toe erosion, promoting conditions of instability. Consequently, the cliffs would continue to erode episodically through landsliding behaviour. Although at Headon Warren the upper cliff has been relatively stable over recent decades, it will become subjected to re-activation of landsliding in the longer-term future. This could potentially occur at some point within the next century, although the presence of a considerable volume of debris material from previous failures provides a degree of protection at the cliff toe.

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report –please see below (re. units IW43 & IW44).

5.2.3 Local Scale process unit: Headon Warren to Cliff End (Totland and Colwell Bays)



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Area: 6B – Totland to Norton).* Policy Units:

- 6B.1 Totland and Colwell (1,945m);
- 6B.2 Central Colwell Bay (840m);
- 6B.3 Fort Albert (544m), part 1 of 2.

Interactions:

Totland and Colwell Bays are two north-eastward facing embayments backed by eroding soft rock cliffs and occupied by narrow pocket beaches of sand and shingle. Warden Point, a local headland (defined by the presence of resistant limestone foreshore reefs) separates the bays. Fort Albert is located on the shoreline of the headland marking the northern limit of Colwell Bay.

The cliffs of Totland and southern Colwell Bays would have eroded naturally and would have been similar in form to those of central Colwell Bay prior to their protection in the early 20th Century. The unprotected cliffs of central and northern Colwell Bay are composed of soft permeable strata overlying impermeable clays in a classic landslide-generating sequence. Rapid seepage erosion, simple landslides and occasional deeper-seated failures are the main recession mechanisms. A wider degradation zone and increased propensity for mudsliding is evident closer to Fort Albert.

Seawall and groyne defences dating from 1910 to 1925 are continuous around Totland Bay extending northwards to include the southern portion of Colwell Bay. Some sections of the cliffs above seawalls are artificially drained in Totland Bay and at Fort Albert.

Totland Bay, where waves attack the seawalls and cliff reactivations have slumped over the seawalls. Photo taken in July 2009, showing the cliff-line in the distance prior to the December 2012 landslide (discussed below).

The cliffs of Totland and southern Colwell Bays presently form relatively steep, partly vegetated slopes following protection of their toes by defences. Although the intention has been to stabilise the cliffs, in many places this has not been achieved fully because significant landsliding has occurred within the slopes above the seawalls, resulting in some cliff top recession.

Colwell Bay, showing the transition from the defended to undefended coast and showing exposed rock ledges in the foreshore, looking north across groynes towards Fort Albert, in 2012.

Cliffs of Colwell Bay, 2012

Fort Albert, at the northern end of Colwell Bay, 2012

Colwell Bay is characterised by rapidly eroding low clay cliffs (15-25m). Only the south-western (Warden point - Colwell Chine) and north eastern (Fort Albert) extremities exhibit relative stability where toe protection structures and artificial drainage have been installed progressively over the past 30 years. The cliffs are formed within the Headon Hill Formation being composed of a lower clayey Colwell Bay Member that is overlain by the sandy Linstone Chine Member. Permeable strata overlie impermeable clays in a classic landslide generating sequence. Rapid seepage erosion and occasional deeper-seated failures are the main recession mechanisms. A wider degradation zone and increased propensity for mudsliding is evident closer to Fort Albert and has prompted recent stabilisation measures (Posford Duvivier, 1989a).

The major sediment accumulation of Shingles Bank located 1 to 2km offshore strongly dissipates and refracts incoming waves from the south-west, west and north-west serving to moderate the shoreline wave climate. Sediments drifting to northern parts of Totland and Colwell Bays are believed to become entrained by strong tidal currents generated at Hurst Narrows and transported either into the West Solent, or seaward to the south-west.

Incoming north-eastward littoral drift is intercepted by groynes in central and southern Totland Bay, thus accounting for the greatest beach volumes in these parts (Barrett, 1985). The beach comprises a steep shingle upper and sandy lower profile.

Totland Bay, littoral drift: Net drift is believed to operate from south to north within Totland Bay although very little gravel is available and only a low gradient intertidal sandy foreshore is present. Observations indicated that beach depletion was the dominant trend in Totland Bay between 1960 and 1990, but the first consistent programme of beach monitoring has revealed a gradual increase in beach volume over the period 1996-2002 (Bradbury et al, 2003). The profile analysis revealed that the beach within Totland Bay varied significantly seasonally with a greater volume being evident in summer. Its profile was also considerably more volatile than at corresponding locations in Colwell Bay and it was reported that an equilibrium profile did not form. These latter features are believed to result from the initially depleted state of the beach and are indicative of interaction with the seawall (Bradbury et al, 2003). (In SCOPAC 2014).

Warden Point at the northern extremity of Totland Bay is a natural headland resulting from an outcrop of resistant strata on the foreshore to form Warden Ledge, which partly intercepted littoral drift prior to sea wall and esplanade construction in the early 1980s. The prominence of this headland has been accentuated by the protection structures and the nearshore seabed has been lowered by beach drawdown, so that deep water now extends directly to the sea wall that collapsed in December 2012 (Lewis and Duvivier, 1981; Barrett, 1985). Due to limited material availability it is probable that north-eastward drift of gravel into Colwell Bay is now totally intercepted (Lewis and Duvivier, 1981; Barrett, 1985; Halcrow, 1997). It is uncertain whether the same holds true for sand or whether northward transfer into Colwell Bay is possible. In SCOPAC 2014.

Regarding littoral drift in Colwell Bay, the bay no longer receives coarse sediment input from Totland Bay by longshore drift, due to depletion of the latter and Warden Point acting as a drift barrier. Within Colwell Bay, net movement is from southwest to northeast as indicated by beach accumulations against groynes (Posford Duvivier, 1989, 1993; Halcrow, 1997), an observation also confirmed by beach sediment grading. The beach in the southwest corner became severely depleted, an effect starting in the 1940s, whilst central parts maintained a relatively stable shingle and sand beach (Lewis and Duvivier, 1973; Posford Duvivier, 1989). This trend led to reinstatement of the beach by nourishment and the rebuilding of retaining groynes between 1966 and 1977 (Barrett 1985), but these latter structures now severely restrict drift. The first consistent programme of beach monitoring has revealed a gradual increase in beach volume over the period 1996-2002 (New Forest District Council, 1997; 1998-2000; Bradbury et al, 2003). The profile analysis revealed that the beach within Colwell Bay varied seasonally with a lower volume being evident in winter, but otherwise maintained a slowly increasing profile volume and an equilibrium form. In SCOPAC 2014.

The northeast extremity of Colwell Bay is marked by Fort Albert, which was constructed in the mid-19th century. Subsequent coast recession and foreshore lowering has created a prominent salient here with deep water adjoining the fort (McInnes, 2008). It is probable that this artificially strengthened headland almost completely prevents north-eastwards drift of coarse sediment and thus promotes downdrift foreshore lowering (Lewis and Duvivier, 1981; Halcrow, 1997). Evidence therefore suggests that Colwell Bay is now an isolated pocket beach, which may only receive sediment from local cliff or shoreface erosion and possible onshore transport. Although potential littoral transport is likely to be towards Fort Albert, negligible accretion has occurred against this barrier and sediments are concentrated in the central part of the bay (Lewis and Duvivier, 1973). Two possible explanations exist: (i) there is no net drift in Colwell Bay, except for a tendency for sediment to move away from the headlands; (ii) net drift is indeed north-eastward, but sediment is lost offshore in the vicinity of Fort Albert due to entrainment by strong tidal currents generated at Hurst Narrows. Insufficient information is currently available to test these possibilities. In SCOPAC 2014.

Totland landslide, December 2012:

On the coast between Totland and Colwell a significant coastal landslip began on the 26th December 2012, and has continued moving since then (as of the latest survey dated September 2014). The site of the landslide is located below Fort Warden near Warden Point; the National Grid reference for the approximate centre of the site is SZ 3240 8770 (Mott MacDonald, 2013).

Aerial photograph of the Totland landslide, which is over 100m in length, taken in April 2013 (i.e. three months after the slide began). The landslide has continued moving since then. (Photo courtesy of HM Solent Coastguard).

This headland had been identified in the SMP2 in 2010 as vulnerable to future increases in landsliding and ground movement. Previous land movements along this headland between Totland and Colwell Bays had been typically slumps from the cliffs onto the seawall, which were then cleared and the seawall reopened. This was the largest ground movement to occur in the area since the historical defences were first constructed.

The landslide occurred within the cliffs behind and below the seawall on the 26th December 2012. A 120 metre length of the seawall was pushed seaward, initially up to 17 metres, and now up to 26 metres with the continued movement over the 21 months since the slip. The former seawall has been fragmented and destroyed. The landslide also pushed forward, tilted and destroyed the piled foundations of the former seawall. The movement created numerous gaps in the former seawall, which are allowing material to be eroded behind and beneath the wall, leading to further collapse of the remnants of the seawall and the problem to be exacerbated.

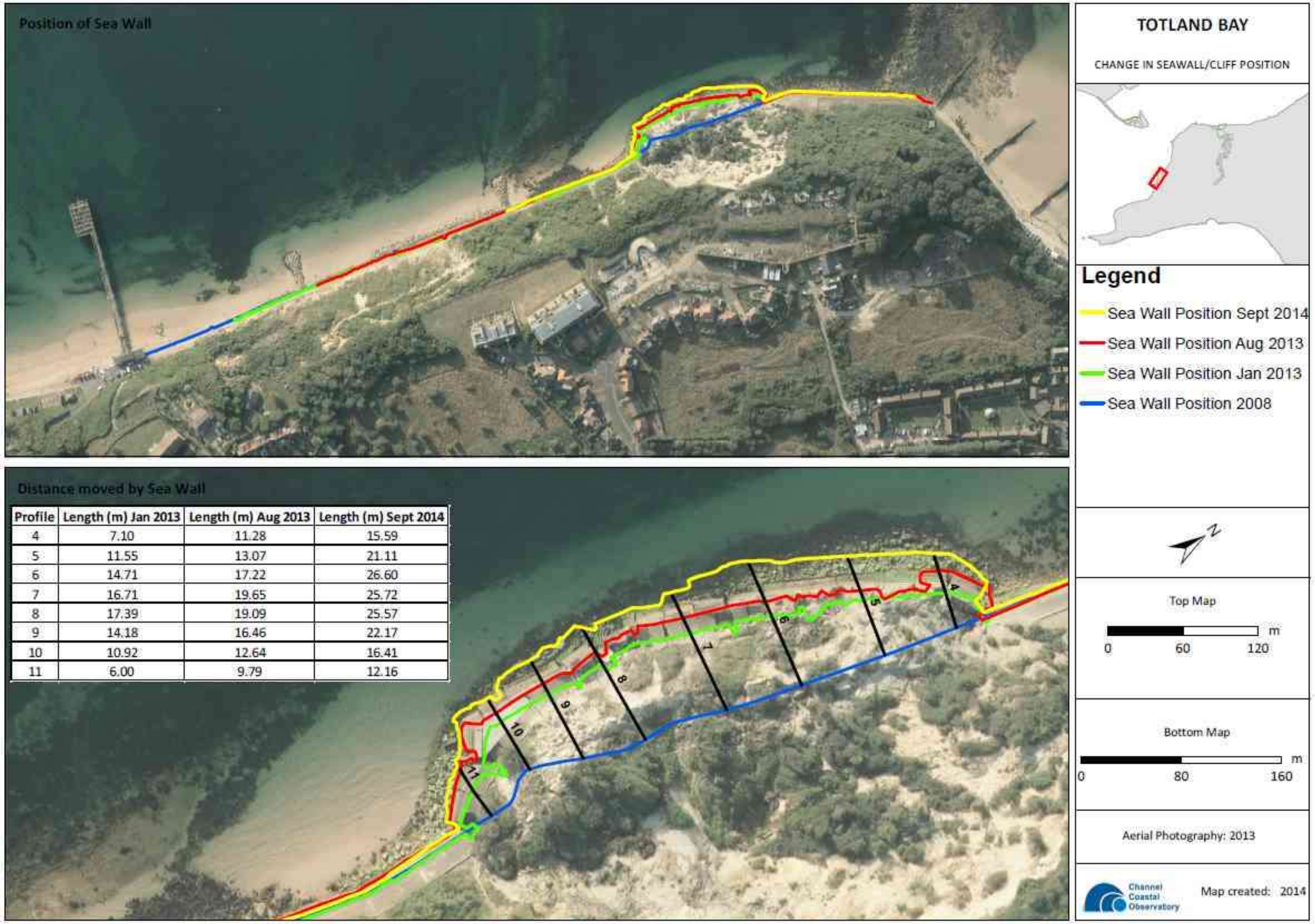
The year of 2012 was a very wet year. The Met Office (2013) stated it was the second wettest year on record for England. On the Isle of Wight the monthly rainfall was above average for the last six months of the year, particularly in the autumn months (Mott MacDonald, 2013).

A report into the Totland landslide (Mott MacDonald, 2013) has concluded that *'the failures have occurred along a basal failure plane at approximately-4m OD (the promenade level is +3m OD). The main cause is believed to be groundwater within the cliff following the above average precipitation levels for the winter of 2012.This increased pore pressures within the interbedded sand and clay cliffs, leading to a reduction in shear strength and the resultant failure below the* *sheet piles associated with the seawall. From site walkovers in September and October 2013, Mott MacDonald has observed instability and in particular mudslides along the rest of the frontage* [to the south of the slip] *that was studied, between the recent landslide and Totland Pier. This is attributed to the erosion of the toe due to overtopping waves and seepage lines associated with the Venus Beds above the How Ledge Limestone which can be traced throughout the cliff. There was also evidence of water run-out from the cliffs and bulging of the toe or slumping onto the concrete promenade behind the seawall - indicating high levels of instability within the rest of the cliff frontage and a correspondingly high risk of future failure, similar to the large scale event of the 2012 winter.*

Mitigation methods have not yet been implemented (September 2014) and are being discussed by the local authority. There are properties near the cliff top above, and this section of seawall was a popular amenity route connecting the two towns of Colwell and Totland, for both local people and tourists.

Southern end of the slip, (looking north from Totland Bay), during re-survey, September 2014 (L.Ellison).


Northern end of the slip (looking south from Colwell Bay), in August 2014 (L.Ellison)



Profile	Length (m) Jan 2013	Length (m) Aug 2013	Length (m) Sept 2014
4	7.10	11.28	15.59
5	11.55	13.07	21.11
6	14.71	17.22	26.60
7	16.71	19.65	25.72
8	17.39	19.09	25.57
9	14.18	16.46	22.17
10	10.92	12.64	16.41
11	6.00	9.79	12.16

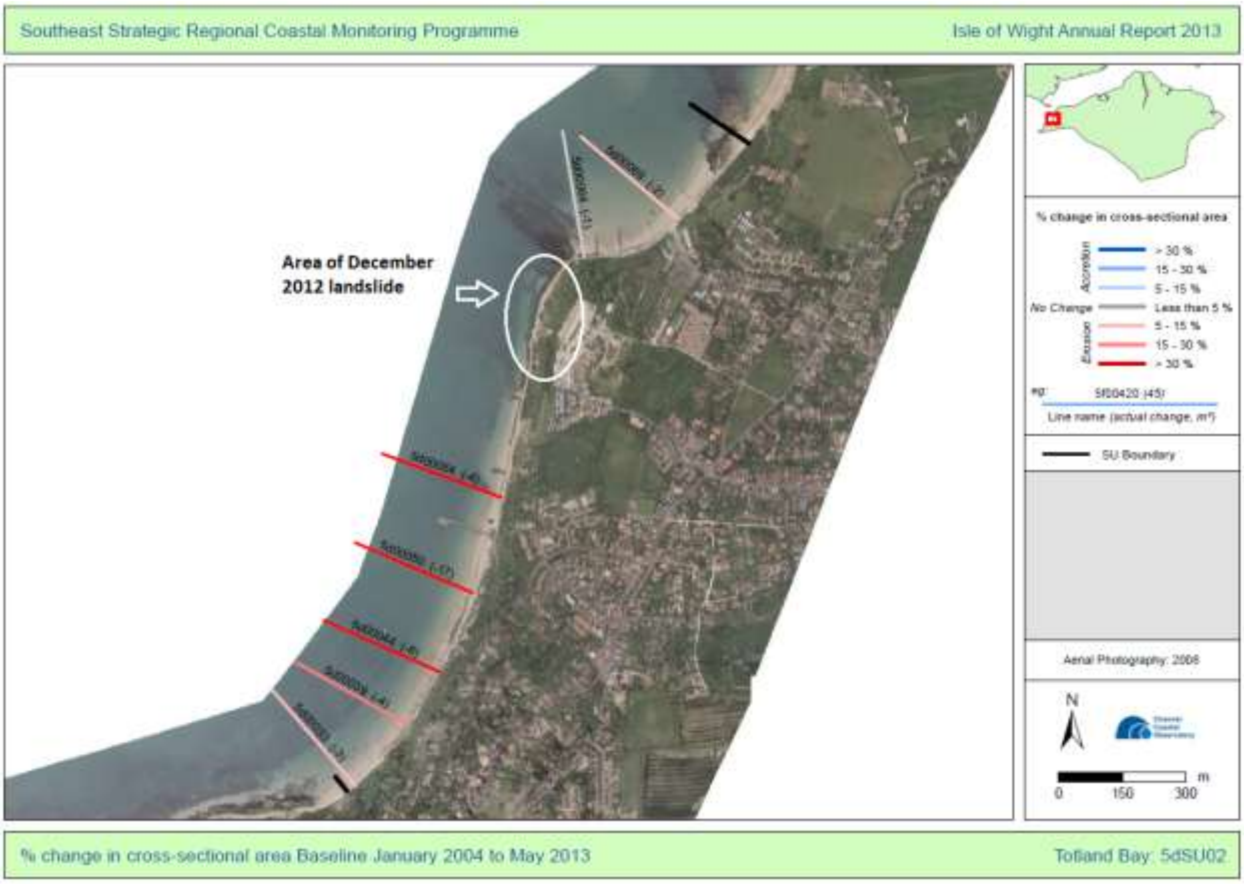
Survey results for the Totland landslide, showing remnants of the former seawall (marked in blue on it's alignment prior to the slide) being pushed progressively seawards over the 21 months following the slip (Channel Coast Observatory, for the Isle of Wight Council, 2014).

Results of the Strategic Regional Coastal Monitoring Programme:
(Maps and text ref. Channel Coast Observatory, 2013, Isle of Wight Annual Report):

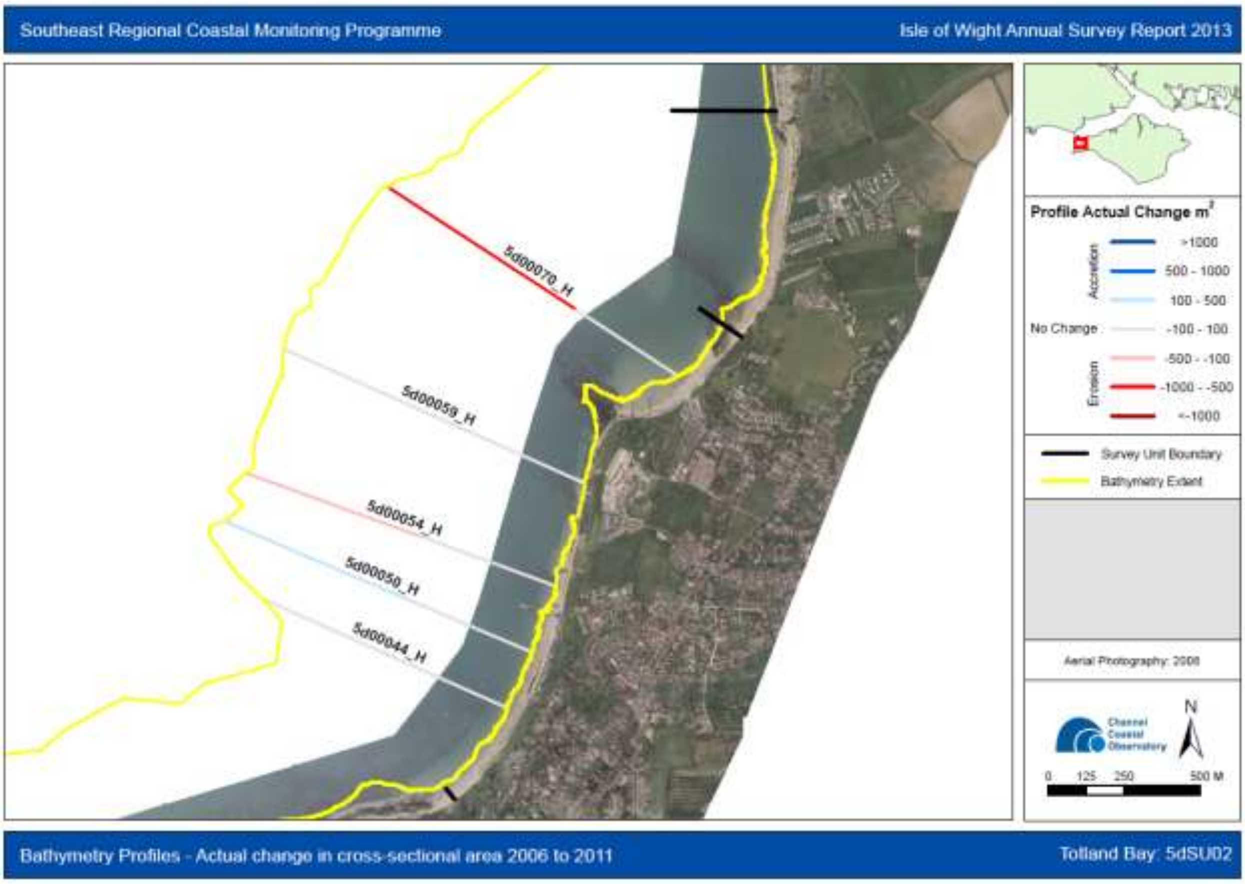
5dSU02 (TOT 3): Totland Bay

- *Spring 2012 to Spring 2013: Over the shorter timescale the majority of this management unit appears stable, but with some patchy erosion. This erosion is particularly apparent to the north of the pier, profile 5d00054. As the beach here is narrow, small actual change can cause large percentage changes. Between profiles 5d00054 and 5d00064 a major landslide occurred in January 2013. This moved the promenade seaward by 26m.*
- *Baseline Spring 2004 to Spring 2013: Over the longer timescale the majority of profiles are eroding. In places, particularly towards the south of the Totland pier, there is significant erosion in the lower beach, predominantly between profiles 5d00044 and 5d00054.*

Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



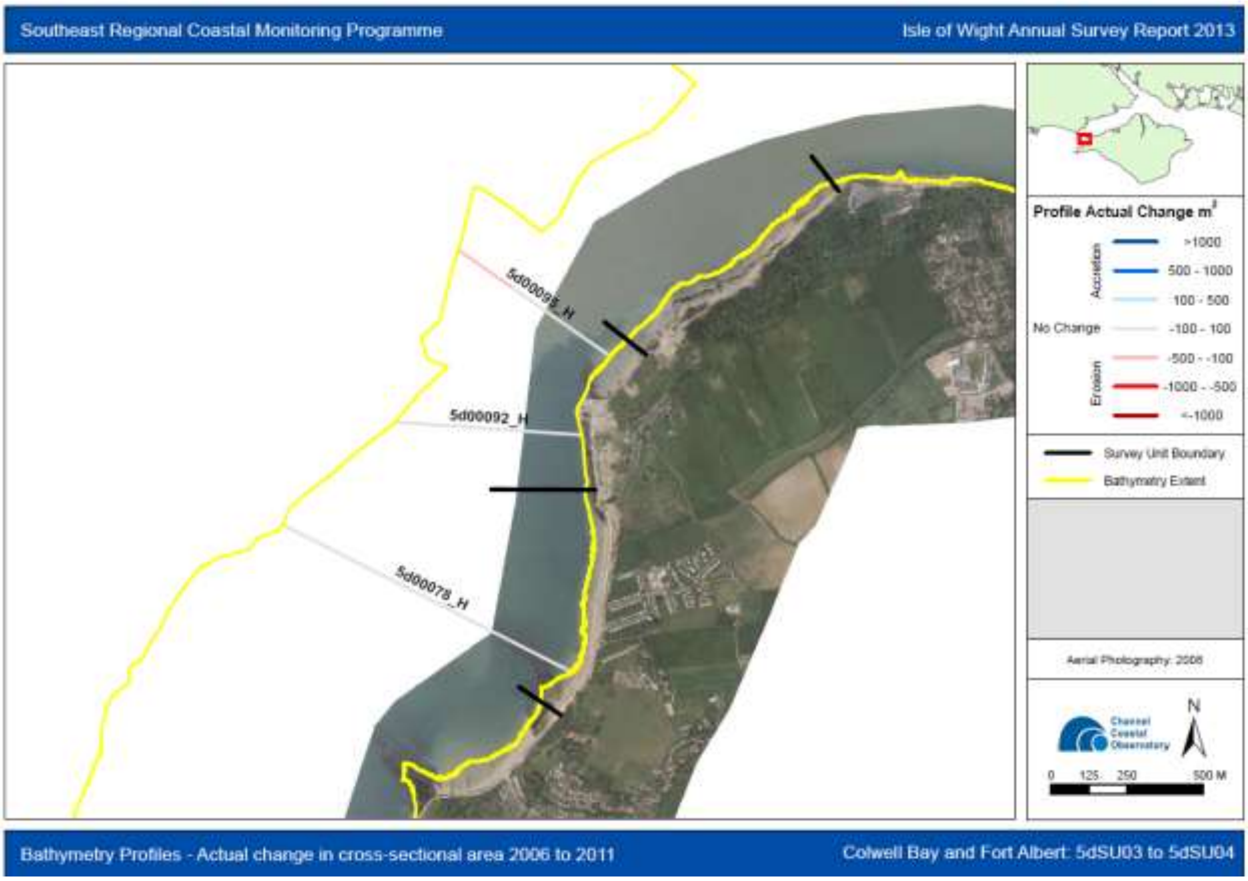
5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

5dSU03 (TOT 4): Colwell Bay

- Spring 2012 to Spring 2013: The majority of profiles are showing little change in this unit.
- Baseline Spring 2004 to Spring 2013: Since 2004 this unit is generally stable with a small area of erosion to the south and accretion to the north.

Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)

10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

Shoreline Movement:
Prior to protection, the cliffs of Totland and Colwell Bays retreated at relatively high rates. Protection almost completely halted recession, but an increasing tendency for instability and failures affecting the cliff top has been observed in recent decades. High recession rates have been recorded over recent decades in central-northern Colwell Bay where retreat of the unprotected cliffs remained extremely active. Beaches in both bays have suffered losses of sediment and lowering and narrowing over the past century.

Totland Bay has been subject to historical coast erosion and cliff-top recession has been measured at mean rates of 0.1-0.3m/yr (maximum 0.56m/yr) covering the period 1907-1961 (Lewis and Duvivier, 1962). A series of cliff falls and a major mudslide in 1960-61 prompted the extension and upgrading of the protection and stabilisation measures. Further improvements to the sea-wall, groynes and cliff drainage were completed in 1993. Seepage erosion within the interbedded clay/sand/limestone members of the Headon Hill Formation is nevertheless a continuing problem, especially to the north of the pier, where shallow rotational failures are over-riding the back of sea defences and destroying slope drainage measures. Rapid recession presently occurring within similar unprotected materials in neighbouring Colwell Bay is a useful analogue of the behaviour that might be expected should the protection fail or be removed. There are no longer any freely eroding cliffs within the bay and no direct sediment inputs to the beaches are possible (Lewis and Duvivier, 1973; Posford Duvivier, 1989a). It should be noted that significant instability continues within some cliff sections and results in periodic extension of debris lobes across the esplanade, typically occurring each year, and significant movement in December 2012 at Warden Point, when a landslip destroyed 120m of the seawall.

The SCOPAC Sediment Transport Study (2014) describes how the southwest part of Colwell Bay has been fully protected by a seawall since 1993. The Headon and Osborne Beds, which form the cliffline in the remainder of the bay, are subject to active erosion at their toes. The geological units of the cliffs comprise gently northward dipping sands and clays with occasional soft limestones, which promote seepage erosion and landsliding. In the south, cliff profiles are regraded and vegetated, but north of Linstone Chine simple steep eroding profiles are characteristic, with a tendency for increased landsliding and wider degradation zones towards Fort Albert. Cliff morphology may follow a cyclic pattern of response to marine undercutting of the toe that results in cliff failure. Marine processes must then excavate protective basal debris produced by failures before another cycle of toe undercutting and cliff failure can begin. Rising topography and increasingly clayey lithological units of the Cliff End Member of the Headon Hill formation complicate conditions towards Fort Albert, where slumps and shallow slides are active processes.

A variety of estimates are available for the mean long-term (100-120 year) recession rate: 0.3-0.6ma^{-1} (Hutchinson, 1965), up to 0.45ma^{-1} (Hydraulics Research, 1977), 0.10-0.60ma^{-1} (Lewis and Duvivier, 1962; 1981), 0.5ma^{-1} (Lewis and Duvivier, 1986; Posford Duvivier, 1989), 0.6ma^{-1} (Barrett, 1985) and 1ma^{-1} for cliff top retreat (McInnes, 1994). Historical map comparisons by Halcrow (1997) indicate a long-term mean of 0.32ma^{-1} in southern Colwell Bay for the period 1866-1975 covering the period prior to full protection. A mean of 0.52ma^{-1} is indicated for the central bay (1909-1975) with 0.93ma^{-1} for the section at Fort Albert.

Differences are due to measurement accuracies and the various time periods covered by map analysis, but all indicate consistent long-term retreat with faster rates operating towards the north of the bay. Recent erosion rates suggest faster than average recession in the Brambles Chine area and especially towards Fort Albert (Posford Duvivier, 1991). Retreat between 0.5 and 1.0ma^{-1} was recorded for the period 1970-85 (McInnes, 1994; Posford Duvivier, 1997) and maximum short-term retreat of the cliff-top was recorded at 1-2ma^{-1} (Lewis and Duvivier, 1986; Posford Duvivier 1989, 1991).

It is uncertain whether such behaviour represents natural short term variation within a stable long term recession cycle, or whether it might be a specific response to altered conditions e.g. increasing exposure of the toe to marine erosion. The eroding cliffs yield sands, clays and occasional soft limestones. The fine sands and clays yielded have little stability on the beach and much of the estimated cliff erosion input (approximately 5,000 m^3a^{-1}) is rapidly lost offshore (Posford Duvivier, 1999). An additional shoreface erosion rate of $17mma^{-1}$, yielding 7,000 m^3a^{-1} of fine sediment is also proposed.

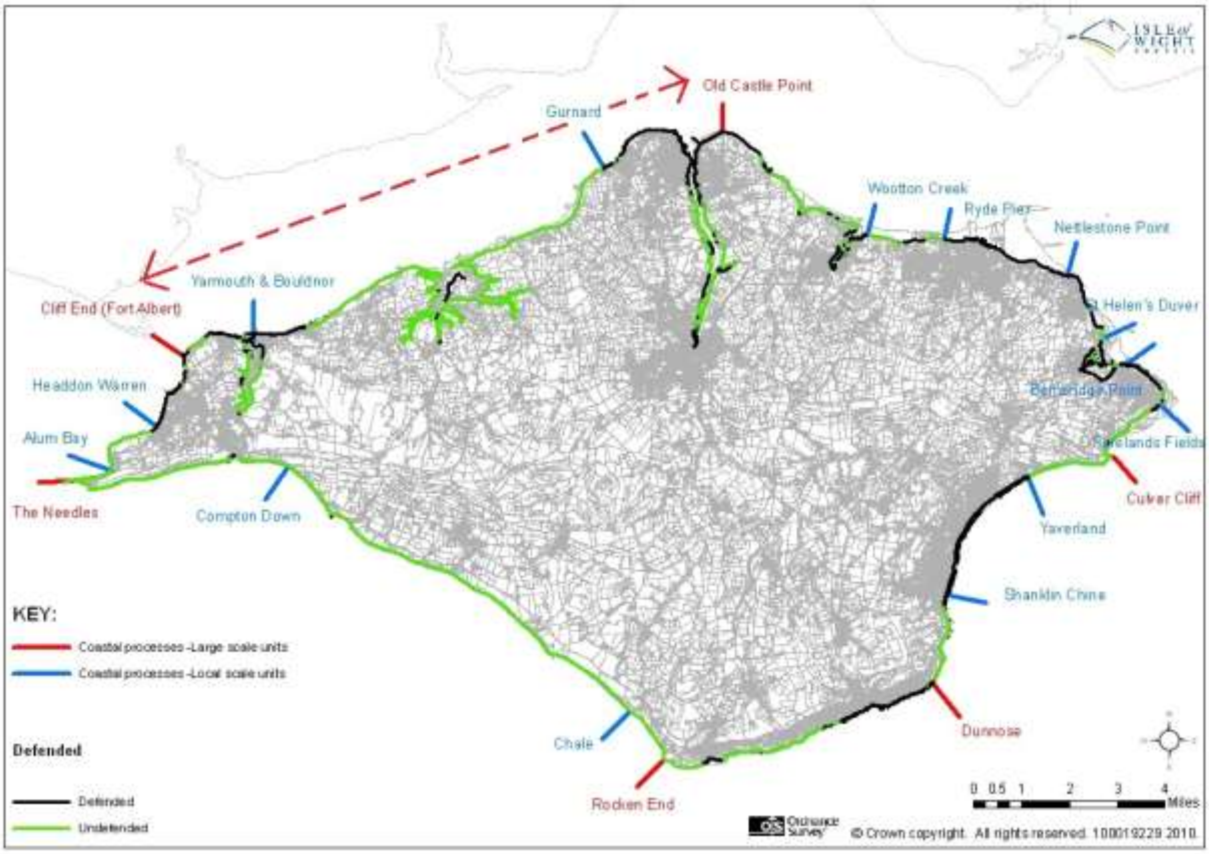
Predictions of Shoreline Evolution:
Futurecoast (2002) estimated that without defences the sea cliffs would continue to experience toe erosion, promoting conditions of instability: a process exacerbated by generally declining beach levels. Consequently, the stabilised cliffs would re-activate rapidly and the presently active cliffs would continue to erode episodically through landsliding behaviour. Increases in sediment supply to the foreshore would result, but this is unlikely to enhance beach volumes significantly because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades.

With present management practices existing defences will reduce the frequency of landsliding events within the backing sea cliffs, but are unlikely to completely eliminate instability where high groundwater levels are a factor. Periodic slope failures will therefore still occur. The fronting beaches will continue to narrow along defended frontages resulting in increasing exposure of defences to wave energy. In combination, these potentially increasing stresses from landward and seaward could significantly reduce stability of the structural defences and consequently trigger further landslides within the sea cliffs, leading to cliff top retreat and increasing damage to the structures. It is likely that shoreline stability cannot be sustained at these locations with current management practices so that significantly improved defences, or an alternative management approach, would be required in the short to medium term (20 to 50 years).

Unprotected parts of this frontage may erode more rapidly as they will be further starved of sediments due to the updrift defences in Totland and southern Colwell Bays. The enhanced sediment supply arising would only partly enhance beach volumes because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades.

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report –please see below (re. units IW45 & IW46).

5.3 Large Scale process unit: Cliff End (Fort Albert) to Old Castle Point



Map showing the boundaries of this large-scale process unit (see red arrow).

Interactions:

Between Fort Albert and Cowes, the coast is sheltered from the open sea and incident waves generated in the West Solent are fetch-limited and (rarely in excess of height of 1.3m) and of relatively low energy (Webber, 1978; Posford Duvivier, 1990; Halcrow, 1997). Thus, actual volumes and rates of drift are well below their potential (Brampton et.al 1998). Despite this, transport throughput is not uniformly low along this coast, for ebb tidal currents are rapid within the West Solent (Webber, 1980). Meandering of ebb and flood flow brings these tidal streams close to the shore at certain points so significant sediment transport is possible by tidal currents augmenting wave action (Dyer, 1971; Halcrow, 1997; Brampton et.al, 1998). (SCOPAC, 2014).

The coast has been formed by erosion into gently north eastward dipping, soft clayey, late Eocene and early Oligocene strata of the Solent Group (Insole and Daley, 1985). Mudslides are an especially prevalent slope degradation mechanism within these strata. The coastal topography is generally undulating with high points at Bouldnor Cliff (61m), Burnt Wood (57m) and Gurnard Cliff (45m) where major landslide systems have developed. Many of the slides, particularly at Boulder Cliff have probably involved base failure (Hutchinson, 1965). Rapid tidal currents flow through the Western Solent channel. The deep-water channel is relatively close to the Isle of Wight coast and in combination with wave action its currents assist in removing fine debris from cliff toes, thereby allowing conditions of instability to continue.

Ageing coastal defences to the north of Fort Albert, at the transition to undefended and eroding coast, 2012

Weak littoral drift generally operates north eastward along the whole coast with the exception of local reversals on the eastern entrances to inlets. Littoral drift is from both sides towards the inlets of Newtown Harbour, the Western Yar and the Medina. The eastern margins of such inlets are especially depleted and cause coastal defence problems.

Throughout the Western Solent the ebb tidal flow is of shorter duration than the corresponding flood (Webber, 1980). As a result, ebb currents are of greater velocity (up to $1.2ms^{-1}$) than the flood, causing net offshore transport of coarse bedload sediments at the mouths of both larger estuaries and small tidal inlets, Well-defined ebb tidal deltas are not reported. In SCOPAC, 2014.

The overall sediment input from the eroding cliffs is considerable, but the fates of these materials are poorly understood. Most of the erosion products are transported offshore and do not contribute to protect local beaches. It may be that the majority are transported away eastwards by the residual flow in the channel, although a series of re-circulating eddies identified within the channel would also have the potential to deliver materials to the mainland shores opposite. It is likely that they are deposited within more sheltered regions such as in Southampton Water and the harbours of the Eastern Solent. This conclusion is supported by studies of clay mineral compositions (Algan et al., 1994) that suggest that fluvially derived clays are greatly diluted in such areas by incoming marine clays consistent with those produced by erosion of Oligocene strata around the Solent. The high eroding cliffs of this unit appear to be the most important sources of fresh fine grained sediment within the Solent. Coarser sediments drift predominantly eastwards along the foreshore and become concentrated in double spits at estuaries and within embayments defined by minor headlands. Wide, low gradient mixed sediment inter-tidal zones are characteristic. Eastward of

Gurnard, marine erosion is generally less active and many of the coastal slopes above the shoreline retain relict landslides. Posford Duvivier (1997) estimated that the eroding cliffs and platforms between Sconce Point and Gurnard Bay currently yield 150-200,00 m^3a^{-1} of fine sediment, very little of which is available to littoral transport, but which may provide (or provided) a source of supply to estuarine mudflats and saltmarshes in the Western Solent. By contrast, the annual yield of coarse sediment is considered to be less than $500m^3$.

Rivers on the north coast of the Island are small due to limited catchments and therefore contribute negligible sediment to the coast. Rendel Geotechnics and the University of Portsmouth (1996) estimate that all of the rivers discharging sediment to this coastline potentially contribute some 2,450 tonnes/yr of suspended load and 740 tonnes/yr of bedload material. However, various barriers and regulation of flows reduce the delivery volume very substantially. The River Medina has a mean flow of $0.5m^3s$ and this comprises only 0.67% of the tidal volume entering at the mouth during a corresponding tidal period (Webber 1978). Thus, marine sediment input to estuarine mudflats and saltmarshes must be the dominant source of supply and fluvial sources are considered to be relatively insignificant.

Generally, tidal regimes at the mouths of estuaries and inlets in the West Solent are characterised by a rapid short duration ebb current and a more pronged lower velocity flood (MacMillan, 1955, 1956; Webber 1969, 1980; Price and Townend, 2000). This regime favours net input of suspended sediments into inlets, so that tributary estuaries and creeks flanking the West Solent are subject to progressive infilling and are flanked by mudflats and accreting saltmarshes.

The estuaries and creeks within this frontage exert an influence on the shoreline, particularly as their inlets generate strong tidal currents that intercept shoreline drift and most possess double spits at their mouths which store sand and gravel that could otherwise contribute to foreshore stocks. The configurations of spits at estuary entrances do not appear stable due to shortages of sediment such that there is a tendency for these features to be driven into each estuary, possibly in association with breaching events. Stable ebb-tidal deltas do not appear to have formed seaward of inlets in spite of their ebb-dominance. The latter is possibly a function of past dredging although this is not known at Newtown Harbour. An alternative explanation is that the rapid shore-parallel tidal currents of the West Solent remove sediments flushed out of inlets such that they become incorporated into channel (e.g. Solent Bank) rather than delta deposits. Due to the absence of sheltering tidal deltas and the likely migration of spits, waves would tend to penetrate increasingly into the estuaries, potentially accelerating the erosion of saltmarshes and intertidal foreshores within.

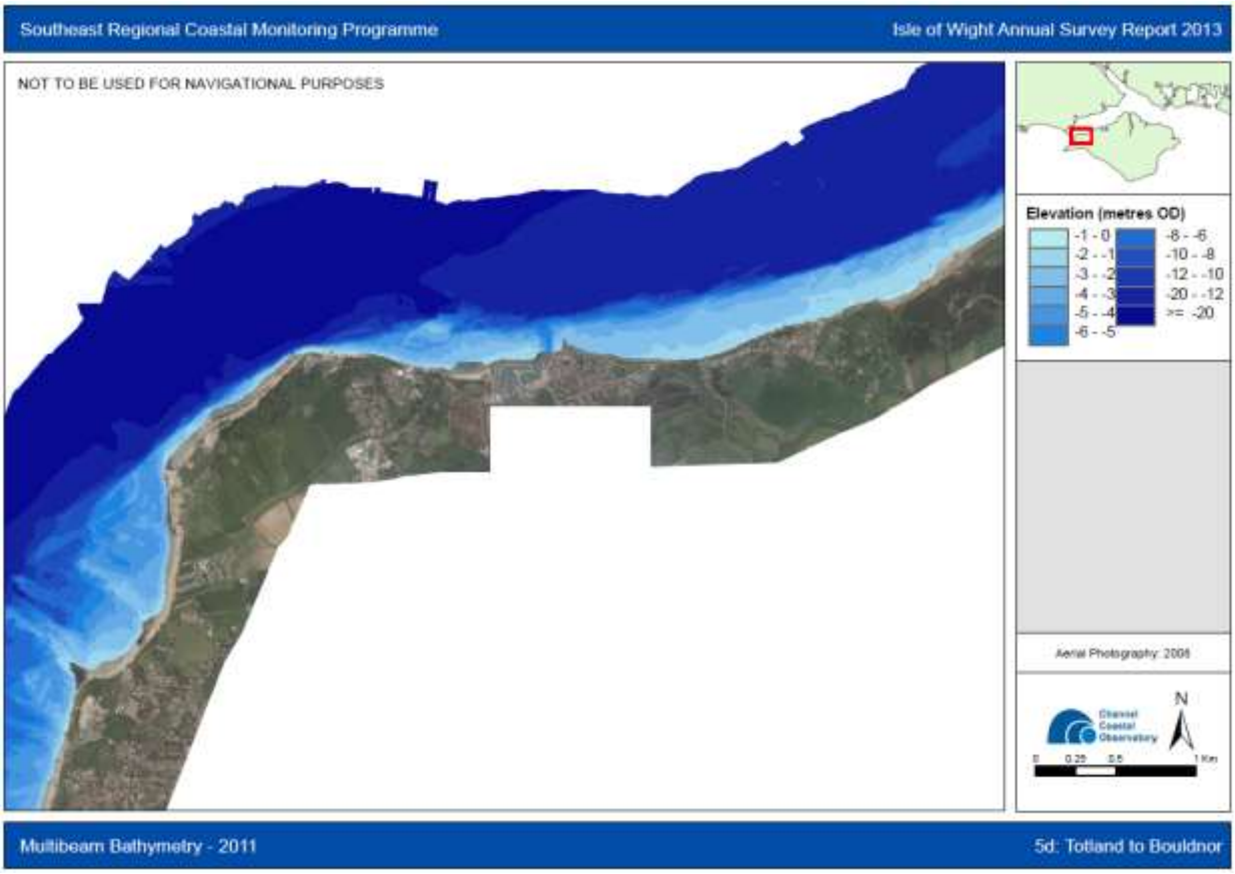
The shoreline exhibits a varied and complex sediment transport pattern due to both coastal configuration and hydraulic regime. Transport sub-cells on the open coast are separated by headlands, and each of the three estuaries has distinct, albeit small scale, circulation patterns (Halcrow, 1997).

In terms of marine sediment input, within the Western Solent Channel there is a significant flux of fine-grained sediment, moved in suspension, by both the flood and ebb tidal currents. Net suspended sediment input to the West Solent is indicated by tidal conditions at Hurst Narrows, so some of this must derive from sources external to the West Solent, but there is no quantitative data available (Halcrow, 1997; 1998). Erosion of the local soft clay cliffs of the north-west Isle of Wight coast is also likely to contribute suspended sediments to the channel. Much of the lower foreshore between Newtown Harbour and Egypt Point comprises fine muds and it is possible (but not proven) that these are of external marine origin (Posford Duvivier, 1999). (SCOPAC, 2014).

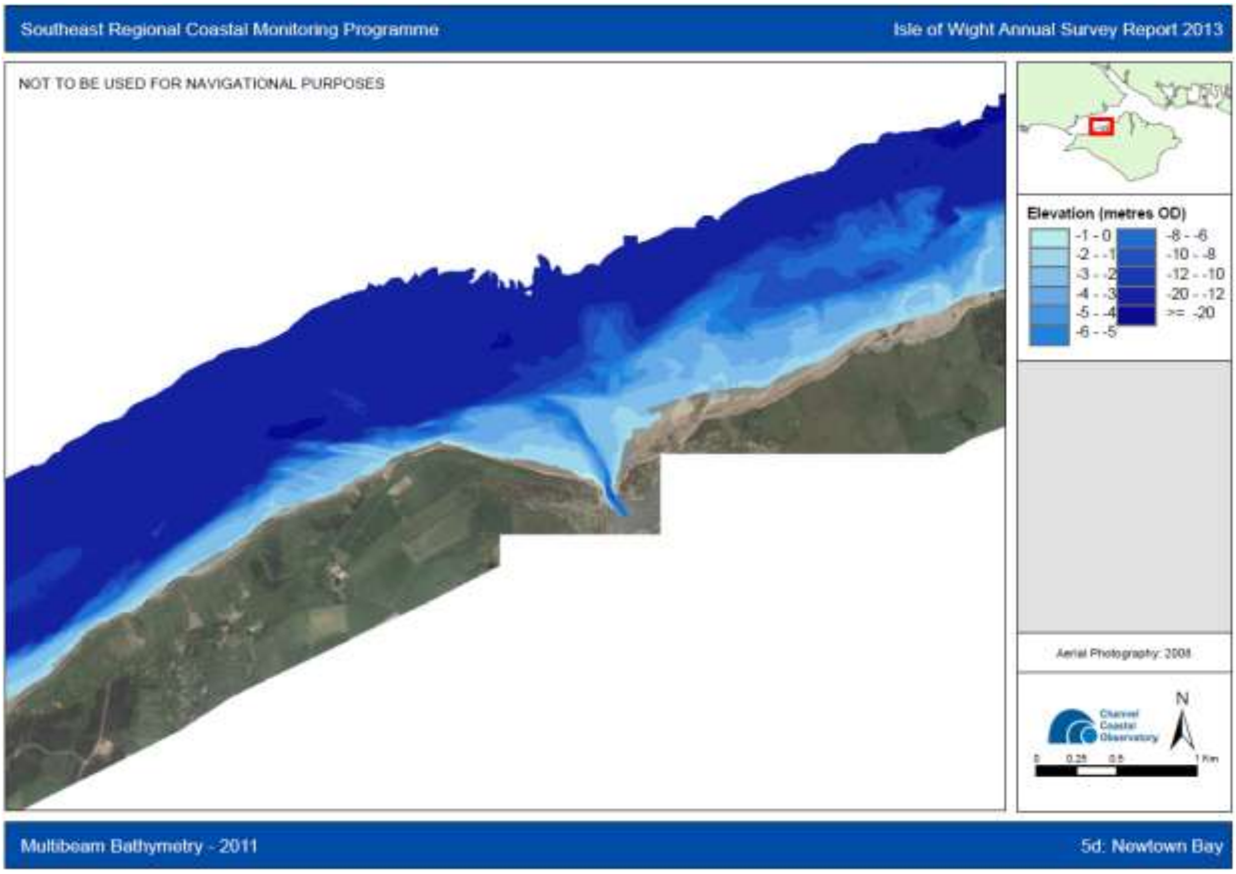
Most of the coast is natural but there has been localised shoreline stabilisation by seawalls at Yarmouth and Cowes, together with various ad hoc interventions at some intervening locations. Norton Spit at the entrance to the Western Yar has been stabilised and its sediments impounded such that natural adjustments of this feature are no longer possible. Solent Bank, a major gravel and sand accumulation within the Western Solent, has been denuded of sediment by aggregate dredging over the period 1950-1990. This intervention has resulted in removal of around 10 million m^3 of material, with consequent lowering of the bank by over three metres. The impacts of these actions upon the shoreline of this frontage are difficult to determine although wave shoaling and refraction could have been affected (primarily at low tide). The entrances to the Western Yar and Medina estuaries have been dredged on several occasions to maintain navigable channels for car ferries. Dredging at estuary entrances and within the main West Solent channel represents a net output from the sediment budget and may result in loss of sediments that might otherwise be transported to shorelines. Furthermore, operations close inshore can cause drawdown that could contribute to the steepening of local inter-tidal zones.

Limited *beach nourishment* has been undertaken at several locations in the past in response to falling beach levels so as to temporarily prevent undermining of coast protection structures and reduce the historical trend of inter-tidal narrowing (Halcrow, 1997). In all cases, volumes are small and designs governed by the perception of critical losses rather than through and systematic long term monitoring of beach profiles and volumes. The main sites are:

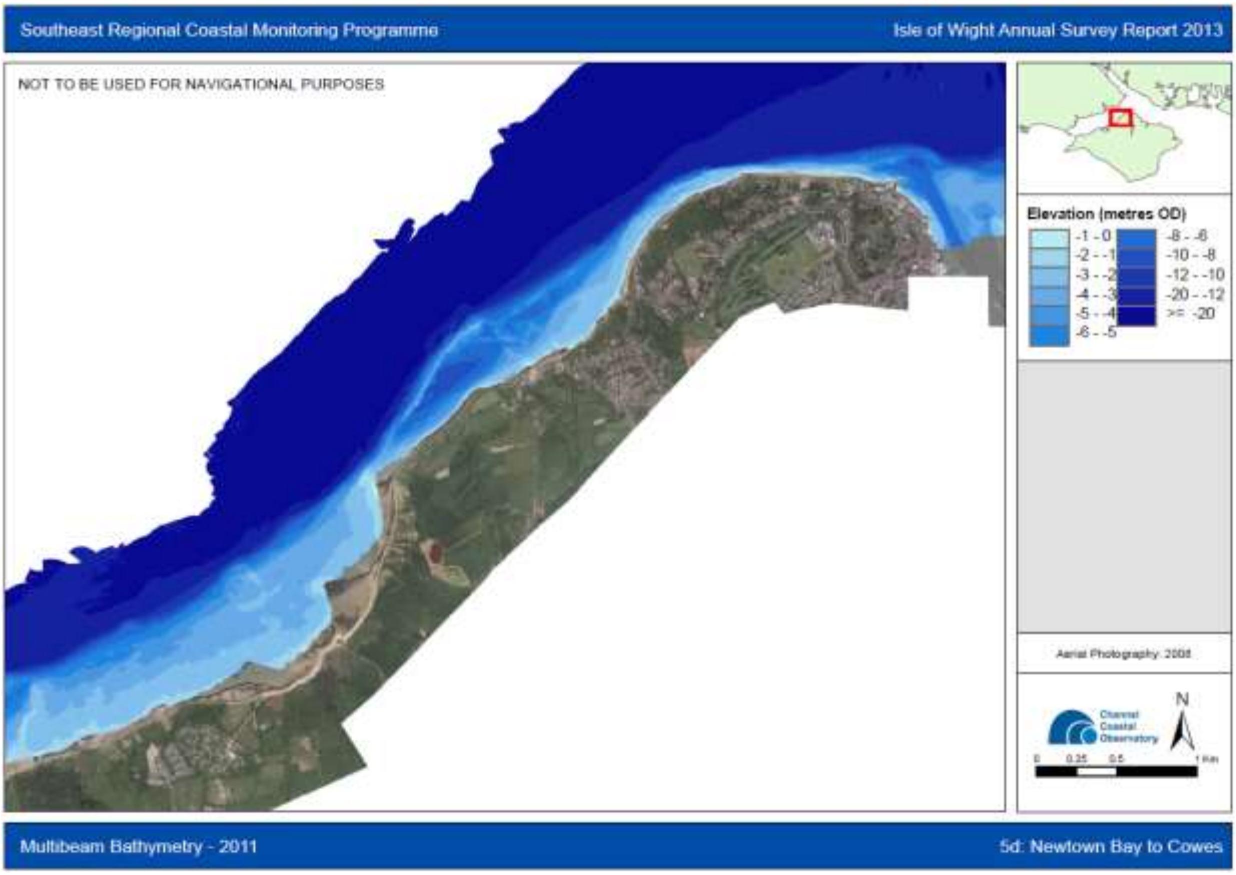
- Yarmouth Pier to Yarmouth Common: Small scale gravel replenishment has been introduced in response to falling beach levels east of Fort Victoria (Hydraulics Research, 1977a).
- Norton Spit: Stabilisation of the spit by groynes and revetments and ad hoc reinstatement of beaches by gravel nourishment/replenishment (Lewis and Duvivier, 1981; Barrett, 1985; Posford Duvivier, 1989a) has been undertaken over the past 25 years.
- Fort Victoria: There has been co-ordinated shingle replenishment seawall repairs and groyne construction immediately east of Fort Victoria, to prevent shoreline recession affecting the coastal access road (Lewis and Duvivier, 1981; Barrett, 1985; Posford Duvivier, 1989a). The source materials have been predominantly rounded pebbles from Solent Bank, and other marine sources.
- Old Castle Point to Shrape Breakwater, Cowes Harbour entrance. No information on quantities are available, but are believed to be small.



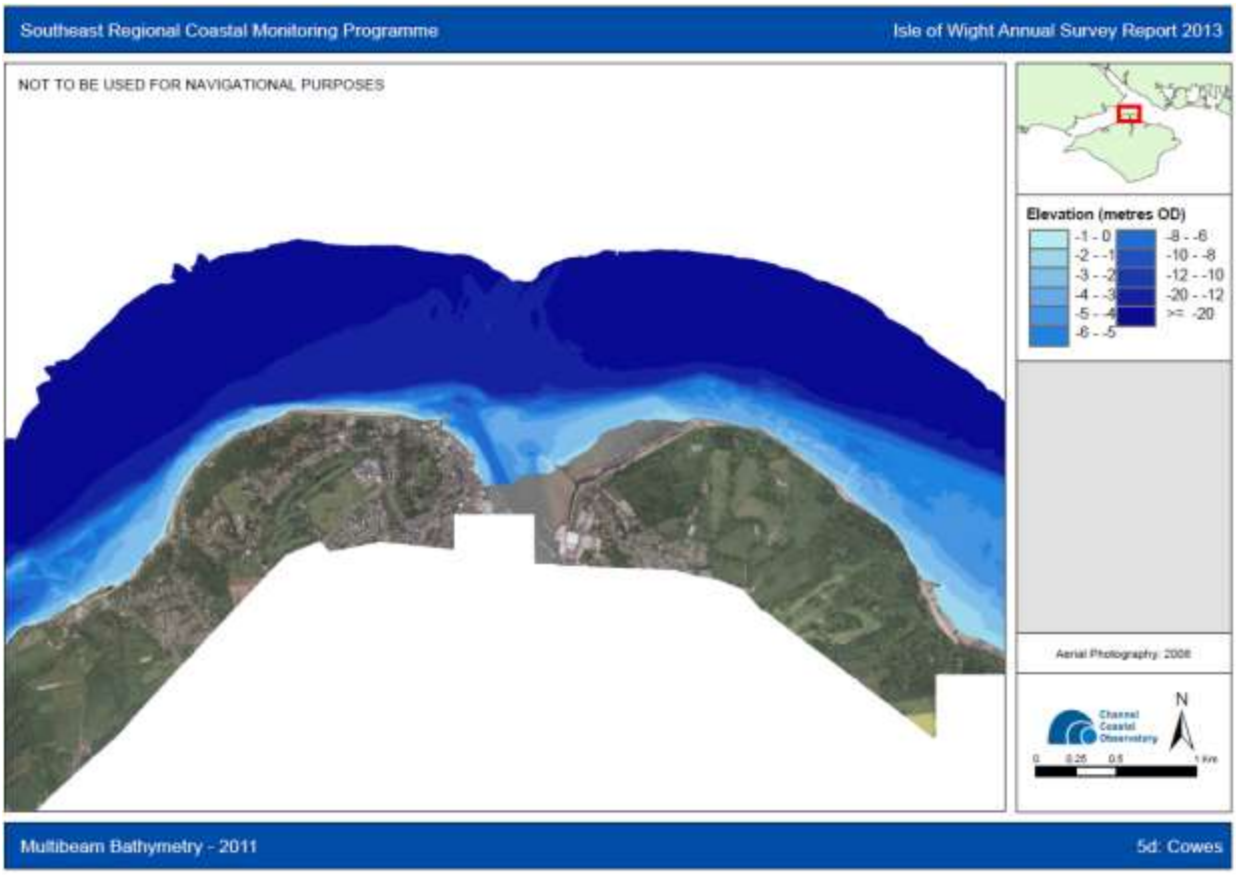
Bathymetry from Fort Albert to Bouldnor (Channel Coastal Observatory, 2013).



Bathymetry around the mouth of Newtown Estuary (Channel Coastal Observatory, 2013).



Bathymetry for the Thorness and Gurnard coastlines (Channel Coastal Observatory, 2013).



Bathymetry around Cowes, East Cowes and the entrance to the Medina Estuary (Channel Coastal Observatory, 2013).

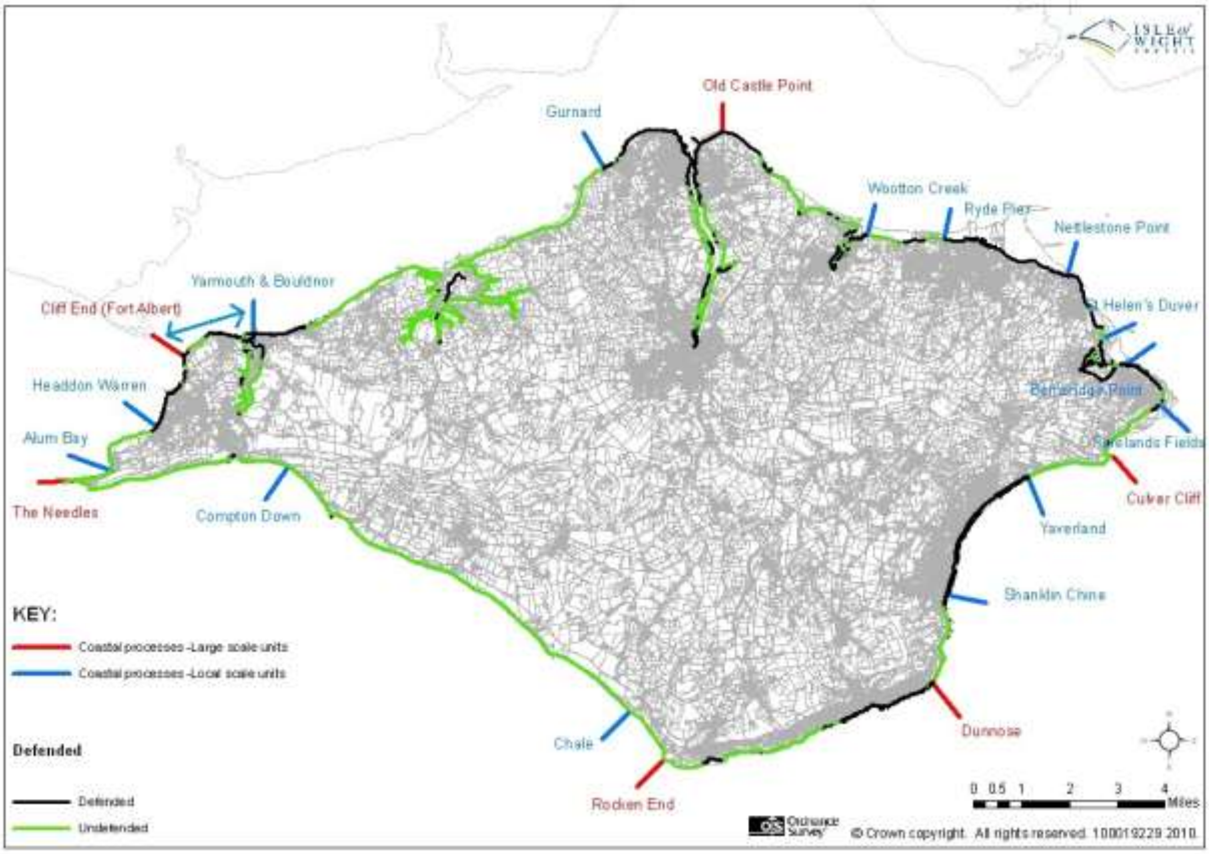
Shoreline Movement:
Inundation of the previous Solent River system occurred during the Holocene Transgression so as to produce an estuarine channel open at each end (the Solent) of which this unit forms the southern margin. Holocene inundation is believed to have proceeded up the eastern Solent before erosion to the west was sufficient to permit a connection with Christchurch Bay. Tidal currents were then transformed from very weak to very strong causing scour and enlargement of the Western Solent.

In marked contrast to the sedimentation dominated northern Solent shores, the coast of this unit has undoubtedly been subject to long term retreat causing the Western Solent to widen and supplying much sediment. Evidence is provided by recognition of an ancient landslide deposit extending up to 100m offshore on a foreshore lobe off Brickfield Farm (Munt and Burke, 1987).

This frontage is characterised by the occupation/re-occupation by marine inundation and erosion of coastal slopes formed in soft Palaeocene, Eocene and Oligocene materials and mantled by relict landslides. It is inherently sensitive to erosion, even when the driving forces are relatively weak. The general evolution trend in future years would therefore be for continued erosion of presently active cliffs together with progressive re-activations of relict coastal slopes.

Potential exists for a breach through the foreshore just east of Yarmouth, enabling the creation of a small tidal inlet at Thorley Brook. Shoreline sediments could become entrained by tidal currents generated at the new inlet and become flushed seaward and lost to the tidal flows of the West Solent.

5.3.1 Local Scale process unit: Cliff End to Yarmouth, including the Western Yar Estuary



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Areas: 6B – Totland to Norton; and 6C – Yarmouth and the Western Yar Estuary).* Policy Units:

- 6B.3 Fort Albert (544m) -part 2 of 2;
- 6B.4 Fort Victoria Country Park (831m);
- 6B.5 Fort Victoria and Norton (1,077m);
- 6C.1 Norton Spit (687m);
- 6C.2 Western Yar Estuary –western shore (3,919m);
- 6C.3 The Causeway (173m);
- 6C.4 Western Yar Estuary –eastern shore (1,975m);
- 6C.5 Thorley Brook & Barnfields Stream (619m);
- 6C.6 Yarmouth to Port la Salle (2,920m) –part 1 of 2.

Interactions:

Eroding soft rock cliffs and foreshore debris lobes are continuous from Fort Albert to Fort Victoria. The clayey materials of the cliffs degrade by mudsliding and simple translational slides, creating a shallow actively retreating coastal slope. Strong tidal currents are effective in removing clayey debris that accumulates at the cliff toe. The shore is drift-aligned with respect to dominant waves approaching from the west. The coastal slope is thickly vegetated and complex in morphology, making the cliff top difficult to discern although, long term toe erosion of a relatively high rate has been recorded from comparisons of historic maps.

An inactive or relict low coastal slope extends from Fort Victoria (Sconce Point) to Norton. Its beaches comprise a narrow strip of sand and gravel above a narrow muddy foreshore. The coastal slope is protected by defences so that the only historical trend has been for narrowing of the foreshore.

Shore stabilisation by seawalls and short groynes is present from Sconce Point to the eastern margin of Yarmouth including Norton Spit. Sconce Point itself has been stabilised by the construction of Fort Victoria. A breakwater has been built eastward from the tip of Norton Spit to train and protect Yarmouth Harbour and the Western Yar estuary entrance. Dredging of Yarmouth Harbour entrance has been undertaken for navigation purposes and in 2009 a trial of beneficial use moved the dredged shingle to the north of the breakwater in order to keep the sediment in the system and help to defend the breakwater structure.


Eroding coastal slopes south of Fort Victoria, June 2009

The geology of the coastal slope is obscured by vegetation and disturbed by landsliding (McInnes, 2008), but White (1921) and geological maps indicate Headon and Osborne beds overlain by Bembridge Limestone and Marls, so cliff erosion input must be predominantly clays with some sands and soft limestones (Halcrow, 1997). Posford Duvivier (1997) estimates an annual cliff erosion yield of 5,000m^3. It is reported that small quantities of gravel are also supplied (Lewis and Duvivier, 1973, 1981). This coast is more sheltered from wave erosion than areas to the west, but is swept by rapid tidal currents of Hurst Narrows so relatively little beach material accumulates. The shoreface between Fort Albert and Fort Victoria is some 250m wide and 20m deep; given an estimated 0.5m/yr erosion rate, the yield of fine sediment is approximately 7,000m^3/yr (Posford Duvivier, 1999). For the shoreface between Fort Victoria and Bouldnor, the respective values may be in the order of 1mm/yr and 3,000m^3/yr.

Sediment drift operates from west to east, but is weak due to limited fetches and shortages of shoreline sediments. Small to moderate quantities of fine sediments yielded by erosion of cliffs between Cliff End and Sconce Point are likely to be transported eastwards in suspension and potentially be available for transport into the Western Yar estuary. Net eastward drift of gravel between Fort Albert and Fort Victoria is indicated by accumulation against sea walls at Fort Victoria (Lewis and Duvivier 1973, 1981), although the morphological evidence is only partial. There is a wide sandy foreshore, but corresponding sand accumulation is absent at Fort Victoria (Lewis and Duvivier, 1973). It is therefore possible that sand is progressively lost offshore to tidal currents and is transported eastward (Halcrow, 1997). Alternatively, there may be no net drift of sand, so that it becomes evenly distributed along the foreshore. Coast protection structures severely restrict drift transport at Fort Victoria, but it has been suggested that limited eastwards movement of coarse sediment was possible around the fort before it was halted by construction of two groynes over the period 1870-73 (Lewis and Duvivier, 1973). This coastal segment has therefore functioned as a self-contained unit since the pathway around Fort Victoria was denied.

Drift direction is presumed to be eastward, but beach levels are low and transported volumes are extremely limited (Lewis and Duvivier, 1973). Nourishment programmes have supplied a small quantity of beach material immediately east of Fort Victoria and at Norton Spit, but groynes have been constructed here to retain predominantly sandy sediment and thus net drift quantities are small or non-existent (Lewis and Duvivier, 1981; Barrett, 1985; Posford Duvivier, 1989; Halcrow, 1997). The alignment of Norton Spit and accumulation behind the western face of the Yarmouth Harbour breakwater indicates that historically net drift has been eastward (Hydraulics Research, 1977; Dyer, 1980; McInnes, 1994; Isle of Wight Council, SMP2, 2010), although visual inspection of sediment distribution against groynes has failed to reveal a preferred drift direction.

The Western Yar Estuary is protected by a narrow eastward trending sand and gravel spit at Norton. The Western Yar Estuary runs inland 3km almost due south from Yarmouth towards Freshwater. Although Norton Spit has in the past grown across the Western Yar estuary mouth it has retreated landward over the past century and is now stabilised. Norton Spit, a popular local amenity area, is stabilised by old railway line and sleepers that need regular replacement. The spit is an important component of the SSSI and is being increasingly inundated from the inlet to the south. The dunes are trying to migrate south and the beach is building and will soon overtop the wooden stabilisation structure that also protects the path. The town of Yarmouth has been built upon a shorter counterpart spit on the low-lying eastern bank and the spit provides protection from wave attack to the Western Yar outer estuary. There is a narrow intertidal foreshore and very little beach material in front of defences. The foreshore at Yarmouth has lowered and narrowed in front of seawall defences. The low-lying valley of Thorley Brook runs parallel to the shore a few tens of metres inland of the shoreline to the immediate west of the town. Further to the west, is a shore frontage of low relict cliffs protected by a seawall. At the Freshwater causeway there are tidal flaps that mark the southern tidal limit of the estuary and protect Afton Marsh from tidal flooding.

Westward drift at Yarmouth: Morphology of the mouth of the Western Yar estuary indicates littoral drift towards the inlet on both sides (Dyer 1980; Halcrow, 1997). This suggests a weak net westward drift over the sector to the immediate east of the inlet mouth, at variance with the eastward-directed littoral transport pathway that operates for most of the rest of this shoreline. A littoral transport divergence is thus implied, but it is difficult to locate precisely because of the small volume and rate of sediment movement. As it may not operate for fine-grained sediments, it is therefore a partial, and probably transient, boundary. This interpretation is based on limited evidence and is therefore of low reliability and requires verification. In SCOPAC, 2014.

Eastward drift, east of Yarmouth: It is generally accepted that net transport within the boundaries of this unit is eastward, although quantitative evidence is lacking (Hydraulics Research, 1977; Lewis and Duvivier, 1981; Posford Duvivier, 1989). Beach levels are extremely low along this frontage and groynes are frequent (Hydraulics Research, 1977; Lewis and Duvivier, 1981) so it is likely that actual drift is currently nearly zero (Halcrow, 1997; Isle of Wight Council, SMP2, 2010).

The coastal areas of the Western Yar Estuary are subject to rapid tidal currents and open sea waves which enter Hurst Narrows. Dominant ebb currents in the Western Solent cause seaward flushing of coarse bedloads and input of suspended sediments into the Yar estuary, most likely derived from clay cliff erosion in the immediate vicinity between Bouldnor and Newtown (Western Yar Estuary Management Committee, 2004). Fluvial transport from the Western Yar catchment is negligible with predominantly marine clays having partially infilled the estuary.

A sequence of dominantly fine-grained estuarine sediments, up to 14m thick contained within a well-defined palaeovalley, has been described for the Western Yar Estuary (Devoy, 1987; Tomalin, 2000) representing pulsed (unsteady) sediment input over the past 7000 years of sea-level transgression. This may have a marine source, but no mineralogical analysis has been undertaken to confirm this. Maintenance dredging has also been undertaken in response to slow but progressive siltation in Yarmouth Harbour (MacMillan, 1955; Western Yar Liaison Committee, 1998), although in this case the tidal prism, which has been reduced by piecemeal land claim since medieval times, provides a possible explanation (Pethick, 1999).

The Yarmouth Estuary tidal inlet is a natural littoral transport boundary, however the adjoining shores are so heavily stabilised that there is very little coarse material in transit that might be intercepted. In terms of estuarine outputs, the SCOPAC Sediment Transport Study (201) concludes that the dominant flow in the Yar Estuary is during the ebb tide and it has been estimated that its sediment carrying potential is five times that of the flood (MacMillan, 1956; Price and Townend, 2000). No measurement of sediment transport has been undertaken to verify this statement. It is reported that sand can be transported into Yarmouth Harbour by strong northerly gales, but training of the ebb flow by breakwater structures is generally successful in flushing such material back offshore (MacMillan, 1956). Maintenance dredging of the harbour and approaches is infrequent and comparison of hydrographic surveys for 1980, 1983 and 1987 revealed that bed levels were stable (Brogan, 1987). It is therefore concluded that the dominant flushing effect of the ebb current rapidly removes fine-grained sediments previously transported into the mouth (Western Yar Liaison Committee, 1998, Pethick, 1999).In the past, significant quantities of sediment may have been transported across the mouth to create Norton Spit, but this is now impeded by groyne and breakwater systems either side of the harbour entrance.

The town of Yarmouth, at the head of the Western Yar Estuary (Yarmouth Harbour Commissioners).

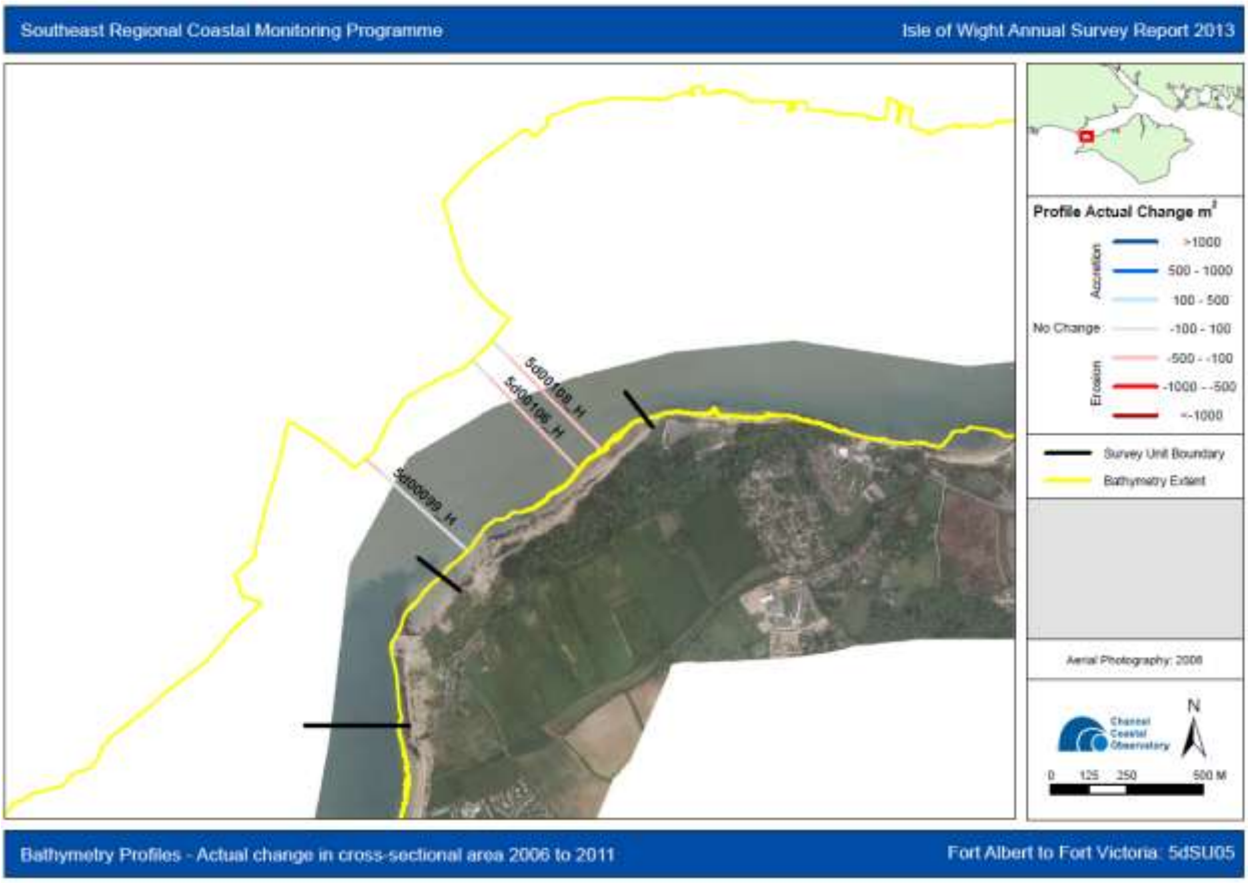
Results of the Strategic Regional Coastal Monitoring Programme:
(Maps and text ref. Channel Coast Observatory, 2013, Isle of Wight Annual Report):

5dSU05 (NEW 1): Fort Albert to Fort Victoria

- *Spring 2012 to Spring 2013: This management unit is stable with the majority of profiles showing no change.*
- *Baseline Spring 2004 to Spring 2013: Over the longer timescale only profile 5d00101 shows any significant change with a 19% loss in cross-sectional area. This has occurred along the entire length of the profile, with beach elevations lowering by up to 0.3m in places.*

Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)

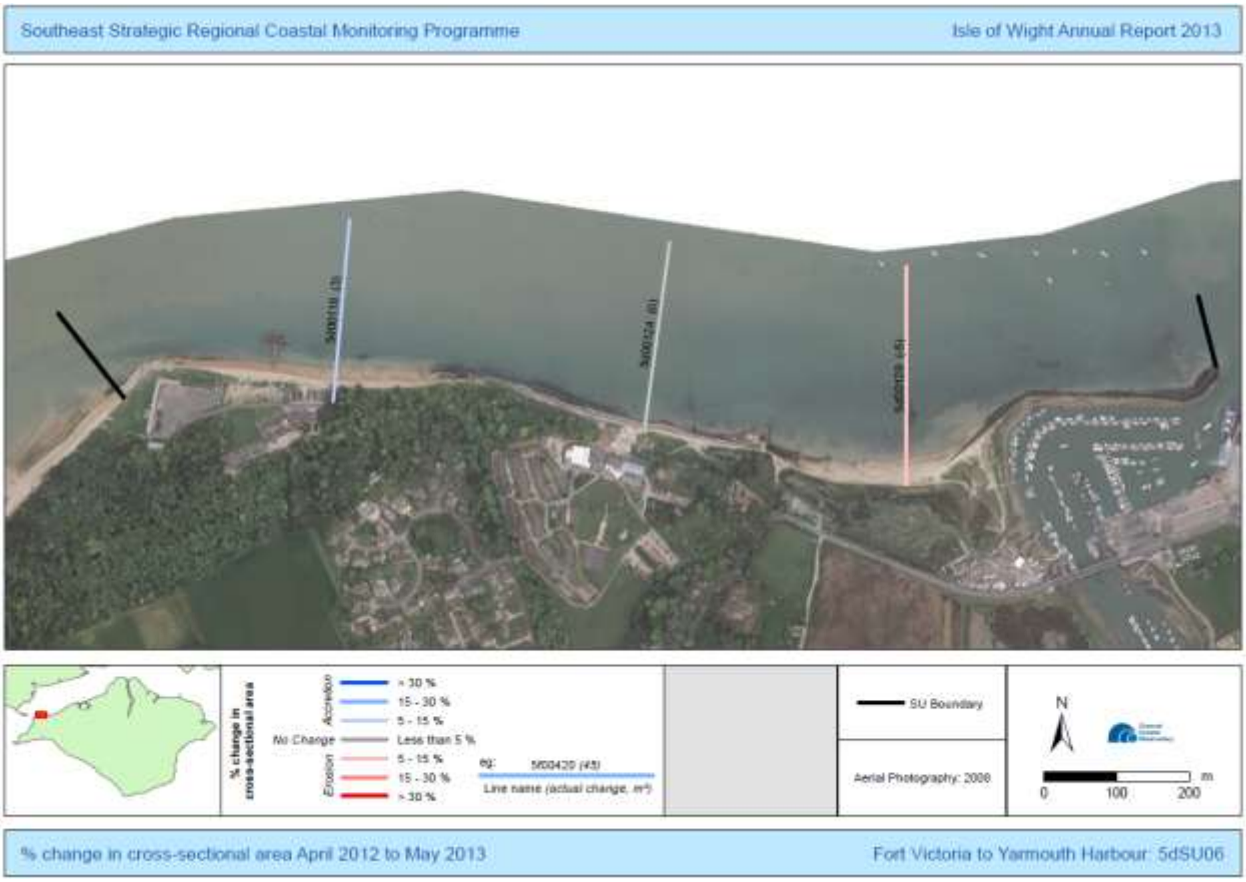
10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



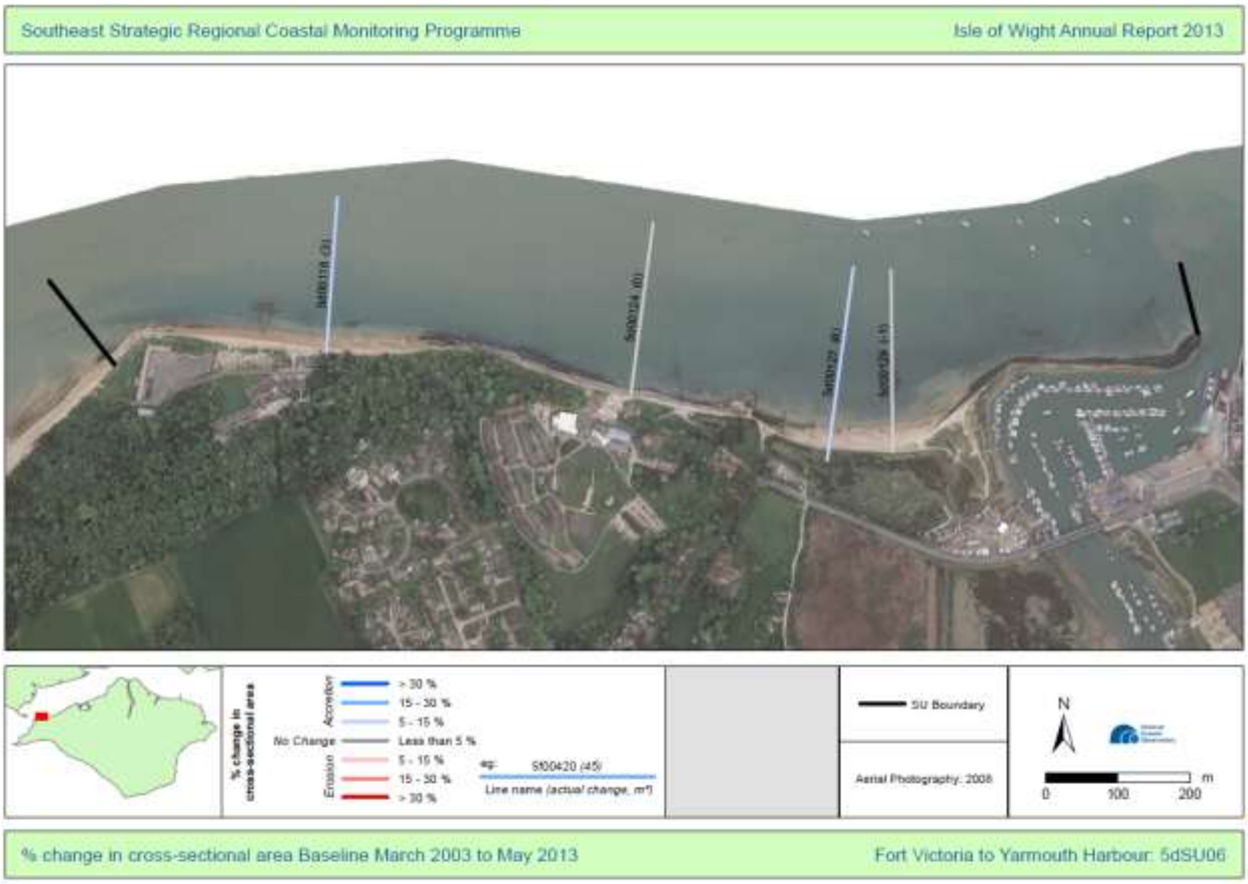
5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

5dSU06 (NEW 2): Fort Victoria to Yarmouth

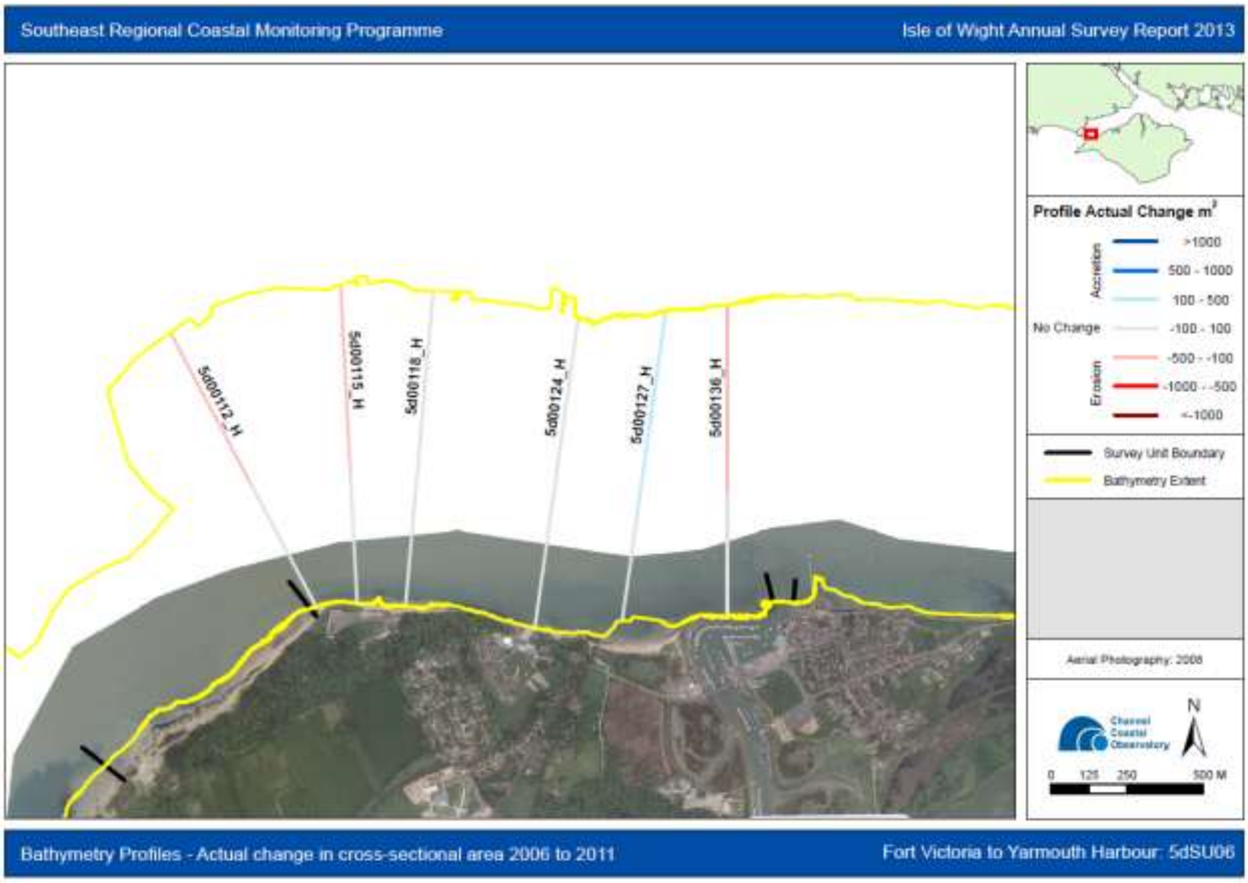
- *Spring 2012 to Spring 2013: Profile 5d00124 was first surveyed in 2010. This section shows accretion to the west of the unit with erosion occurring to the east notably a -6% change occurring on profile 5d00129 with the majority of erosion occurring in the mid to lower beach.*
- *Baseline Spring 2003 to Spring 2013: This profile is also stable over the longer timescale.*



Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



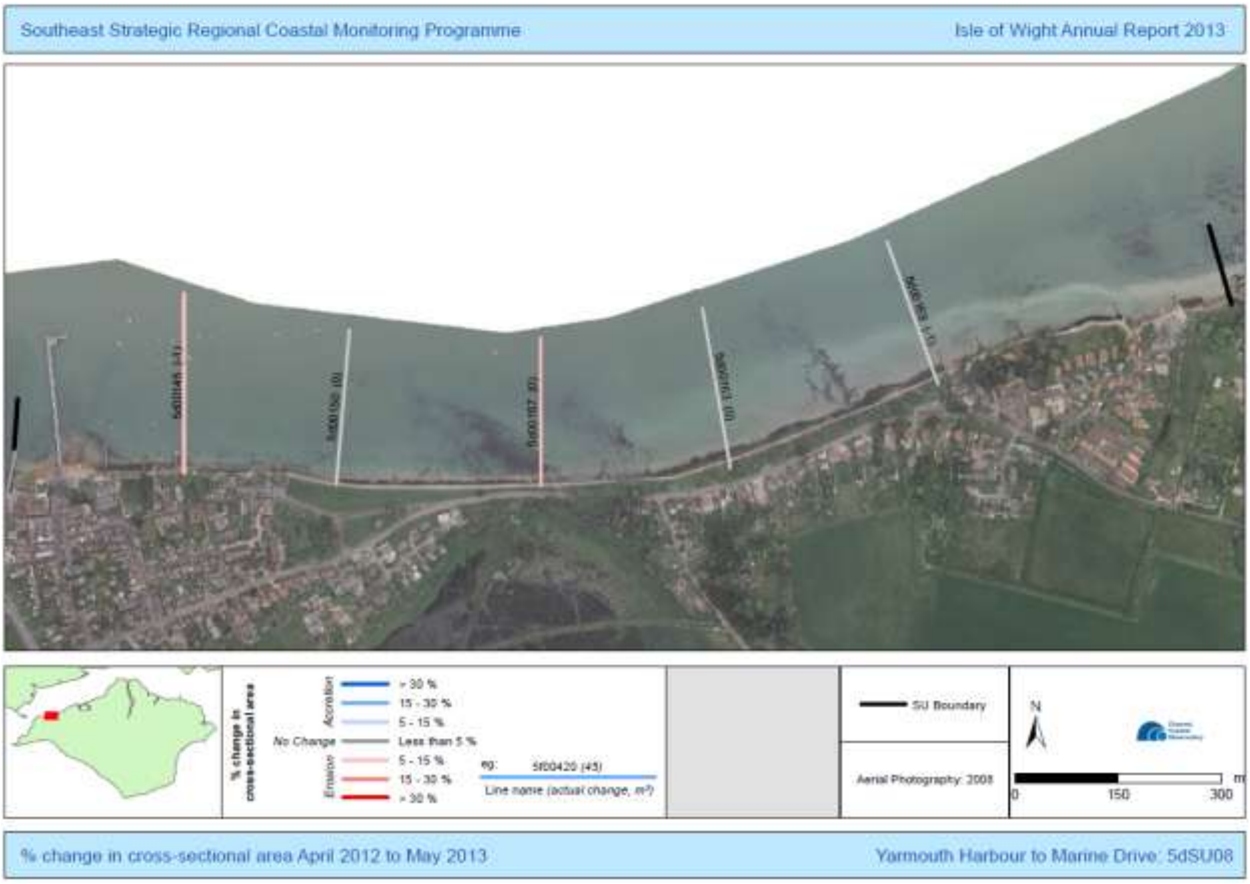
10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



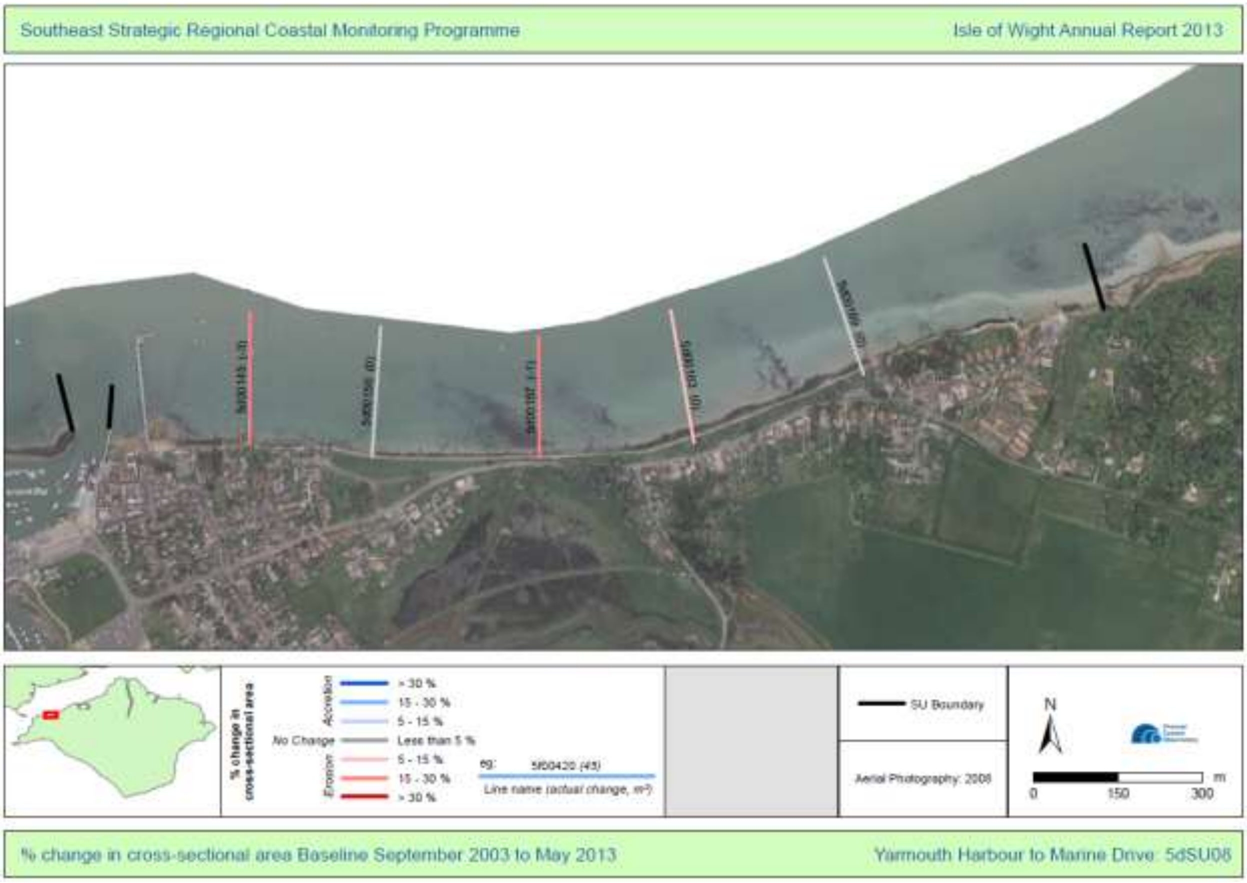
5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

5dSU08 (NEW 3): Yarmouth to Marine Drive

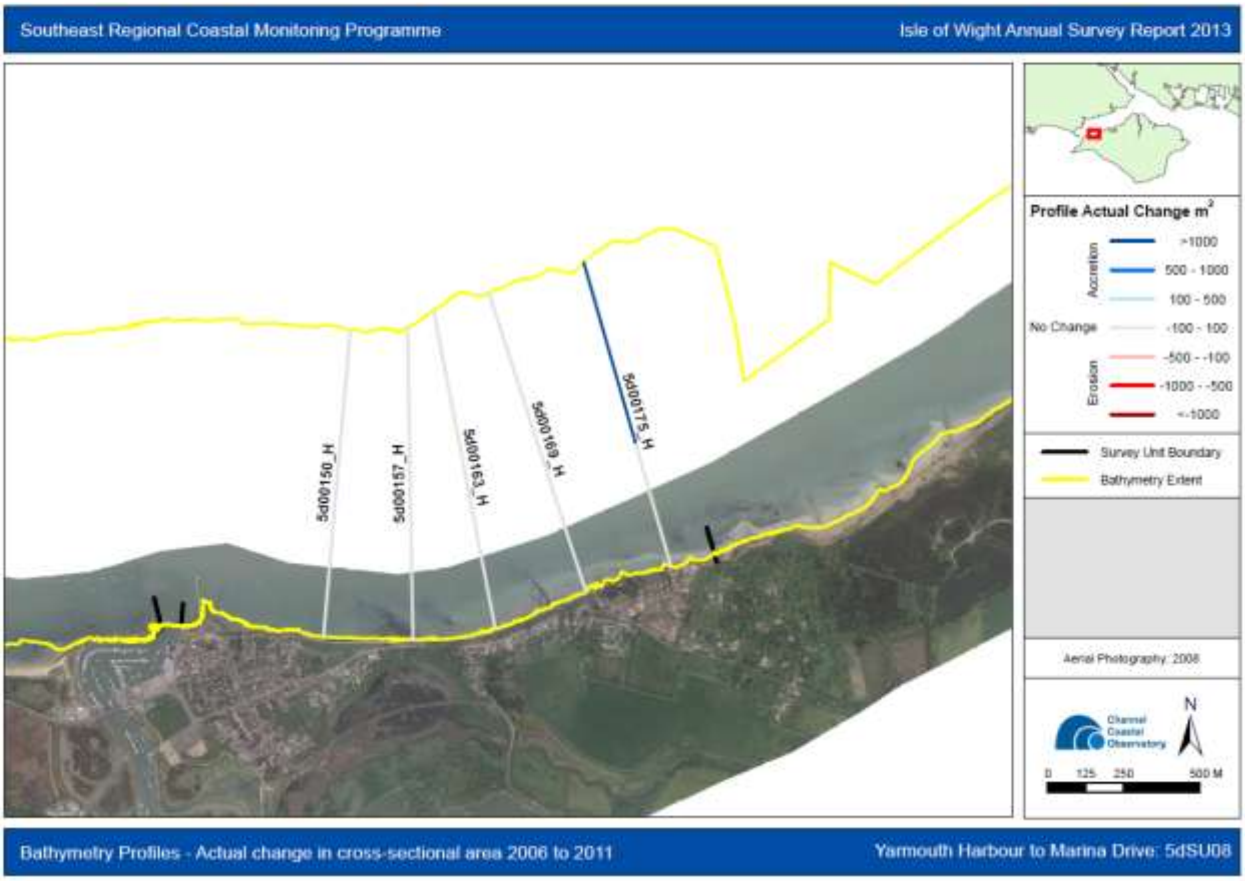
- *Spring 2012 to Spring 2013: There has been little or no change over the shorter time-scale.*
- *Baseline Summer 2003 to Spring 2013: Over the longer timescale, profiles 5d00145 and 5d00157 show some erosion along the profile length. The other profiles in this unit are stable.*



Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

Shoreline Movement:

From Fort Albert to Fort Victoria, a relatively low angle coastal slope is degrading primarily by mudsliding in lower parts with some upper parts thickly vegetated and relatively inactive (Hutchinson, 1965; Lewis and Duvivier, 1973; Posford Duvivier, 1990b; Halcrow, 1997). A sea wall protects the cliff toe for 200m to the northeast of Fort Albert, but there is considerable instability of the slopes behind. Along the unprotected sections of this unit to the north, the soft clays at the cliff toe appear to be eroded faster than the rate of supply of material from mudslides, thus some lower slopes are oversteepened and controlled by shallow failures (Halcrow, 1997). Serial map comparisons do not indicate any discernible cliff-top erosion, possibly due to the thickly vegetated and complex morphology of the upper slope (Lewis and Duvivier, 1973). Despite this, long-term toe erosion at 0.5m/yr has been calculated (Lewis and Duvivier, 1981; Posford Duvivier, 1989a, 1990b, 1997; Halcrow, 1997). It would appear that aggressive toe erosion is leading to progressive reactivation of relict landslides upslope, so that the scale of landsliding is likely to increase in future as the full slope becomes active.

Predictions of Shoreline Evolution:

Futurecoast (2002) estimated that without defences:

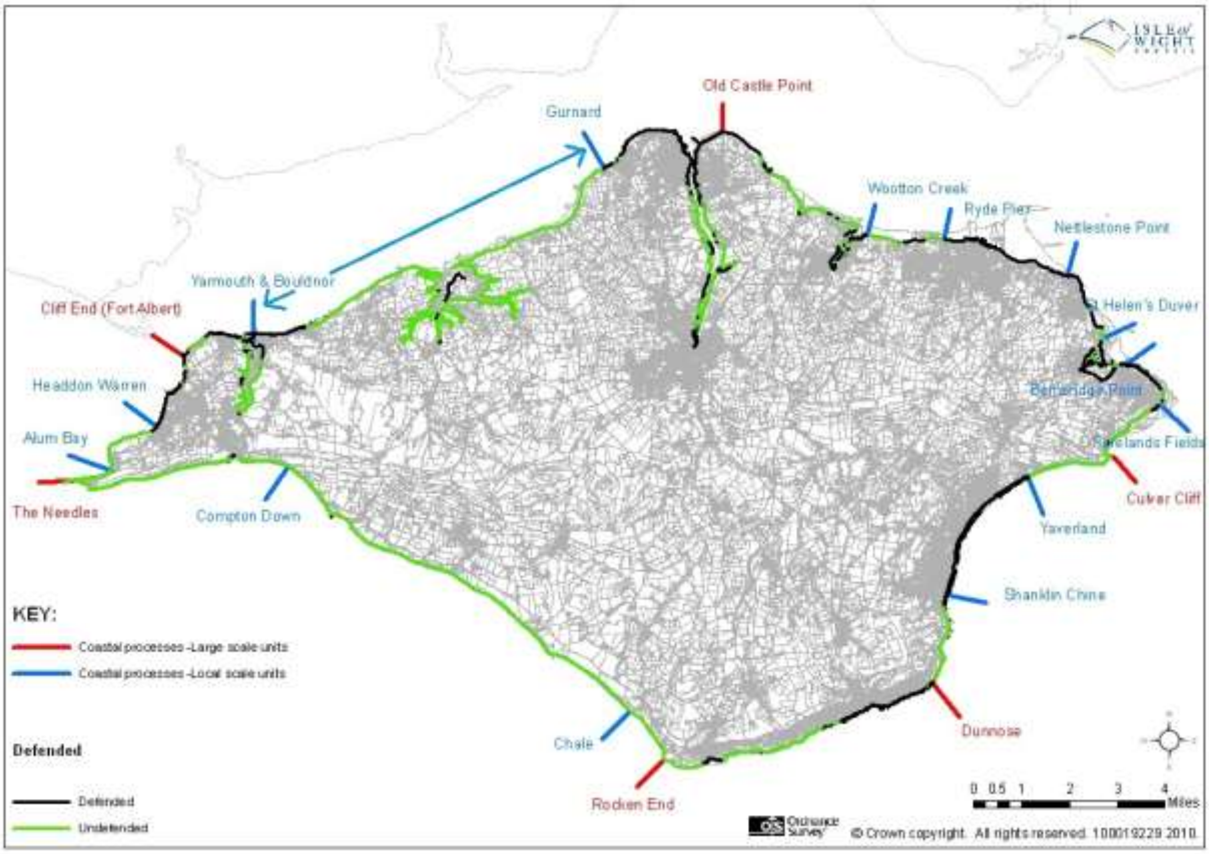
- The cliffs between Fort Albert and Sconce Point would continue to recede through mudsliding, with the fresh material derived largely from being transported offshore in suspension.
- From Sconce Point to Norton continuing foreshore erosion may in the long term cut into the relict coastal slope eventually triggering formation of low eroding cliffs over 30 to 50 years. This process is likely to be slow due to the low wave energy.
- Norton Spit is depleted and would be likely over the forthcoming 30 years to become subject to landward migration such that it would increasingly recurve into the estuary and possibly breach. This process may be slowed by sediment inputs released from updrift as recession processes within cliffs re-activate. However, the spit could migrate and breach before this potential sediment supply becomes fully active. Any breach in the spit could allow greater wave penetration into the Western Yar estuary.
- The Yarmouth shoreline is likely to retreat at slow to moderate rates as the foreshore is narrow and provides limited protection. Immediately east of Yarmouth there is the possibility that shore erosion over the forthcoming 50 to 100 years could cut through into the lowland valley of Thorley Brook to produce a small new tidal inlet. This could potentially link to the Western Yar estuary leaving the town of Yarmouth as an island.

With present management practices Futurecoast (2002) estimates that between Fort Albert and Sconce Point the unconstrained response described above will not be unduly affected. Where defences exist elsewhere, the upper shore would be held static by the structures, but slow rates of foreshore lowering and narrowing would continue due to sediment starvation. Breaches of Norton Spit and Thorley Brook would therefore be prevented, but the defences themselves would gradually become increasingly exposed to wave action.

The Western Yar Estuary appears to be capable of continuing to accrete fine sediments and monitoring of the saltmarsh since 2004 has shown that it is relatively stable. The monitoring will continue as the saltmarsh may be sensitive to future climate change and sea-level rise unless vertical accretion can compensate (Halcrow Maritime et al, 2001).

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report –please see below (re. units IW47 to IW51).

5.3.2 Local Scale process unit: Bouldnor to Gurnard, including Newtown Estuary



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Area: 6C (edge of); and 7 – Bouldnor Copse to southern Gurnard Bay).* Policy Units:

- 6C.6 Yarmouth to port la Salle (2,920m) -part 2 of 2;
- 7.1 Bouldnor Copse and Hampstead (4,424m);
- 7.2 Newtown Estuary (26,269m);
- 7.3 Thorness Bay and southern Gurnard Bay (6,139m).

Interactions:

Large quantities of primarily fine sediments are contributed to the West Solent by cliff erosion within this frontage. This constitutes the major direct input of fresh sediments to the Solent and may be of critical importance to its sediment budget and maintenance of intertidal features.

Cliff recession yields significant sediment volumes, but much is clay and silt so only a small proportion, estimated at 15% (Bray and Hooke, 1997), of total cliff input is stable on the beach. Posford Duvivier (1997) estimates a total annual sediment yield of 65,000m^3, of which less than 500m^3 is gravel. Some gravels are supplied from Pleistocene cliff-capping coarse deposits (Hydraulics Research, 1977a; Posford Duvivier, 1995; Halcrow, 1997) and Moorman (1939) reported gravel scree beneath the steep upper cliff. Mapping and sediment sampling of the gravel outcrops has not been undertaken so exact contributions remain unquantified although they could be significant on this low drift rate coast. The erodible shoreface materials may be scoured to a depth of 0.12m/yr, yielding some 23-25,000m^3/yr of fine sediment (Posford Duvivier, 1999), which is transported offshore as suspended load.

Around Thorness Bay, map and field evidence indicates that cliff erosion supplies material from (i) the Bembridge and Osborne Beds; (ii) Plateau Gravels, which cap the high cliffs immediately south of Gurnard Ledge (White, 1921). The solid strata contribute predominantly clay sediments that are transported offshore but also some limestone boulders, which temporarily remain on the foreshore as boulder arcs that mark the seaward, limit of former mudslide surges. Posford Duvivier (1997; 1999) estimate a total sediment yield of 75,000m^3/yr for the sector between Newtown Harbour and central Gurnard Bay. Estimates suggest that less than 500m^3 is coarse material. Mapping and sampling of the gravel outcrops has not been undertaken so exact contributions remain unquantified, although they could be significant on this low drift rate coast. A shoreface erosion rate of 12mma^{-1}, yielding 11,000m^3a^{-1} of fine material, has been calculated by Posford Duvivier (1999).

Cliffs developed within the predominantly clayey strata of the Bouldnor Formation (Solent Group) rise from beach level at Bouldnor village to 61m at Bouldnor Cliff and 35m at Hamstead Cliff before declining steadily east to the Newtown Harbour inlet. The coastal slope is underlain principally by gently northward dipping clay-rich Hamstead Beds of the Bouldnor Formation (White, 1921; Daley and Insole, 1984; Hutchinson and Bromhead, 2002). Dip is locally reversed (from NE to SW) due to the proximity of the Hampshire Basin syncline so that underlying Bembridge Marls and Bembridge Limestone rise to beach level in the north east.

The coastal slope exhibits complex morphology and degrades by deep-seated rotational slides at the backscar and by mudsliding within extensive mid and lower mudslide dominated terraces. Morphology comprises a steep upper cliff, with several embayments associated with zones of past failures feeding small mudslides. These move over a series of terraces formed by more resistant limestone and converge to form a major mudslide lobe, which periodically surges up to 100m across the foreshore (Munt and Burke, 1987) during surging phases and suffers marine erosion thereafter. Similar landforms are developed at lesser scales throughout this unit. Air photos show the foreshore to be littered with old boulder arcs; the residue of previous mudslides. Mudsliding is long established and is recorded back to at least 1913 (White, 1921; Hutchinson, 1965; Moorman 1939 and Posford Duvivier 1995). These landforms have been classified as relatively shallow, multiple translational slides (Bromhead, 1979).

Mudslide movement is seasonal and controlled by precipitation, groundwater availability and enhanced porewater pressures generated by undrained loading at the head of the mudslide (Hutchinson and Bhandari, 1971; Bromhead, 1979). It is postulated that enhanced porewater pressures by undrained loading has greater effect on initiating a slide than toe erosion by marine processes (Bromhead, 1979; Hutchinson and Bromhead, 2002). This could explain the continued instability and rapid mudsliding despite the limited wave energy available for toe erosion. However, active undercutting of the cliff toe operates in many places and mudslide instability is maintained by marine erosion of lobes as they extend seaward. There may be some linkage between deep-seated failures of the terrestrial cliffs and past erosion of the 8 to 9m high submarine cliff located between -4 and -12m OD (Hutchinson and Bromhead, 2002).

The nature of landsliding varies spatially according to the properties of the geological unit at the toe of the cliff, the relatively resistant units at the base of the Hamstead Member and the top of the Bembridge series are identified as the critical control of this variability (Halcrow, 1997).. At Bouldnor Cliff this resistant layer lies at 1-3m above mean sea-level and provides optimum conditions for mudsliding. This persistent tendency for shallow mass movement has apparently increased in both magnitude and frequency of events here since the mid-1980s (Posford Duvivier, 1995). To the west, the resistant layer is well below this level and the soft clays exposed at beach level are rapidly eroded at rates in excess of mudslide supply. The slope becomes oversteepened facilitating deep-seated failures. To the east, resistant strata rise well above beach level (as demonstrated by the prevalence of foreshore reefs) and increase the resistance of the base of the slope to marine erosion so that recession is less rapid and mudslides are less well developed (White, 1921, Hutchinson, 1983).

From Bouldnor to Newtown Harbour the coast is characterised by sediment inputs from local coastal erosion. Clays are removed offshore in suspension, but sands and gravels forming narrow back beach sediment drift eastward to supply the western shingle spit (Hamstead Duver) at Newtown Estuary entrance. Eastward alignment of this spit is regarded as evidence of net eastward drift (Dean, 1995; Dyer, 1980; Hydraulics Research, 1977; Lewis and Duvivier, 1981; McDowell, 1990a and b; Posford Duvivier, 1989; McInnes, 1994; Halcrow, 1997). Supply to this segment from updrift (westwards) is negligible. Beaches are often little more than a patchy veneer of gravel and coarse sand overlying an erosional surface cut into substrate materials. Observations of a major mudslide lobe, which temporarily extended across the beach beneath Bouldnor Cliff (Moorman, 1939), revealed beach accretion on its western side, and erosion of gravel and boulders from the mudslide toe, a process that continues to operate. It was stated by Moorman (1939) that these materials were transported eastwards from the lobe. Mud or landslide debris lobes or barriers therefore periodically impede transport across the inter-tidal zone. Small scale "surges" take place when they break down. Although recording was over a limited time period, this evidence corroborates other contextual information suggesting net eastward drift. In SCOPAC, 2014.

The Newtown Estuary occupies a low valley complex, with narrow twin gravel spits protecting diverging branches of the estuary behind, extending over 3km inland. An in-filled low valley also occurs further east within Thorness Bay, fronted by a gravel beach. The Newtown Estuary gravel entrance spits are exposed and evolving, the eastern spit overtopping at high tides. The estuary has very little development surrounding it, with large areas of the site owned and managed by the National Trust since 1965. Newtown Estuary is unique in the Solent in retaining a major concentration of the native S. maritima, and features eight nationally scarce species of flora and a diverse fauna including three nationally rare (red data book) species and 14 nationally scarce species (Gardiner et al, 2007).

The historical change and roll back of the spits since 1898 has been investigated by the BRANCH project (Gardiner et al, 2007) by mean high water analysis, which revealed that the average erosion rate along the frontage of the western spit was 0.6m/yr. Along the eastern spit average rollback of 0.62 m/yr occurred along the spit frontage between 1962 and 1995, with less change prior to this. The eastern spit has historically breached and the higher portions of the spit (in the east) are currently undergoing active slope erosion of fine sediments on the outer and inner faces. There is limited sediment supply to the spits and they are likely to continue to break down with sea level and allow increased wave penetration into the Estuary.

The SCOPAC Sediment Transport Study (2004) also examined the behaviour of the Newtown Spits. The western shingle spit (Hamstead Duver) at Newtown Estuary entrance has shown significant morphological variation according to analysis of maps and charts covering the period 1879-1973 (Hydraulics Research 1977a). Shorewards recession and recurvature into the harbour has been the dominant trend, although there are two features indicative of long-term gravel accretion. First, a relic spit is located in the harbour entrance behind the active one and secondly, a gravel foreland has formed at Hamstead Point in front of low inactive cliffs. Such features would be consistent with accretion/erosion cycles at the shore caused by variation in littoral drift supply. Drift rates could have reduced recently due to a variety of reasons: (i) increased coast protection and correspondingly reduced supply along the updrift coast; (ii) temporary blockage of the foreshore by mudslides and debris accumulations between Bouldnor and Hamstead; and (iii) variation in cliff erosion input at Bouldnor and Hamstead Cliffs (Halcrow, 1997). Since the cliffs have been increasingly active in recent decades it is likely that supply to the shore has increased, although there may be a lag for materials to be released from mudslide lobes and contribute to drift towards Hamstead Duver. It should be recognised that other factors may also affect the dynamics of this spit, such as the tidal regime of the estuary and possible onshore-offshore sediment transfers involving gravel banks in the West Solent (Hydraulics Research 1977, 1981; Dean, 1995; Tubbs, 1999). In SCOPAC, 2014.

Westwards drift at Brickfield Spit: The spit to the east of Newtown River entrance is aligned westward from the solid coast, which tentatively indicates a low volume net westward drift (Dyer, 1980; Lewis and Duvivier, 1981; McDowell, 1990a and b; McInnes, 1994). It is suggested that westward drift is a local phenomenon associated with the hydraulics of the inlet entrance. Thus, there is a conjectured transient drift divide offshore Brickfield Farm. However, human modification of this coastline, involving previous attempts at land claim, may account in part for the present structure (Tubbs, 1999). The spit has a history of sediment depletion and has receded landwards over saltmarshes that subsequently became exposed and eroded on their seaward face (Halcrow, 1997). Timber groynes and revetments have been installed in past attempts to stabilise the spit, but recently it has breached to form a small new inlet and is overtopped on high-tides. Potential underlying geological strata may help to retain the curved plan form of the coast.

At Newtown Harbour it is reported that sediment mobility is greatest at the harbour entrance, with fine silt and clay accumulating as mudflats and marsh sediments within the inner estuary (Hodgson, 1962; Hydraulics Research, 1981; Tubbs, 1999). The bed of the main channel is composed of coarse pebbles and ebb tidal currents exceeding $0.5ms^{-1}$ have been recorded (Howard, Moore and Dixon, 1988). As a result, offshore flushing of coarse sediments may occur, fed by gravel driven by wave action along the spits flanking the harbour entrance. Although this has not been experimentally proven, the opposed alignment of these spits suggests drift convergence at the harbour mouth that would feed the losses seaward (Lewis and Duvivier, 1981). Previous research has not reported the existence of an ebb tidal delta, although the Newtown Gravel Banks surveyed by Hydraulics Research (1977a and 1981) may perform this function. It is uncertain whether coarse sediments are recycled back shorewards from these banks, although several distinctive bar-like features can be observed within the intertidal zone. (SCOPAC, 2014).

Regarding Marine sediment input, the SCOPAC Sediment Transport Study (2014) comments on onshore transport to Newtown Spits: A time series for the twin gravel spits that flank the harbour entrance from both OS maps and Admiralty hydrographic charts revealed significant changes in morphology, as well as shoreline retreat, over the period 1879-1951, over which time the adjoining shorelines also evolved. The sediment source for periods of spit growth was attributed to net onshore supply, involving complex sediment circulation between Solent Bank, Newtown Gravel Banks and Newtown Spits (Hydraulics Research 1977a). Possible transport mechanisms and pathways are poorly understood because a phase of spit recession between 1914-1951 occurred at the same time as major growth of Solent Bank. Significantly increased bed levels over Newtown Gravel Beds between 1963 and 1973 accompanied diminution of the size of Solent Bank (Hydraulics Research 1977a). This evidence suggests the following:

- Significant transfers and/or exchanges of sediment may occur between Solent Bank, inshore gravel banks and onshore spits.
- Morphological changes suggest possible onshore transport from Solent Bank and offshore transport from the shingle spits. Both pathways apparently supply the Newtown Gravel Beds, although whether they can operate nearly simultaneously has not been researched.

Interpretation of this information is uncertain because little reliable evidence for the transport mechanisms is available and it is not obvious how these changes relate to the recirculating eddy of tidal sediment transport identified by Dyer (1971). Information on sediment transport in this area is therefore of low reliability, with regard to directions and pathways, but of somewhat higher reliability as an indicator of ongoing onshore-offshore sediment exchange (SCOPAC, 2004)

Other studies have revealed beach and associated nearshore changes which may indicate complex sediment transfers both on and offshore, involving possible bedload transfer of coarser sediment grades. Trott (2001) records late Iron Age and Roman artefacts that have accumulated on a gravel bank close to maximum low water at Bouldnor. As there is no evidence for the derivation of this material from cliff erosion, the tentative conclusion is that there is considerable mobility of coarse material in the inter-tidal zone. Aerial photographs also reveal various gravel bars and other morphological features within the intertidal zone that could be indicative of shoreward migration of gravel from channel deposits.

A proportion of the sediment stored in inter-tidal flats and saltmarsh is presumed to derive from input by the small rivers discharging into Newtown Harbour. Most input however, is likely to have been transported by the flood tide, and originate from cliff, platform and shoreface erosion of suspended sediment from the adjacent open coastline. The tidal prism of the harbour has not been constant, as a result of piecemeal land claim in the nineteenth and twentieth centuries, and the submergence of a previously reclaimed area resulting from a storm surge in 1954 (Halcrow, 1997).

Saltmarsh erosion occurs at a few sites (Howard et al, 1988; Raybould, et al., 2000; Bray and Cottle, 2003) and the strong ebb current may remove silt released by this process. Spartina anglica 'dieback' can be traced to 1935 in the Solent, but its role in trapping and subsequently releasing sediment has not been researched at this site (Tubbs, 1999). In comparison to most other Solent estuaries, Spartina loss has been limited and some areas remain accreting. In Newtown Harbour *S. anglica* only appeared in 1932 and has spread slowly. Approximately 17ha have developed since the breach of the seawall in 1954 (Isle of Wight Biodiversity Action Plan, 2004). This site is unique in the Solent in retaining a concentration of the native *S. maritima*, especially around the area of Walter's Copse, where it has a long established presence. Total area of all types of saltmarsh is estimated as being 120 ha. Die-back is not reported as occurring within Newtown Harbour, indeed slow colonisation by *S. anglica* appears still to be continuing in at least two locations. In SCOPAC, 2014.

Newtown Estuary, view looking east along the Eastern spit, showing the furthest section of the Eastern Spit partially submerged/overwashed at high tide. November 2009.

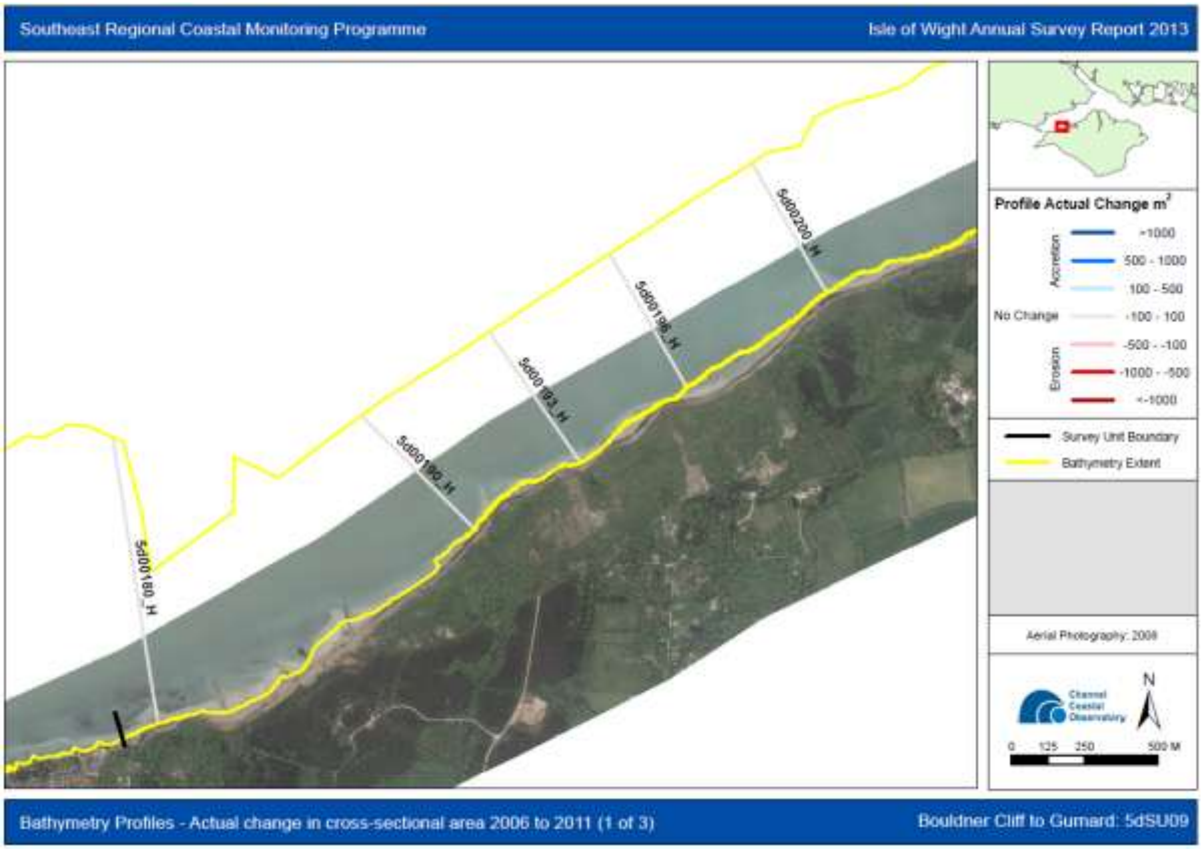
For some 2km eastward of Newtown Harbour there are steep, but low eroding cliffs with basal landslide debris and fallen trees on the beach (Hydraulics Research, 1981). Cliffs increase slightly in height eastward and landsliding rather than rockfall becomes increasingly evident as the major cliff recession process. Historical map comparisons by Halcrow (1997) indicate a long-term mean retreat rate of $0.73ma^{-1}$ for the period 1909-1995.

Further east, the coastal slope rises in height to 57m near Burnt Wood. At this location there is active shallow translational landsliding and transport of debris in mudslides (May, 1966; Hutchinson, 1965; Halcrow, 1997). The lower part of the coastal slope at Burnt Wood is composed of the relatively more resistant Bembridge Limestone units, while the upper slopes are composed of the clayey Hampstead Member of the Bouldnor Formation and capped by Plateau Gravels. Retreat is generally less rapid here, probably due to the outcrop of resistant Bembridge strata slightly above beach level. Mean cliff top retreat of 0.36m/yr was measured from map comparisons covering the period 1868-1963 (May, 1966). Posford Duvivier (1999) propose a higher rate of 0.6m/yr. Historical map comparisons by Halcrow (1997) indicate a long-term mean of 0.99m/yr for the period 1909-1995. These different estimates reflect considerable spatial and temporal variation in the recession process and also some uncertainty in the exact cliff top position due to the obscuring presence of woodland and scrub.

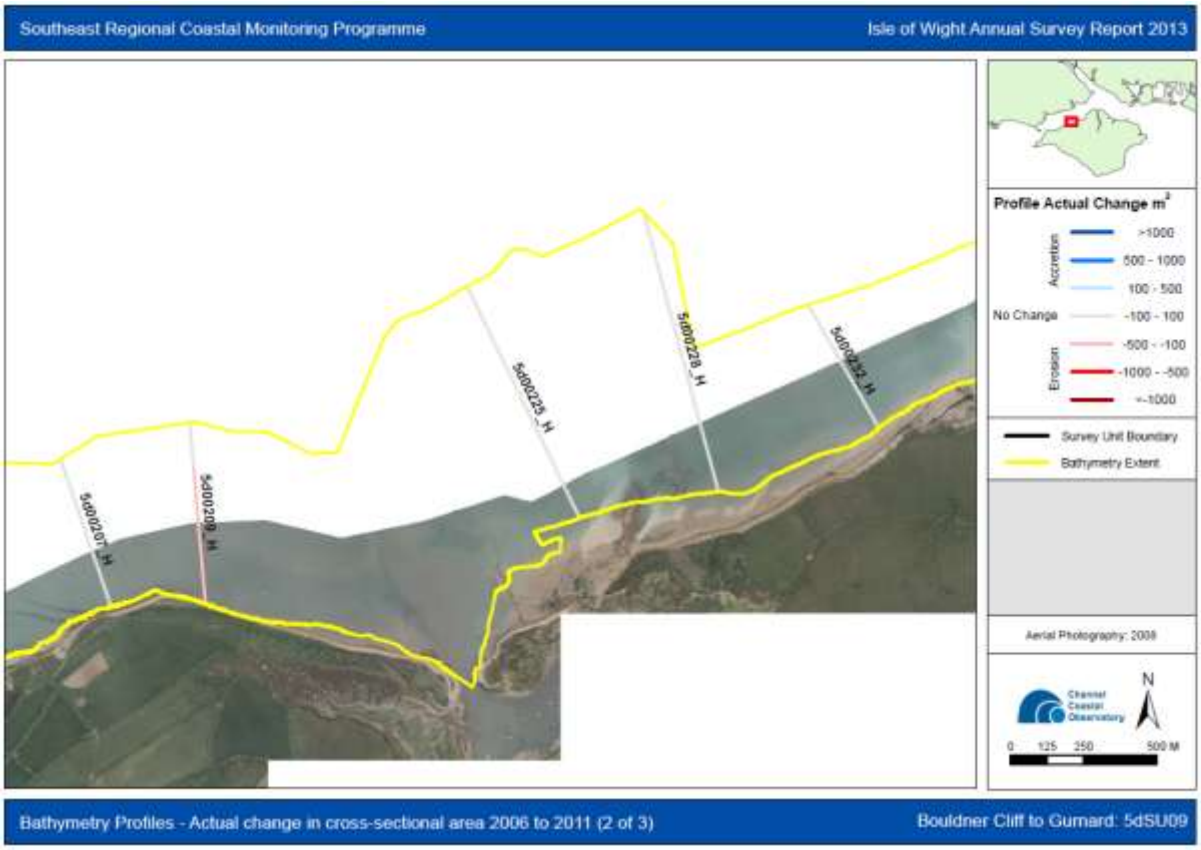
Material supplied is predominantly clay, but a limited gravel input is also reported (Lewis and Duvivier, 1981, Halcrow, 1997). The latter is probably limited to a deposit of Pleistocene Plateau Gravel at Burnt Hill, although it may also derive from erosion of in situ Pleistocene gravel-bearing deposits on the foreshore (Lewis and Duvivier, 1981).
The cliffs between the Thorness and Gurnard rise to 45m and comprise clays and marls of the Bouldnor formation overlying Bembridge limestone at beach level. The limestones outcrop as foreshore reefs to form the protective Gurnard Ledge. There is much evidence of coast erosion with debris accumulations on the foreshore being fed with material from mudslides and shallow translational slides within a cliff degradation zone (May 1966; Hydraulics Research 1977a, 1981). The partly vegetated appearance of the landslide degradation zones suggests that recession may be slower than at corresponding sites to the west, a possible result of the additional protection afforded by Gurnard Ledge. The ledges themselves have also receded suggesting that their protective capacity is limited. Cliff erosion supplies predominantly clay sediments, but also some limestone boulders which temporarily remain on the foreshore.

From Brickfield Farm to Gurnard, net north-eastward drift is indicated by eastward deflection of stream mouths by small, mixed sediment bars at Thorness and Gurnard (Hydraulics Research, 1977a; Dyer, 1980; Posford Duvivier, 2000; Tubbs, 1999). Drift is fed by local cliff erosion, with only a small proportion of sediment yield retained by beaches in front of cliffs on this frontage. A considerable quantity of gravel is stored on the upper and mid foreshore within Thorness Bay, where it has formed a barrier across the stream and its low marshy valley. It is uncertain whether all of this material could have been supplied by drift from local eroding cliffs, or whether material could have arrived as small barrier beaches, or swash bars that have moved onshore, fed from relic gravel sources in the West Solent. Gurnard Ledge certainly functions as a partial impediment to drift tending to assist coarse sediment retention within Thorness bay, causing depletion of the beaches to its northeast.

Results of the Strategic Regional Coastal Monitoring Programme:
(Maps ref. Channel Coast Observatory, 2013, Isle of Wight Annual Report):
The Southeast Strategic Regional Coastal Monitoring Programme does not monitor beach profiles along this stretch of coastline. However, Bathymetry profiles are provided on the maps below.



5-year change in the cross-sectional area of bathymetry profiles at Bouldnor, from 2006-2011 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles at the mouth of Newtown Estuary, from 2006-2011 (CCO, 2013)

5-year change in the cross-sectional area of bathymetry profiles, Thorness Bay and Gurnard, from 2006-2011 (CCO, 2013)

Shoreline Movement:

High long term cliff recession rates are typical within this frontage, although it should be noted that the cliff top recession process involves high magnitude low frequency failures that can result in loss of between 5 and 25m within single events associated with intense mudsliding downslope.

The upper foreshore has retreated in accord with cliff recession along the majority of this frontage, but mean low water appears to have moved back more rapidly so that the foreshore has narrowed. The western spit at Newtown (Hamstead Duver) has retreated and re-curved partially into the harbour. However, there is some evidence of long term accretion in the form of: (i) a relict spit located in the harbour entrance behind the active one; and (ii) growth of a gravel beach or small foreland in front of the eastern most parts of Hamstead Cliffs such that relict slopes have formed. It appears that this accretion is fed by sediments drifting eastwards following delivery to the shore at Hampstead and Bouldnor Cliffs.

The eastern spit at Newtown entrance has a history of sediment depletion and has receded landwards over saltmarshes that subsequently became exposed and eroded in the seaward face. Timber groynes and revetments have been installed in past attempts to stabilise the spit, but recently it has breached to form a small new inlet subject to tidal flows at high water.

Mean long-term cliff-top retreat over the period 1868-1963 was 0.61m/yr (May, 1966; Posford Duvivier, 1997), but a high rate of 3m/yr was recorded for a part of the Bouldnor Cliff complex over the period 1922-1962 (Hutchinson, 1965). Historical map comparisons by Halcrow (1997) indicate long-term (1909-1995) mean cliff top recession of 1.13m/yr for western and central Bouldnor and 0.84m/yr for Hampstead Cliff. Although, map comparisons covering the period 1908-1971 indicated locally rapid recession of mudslide lobe toes at rates of up to 1.6m/yr (Webber, 1977), it appears that cliff top recession has been more rapid than recession of mean high water at the toe leading to an overall flattening of the slope profile (Halcrow, 1997).

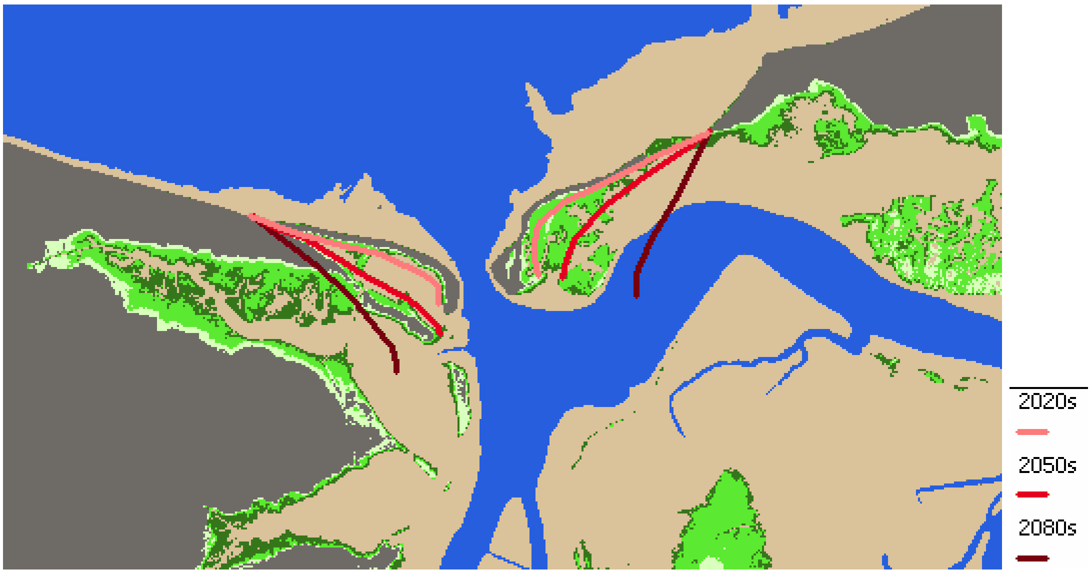
The entire coast between Whippance Farm (Thorness Bay) and Gurnard displays evidence of coast erosion, with cliffs up to 45m in height, much active mudsliding and shallow translational slides that supply debris accumulations on the foreshore (Hutchinson, 1965; Hydraulics Research 1977a, 1981; May 1966; Bird, 1997; Halcrow, 1997; Posford Duvivier, 2000, Hutchinson and Bromhead 2002; Moore and McInnes, 2002). The landform assemblage is comparable to that at Bouldnor and Burnt Wood, but smaller in scale. Recession has been measured at 0.36m/yr for the period 1868-1963 (May, 1966) and 0.6m/yr, 1862-1938 (Hydraulics Research, 1977a). Some basal protection afforded by Bembridge Limestone ledges at Gurnard Ledge, and to the east, results in some increased cliff stability and slower retreat rates to the northeast of the Ledge compared to the cliffs to the south. These ledges eroded by 0.6m/yr to 1.2m/yr over the period 1862 to 1938 which suggests that their protective capacity is limited (Hydraulics Research, 1977a; Posford Duvivier, 1997; 1999). Historical map comparisons by Halcrow (1997) indicate long-term (1909-1995) mean cliff top recession of 0.48m/yr for the cliffs to the south of Gurnard Ledge and 0.18m/yr for those to the northeast.

Predictions of Shoreline Evolution:
Futurecoast (2002) estimated that without defences the trend for narrowing of the foreshore suggests that debris and cliff toe erosion are likely to continue or intensify into the future such that the cliffs are likely to remain unstable and actively eroding.

Increases in sediment supply to beaches due to the acceleration of freely eroding cliffs would be unlikely to generate substantial protective beaches because most of the cliff materials are clay and mechanisms exist for seaward removal of these sediment grades. Instead, there may be very local increases in beach accumulation at Hamstead Duver and in Thorness Bay.

The breached eastern Newtown Spit would be unlikely to seal naturally due to limited sediment supply, possibly resulting from the proximity of the drift reversal and divide. Instead it is likely that the breach would enlarge in the short-term and the spit breakdown further as sea level rises. The corresponding western spit is rather more stable because it is sustained by a modest sediment supply from the cliffs to the west. It would be likely to remain static, or slowly migrate into the harbour inlet. The effect of these changes would primarily be to permit increased wave penetration into the harbour with implications for the erosion of saltmarshes and mudflats.

The estuaries appear to be capable of continuing to accrete fine sediments and their saltmarshes have been relatively stable, although trends for slow to moderate saltmarsh erosion have become apparent recently in the Western Yar and Medina. Since these are all valley type estuaries with relatively steeply sloping margins their saltmarshes are likely to be sensitive to future climate change and sea-level rise unless vertical accretion can compensate (Halcrow Maritime et al, 2001).

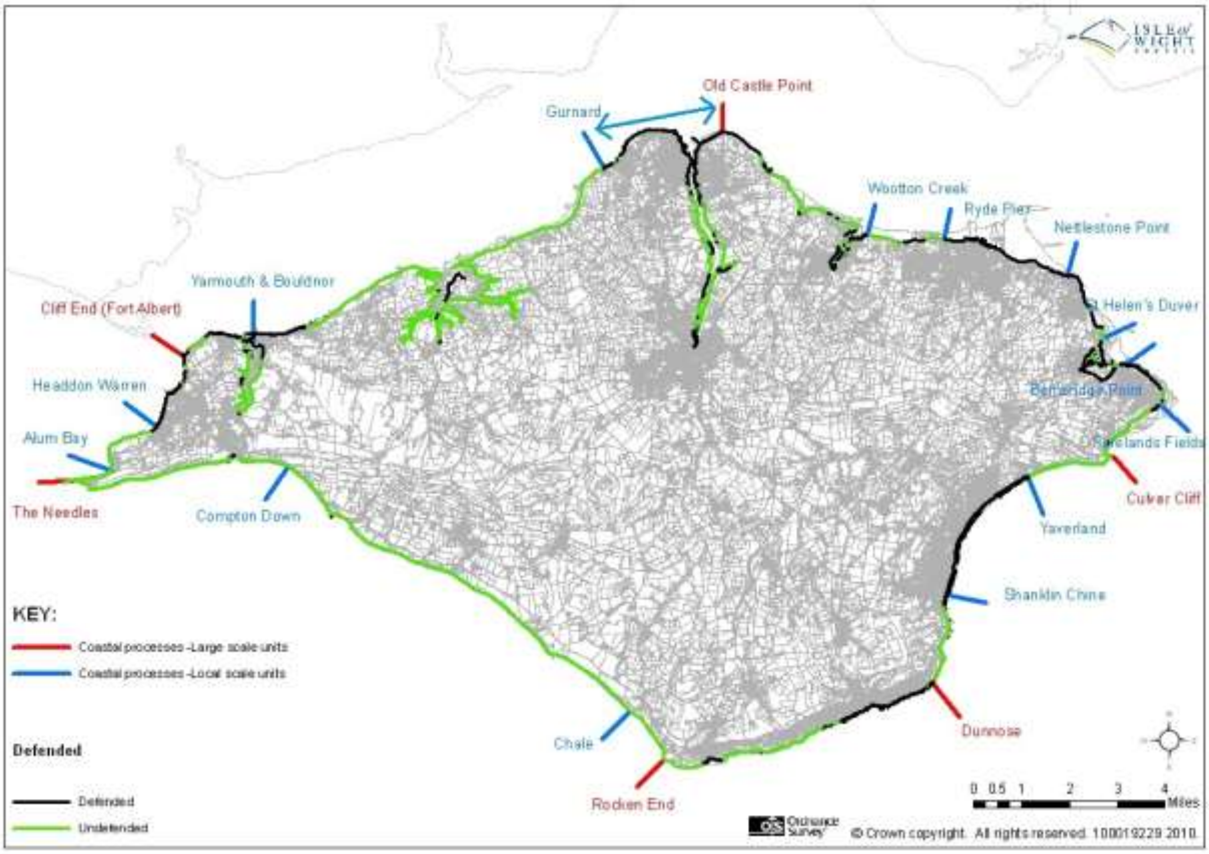


Potential future spit recession in Newtown Estuary, as calculated by the BRANCH Project, and described in more detail below. Copyright of the BRANCH Project (Gardiner et al, 2007).

The BRANCH project (Gardiner et al, 2007) predicts future spit retreat at Newtown by the 2020s, 2050s and 2080s under a medium-high sea-level rise scenario, using the Leatherman equation to predict future retreat allowing for sea level rise (i.e. Future recession rate = Historical recession rate x (future sea level rise / historic sea level rise)). This prediction assumes a likely pivot point and minimal retreat of the neighbouring cliffs, historical sea level rise of 0.137cm/yr, and historical retreat rate of 0.6m/yr for the western spit and 0.62m/yr for the eastern spit. This simplifies the issues contributing to spit recession. The Western spit is likely to continue rolling back, although the presence of an inner spit may affect this behaviour. On the eastern side the spit is likely to continue to roll back south eastwards away from the prevailing wave direction, but may submerge as it reaches the deep water channel. Increased erosion of neighbouring cliffs may feed additional sediments into the system, potentially replenishing the spits, however increased wave action and storm frequency could also promote even faster retreat and assist the breaching of the eastern spit, opening up the Estuary to increased wave action, particularly the eastern side and the vulnerable saltmarsh habitat.

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report –please see below (re. units IW52 to IW54).

5.3.3 Local Scale process unit: Gurnard to Old Castle Point, including the Medina Estuary



Map showing the boundaries of this local-scale process unit (see blue arrow).

SMP2 Policy Units in this area: *(in Management Areas: 1A – Gurnard, Cowes and East Cowes; & 1B Central Medina Estuary and Newport)*. Policy Units:

- 1A.1 Gurnard Luck (433m);
- 1A.2 Gurnard Cliff (346m);
- 1A.3 Gurnard to Cowes Parade (2,616m);
- 1A.4 West Cowes (3,481m);
- 1A.5 East Cowes (2,814m);
- 1A.6 East Cowes Outer Esplanade (828m).
- 1B.1 Central Medina – NW (2,697m);
- 1B.2 West Medina Mills (370m);
- 1B.3 Central Medina – SW (1,486m);
- 1B.4 Newport Harbour (1,634m);
- 1B.5 Central Medina – East (5,111m).

Interactions:
This is a relatively self-contained frontage, although re-activation of cliff recession supplies predominantly fine sediments to the Solent.

Along the Gurnard frontage a wooded coastal slope extending to a height of 40m is protected at its toe by low cost revetments and assorted sea walls in generally poor repair. Slope morphology comprises numerous undulations, hollows and ridges which indicate past landsliding. Site observations have revealed several active landslides which have extended downslope and surged out across the foreshore (Hydraulics Research, 1981). The slope is formed in similar materials to that of Thorness Bay and could exhibit a similar degree of landslide activity should it be exposed to active toe erosion. Even with satisfactory toe protection, seepage erosion could continue.

Gurnard Luck, 2014 (L.Ellison)

Weak net eastwards littoral drift is reported along the depleted beach from Gurnard around Egypt Point (Posford Duvivier, 1990a). Concrete rubble groynes at Egypt Point selectively intercept sediments, but quantities are small because of the presence of protection structures and a lack of available material (Halcrow, 1997; Posford Duvivier, 2000). Beaches comprise sandy gravels becoming coarse gravel and cobbles under the seawall and are very depleted around Egypt Point, but widen eastwards to Cowes (Posford Duvivier, 2000).

Cowes Esplanade, looking west towards the Medina Estuary (Isle of Wight Council)

The coastal slopes of Oligocene clays, marls and limestones form a prominent headland separating the Medina River and Estuary from the Western Solent. The headland is characterised by a plateau forming the higher ground above gently sloping coastal cliffs up to 35m in height.

Landsliding in the Cowes-Gurnard Coastal Slopes:

At the northern-most point of the Isle of Wight, the coastal slopes form a prominent headland separating the Medina River and Estuary from the western Solent. The headland is characterised by a plateau forming the higher ground above gently sloping coastal cliffs of varying height up to 35m

The north-facing coastal slopes under the towns of Cowes and Gurnard are affected by significant slope stability and landslide problems from Gurnard marshes to Market Hill, Cowes, over an area of about 100ha, and up to 0.6 km inland of the shoreline. The coastal slopes between Cowes and Egypt Point have, historically, been extensively developed for residential, leisure and retail purposes.

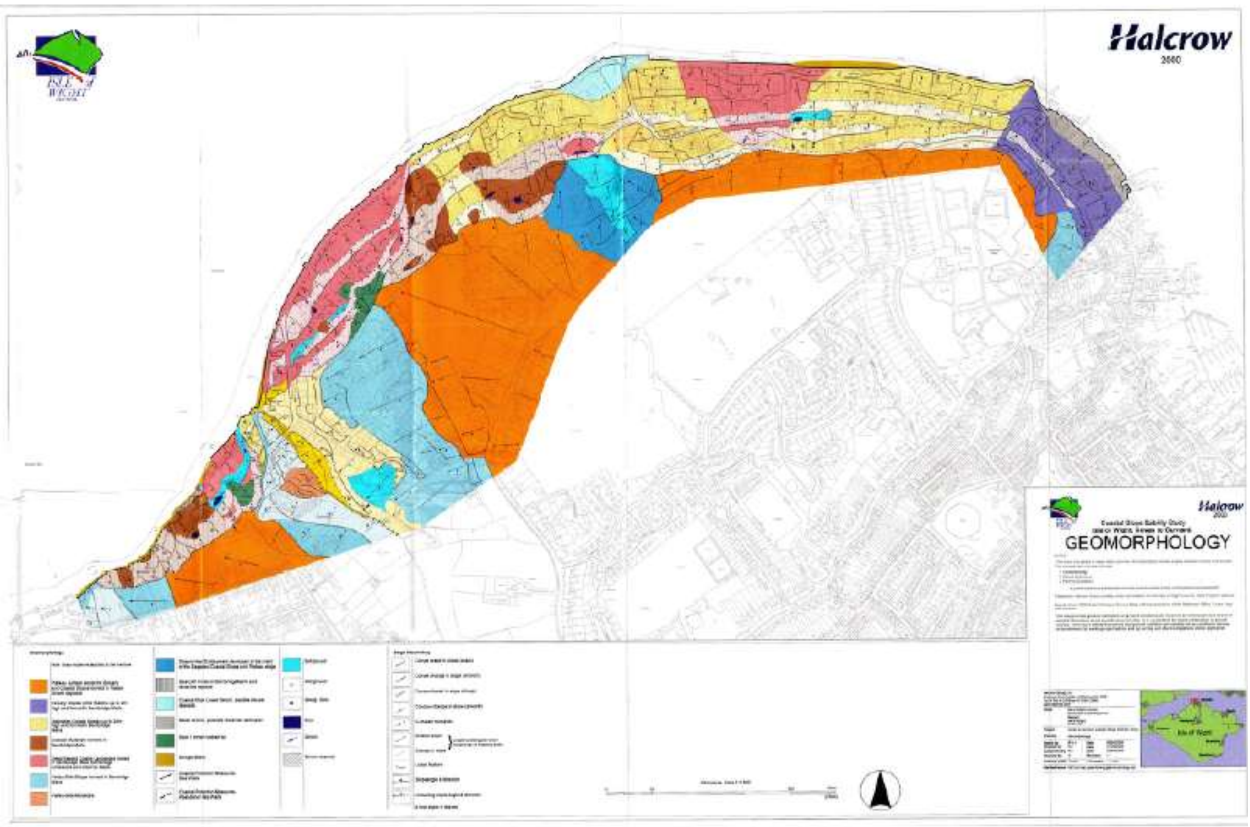
Degraded coastal slopes, coastal mudslides and deep-seated coastal landslides occur over four cliff behaviour units or coastal landslides. The system extends offshore below the current sea defences. The nature of ground movement is by sub-surface movements associated with the progressive creep of deep-seated landslides; surface or superficial slope movements arising from the erosion or failure of steep slopes; the differential movement and settlement of clay slopes; and compression or ground heave. There are four distinct cliff behaviour units or coastal landslides characterised by different failure mechanisms, scale and magnitude of various types of ground movement.

Contemporary problems arising from ground movement tend to result from superficial movements, the nature and significance of which varies along the frontage. Poor drainage, increased rainfall, beach steepening and increased toe erosion will promote active landsliding and could result in rapid retrogression upslope towards cliff top development. A decline in the current levels of coastal protection would also lead to an anticipated significant increase in coastal slope instability in future years.

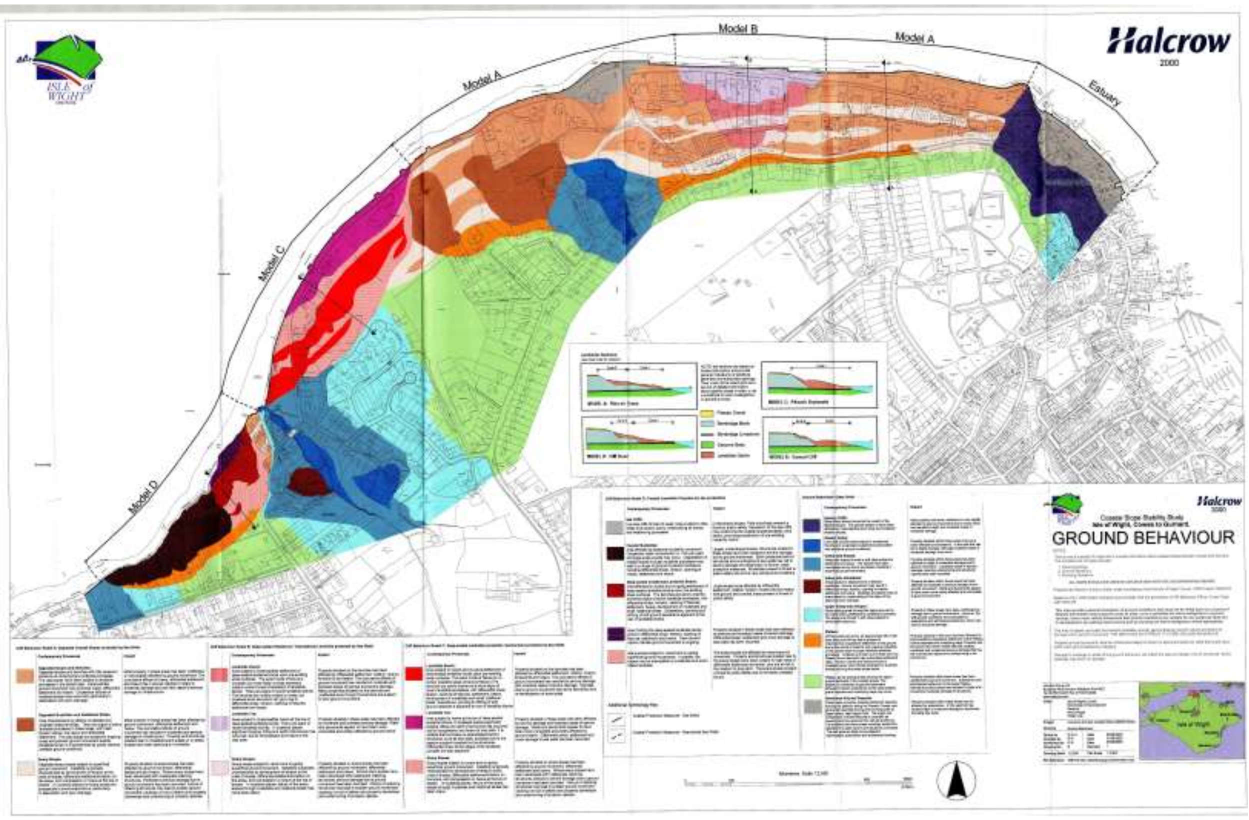
At Gurnard, the slopes were reactivated after the winter of 2001. At Gurnard Cliff, coastal mudslides have resulted in undermining and recession of the cliff top, active settlement of the cliffs and translational movement of debris to the foreshore.

Detailed geomorphological, ground behaviour and planning guidance mapping is available and an accompanying report was produced (Isle of Wight Council, 2000). The report provides general guidance and information on ground stability conditions along the coastal frontage from Market Hill, in central Cowes, west to Gurnard Marsh, and north of Baring Road located along and above the coastal slopes. The series of maps are intended to assist decision-making by informing the planning process as well as provide a basis for assessing the requirements for stability investigations and reports in support of future development proposals in the study area.

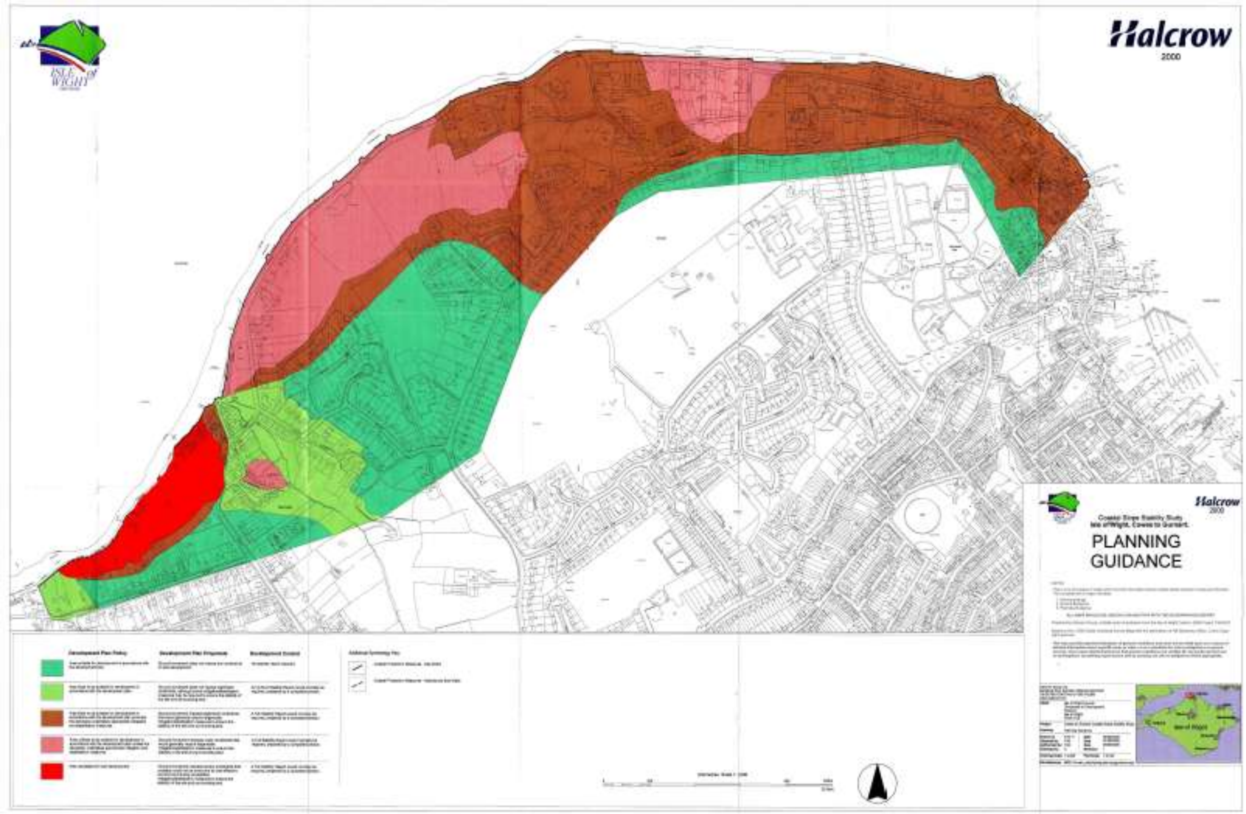
The maps below cannot provide full information when shown here in summary form, but provide an indication of the level of detail available for the developed areas of the town in the 1:2,500 scale maps accompanying the Cowes to Gurnard Coastal Slope Stability Study (Isle of Wight Council, 2000), for Geomorphology, Ground Behaviour and Planning Guidance.



Geomorphology Map, Cowes-Gurnard coastal slopes (Halcrow, for Isle of Wight Council, 2000)



Ground Behaviour Map, Cowes- Gurnard coastal slopes (Halcrow, for Isle of Wight Council, 2000)



Planning Guidance Map, Cowes-Gurnard coastal slopes (Halcrow, for Isle of Wight Council, 2000)

Medina Estuary:

Westwards directed, but very weak, littoral drift occurs between a drift divergence at Old Castle Point (east of East Cowes) towards the Shrape breakwater at the mouth of the Medina estuary. The Shrape Breakwater prevents input into Cowes Harbour. Falling beach levels and lack of significant accretion against the breakwater indicate low drift rates, which have necessitated some recent beach nourishment. The lack of supply is due to the small source area and the impact of protection structures in reducing cliff erosion (Posford Duvivier, 1994). Cowes Harbour entrance therefore represents a drift convergence boundary, although the very small quantities of sediment moved by littoral transport towards the Medina entrance, together with the effect of the Shrape breakwater, makes this little more than a notional feature.

To the west of Old Castle Point, the towns of Cowes and East Cowes (on the right) at the mouth of the Medina Estuary, with the Shrape Breakwater protecting the entrance to the harbour (Isle of Wight Council).

In 2014 a new offshore breakwater (not shown in the photo above) is being constructed at the mouth of the Medina Estuary, seaward of the Shrape Breakwater, to provide additional shelter and harbour facilities for Cowes and East Cowes.

The *Cowes Outer Harbour Project* comprises three main elements: *'1) A system of wave protection to create a properly protected outer harbour for the benefit of both Cowes and East Cowes. This consists of a new rubble mound outer breakwater and a short extension to the Shrape breakwater; 2) A marina of 300 permanent berths with separate dedicated provision of visitor and event berths to support the waterfront regeneration of East Cowes. 3) Dredging of a new eastern channel to improve vessel safety within the harbour, especially during major yachting events such as Cowes Week and the annual Round the Island Race.'* (ABP Mer, Cowes Outer Harbour Environmental Impact Assessment, Non-Technical Summary, www.coweshharbourcommission.co.uk, available in Oct.2014).

The Environmental Impact Assessment for the Cowes Outer Harbour project identifies the following impacts on physical processes:

Beneficial Effects: The scheme will have a direct major beneficial impact upon the wave climate within Cowes Harbour, achieving the design objective of reducing the wave climate to less than 0.3m in height in the area of the new marina and across much of the outer harbour. Greatest protection is provided from the north east and north sectors as some penetration of uninterrupted waves will continue to occur in the main fairway.
A minor, indirect, beneficial impact will result in a change to the wave propagation up the estuary which will cause a slight lowering of water levels and a small (0.5%) increase in the tidal range. The effect of this is to increase the area of intertidal throughout the estuary by 2.27 hectares that will offset the 1.42 hectares direct loss resulting from the marina dredge (see below).

Neutral Effects: The model results for the proposal have confirmed what had been expected in that the effects of changes in the outer harbour will have very little effect upstream of the Chain Ferry which tends to act as the 'true' estuary entrance. The only marked changes to physical processes upstream of the Chain Ferry are the slight changes to wave propagation affecting water levels as described above.

Adverse Effects: While the breakwater will have a major positive impact upon the wave climate within the harbour, a resulting effect of the structure will be to restrict the flow through the mouth of the estuary. To the north of the Royal Yacht Squadron where the channel is influenced by a combination of the east-west Solent tide and the Medina tide ("Harbour tide"), the existing flow maximum of 1.9 knots at high water will not be exceeded. However, the breakwater does create stronger flows than are currently experienced on the ebb tide which will combine with Solent flows to create a 1.2 knot maximum tidal speed on the ebb. In the main fairway, maximum flows on the ebb tide increased from around 0.7 knots to 1 knot.
The effects will be less pronounced in the proposed eastern channel where a current maximum flow of about 0.8 knots between the Shrape breakwater and the proposed outer breakwater will increase to about 1 knot.
The capital dredge for the marina will remove 1.42 hectares of intertidal mudflat; however, this indirect loss of intertidal will be compensated for by an indirect gain in intertidal of 3.69 hectares - i.e. a net gain of 2.27 hectares.
The development will result in an increase in the maintenance dredging commitment for the Medina but this is predominantly associated with the new marina dredge. The dredge requirement in and around the new marina will be offset in part by some redistribution of sediment occurring on the western side of the outer harbour; the channels will continue to be largely self-scouring. Significantly, the water flows remain largely unchanged upstream of the Chain Ferry and, therefore, as one would expect, no marked changes to sedimentation are predicted to occur south of the Chain Ferry.'

(Ref. ABP Mer, Cowes Outer Harbour Environmental Impact Assessment, Non-Technical Summary, as available on www.cowesharbourcommission.co.uk, Oct.2014).

The Medina Estuary extends 6.8km from Cowes and East Cowes southwards to its tidal limit at Newport Harbour. The channel, near its entrance, is confined by development, to 98m in width at the Cowes Floating Bridge. It lies in a wide shallow valley with a gentle incline on either side. Upstream, sediment build up has formed characteristic mudflats covering 66 hectares which support a large number of species, including shellfish, algae and locally and regionally important species of worm, also important sources of food for fish and bird populations. The estuary's shoreline is approximately 14.4km. At low water a single, relatively wide but shallow channel remains. The mid and upper reaches are largely bordered by agricultural land, hedgerows and woods, whereas the lower reaches and mouth are lined by docks, boatyards and marinas. (Medina Estuary, iwight.com 2009).

The estuary narrows to 98m in width at the point where the floating bridge crosses and this constriction is considered to be a geological control on the estuary, such that the future evolution of the estuary will remain strongly influenced by this zone. Due to this it is argued that the 'true' estuary mouth is at this location and the areas to the north exhibit some characteristics of an open coast bay (ABPmer, 2007).

The Medina Estuary operates as a natural littoral transport boundary as its dominant ebb tidal flow generates net offshore flushing of incoming shoreline sediments. The process is probably less significant than in the past because there is very little incoming littoral drift due to widespread shoreline stabilisation and drift interception. The flushing effect was enhanced by construction of the East Cowes (Shrape) breakwater in 1936/37 which reduces the amount of suspended sediment entering the Estuary, and ebb tidal flow was shifted westward by the breakwater into the centre of the inlet. The flood currents dominate along the western margin. Comparisons of hydrographic charts dating back to 1856 indicate that some cyclic variations of the sea bed may have occurred prior to construction of the breakwater, but subsequently the bed has been relatively stable (Webber, 1969; Bunce et al., 1987). This is attributable to the net offshore transport of sediment which maintains stable channel configurations and prevents siltation even in recently dredged berths (Webber, 1969). Small sand and gravel banks exist where dominant ebb and flood flows crossover; these are probably not sediment sinks but temporary accumulation zones for sediment subject to net offshore transport (Webber, 1969). Banks further offshore such as Prince Consort Shoal and Brambles Bank are probably permanent sediment sinks (Dyer, 1980) and in the past might have been supplied with sediments flushed seaward out of the Medina inlet.

The SCOPAC Sediment Transport Study (SCOPAC, 2014) comments on fluvial sediment input to the Western Yar, Newtown Harbour and Medina Estuaries. It notes that rivers on the Isle of Wight are small due to limited catchments and therefore contribute negligible sediment to the coast. Rendel Geotechnics and the University of Portsmouth (1996) estimate that all of the rivers discharging sediment to this coastline potentially contribute together some 2,450 tonnes a^{-1} of suspended load and 740 tonnes a^{-1} of bedload material. However, various barriers and regulation of flows reduce the delivery volume very substantially. The River Medina has a mean flow of $0.5m^3s^{-1}$ and this comprises only 0.67% of the tidal volume entering at the mouth during a corresponding tidal period (Webber 1978). Thus, marine sediment input to estuarine mudflats and saltmarshes must be the dominant source of supply and fluvial sources are considered to be insignificant. Several small coastal streams, e.g. Gurnard and Thorness, have been partially or wholly infilled behind spits that have grown across their mouths. It is not clear if this represents marine or river-derived sediment. If present day spits are the product of breaching of medieval or earlier barriers then there could have been a significant earlier phase of trapping of fluvial sediment (Tubbs, 1999). Conversely, it could be that spits grow across inlets when marine infilling has reduced the flushing effect of their tidal exchange.

In terms of estuarine outputs (SCOPAC, 2014), the ebb tidal flow is of shorter duration (4 hours) than corresponding flood flow (5 hours) so ebb currents are more rapid (Webber, 1969). This produces a net offshore flushing effect of sand and gravel at the harbour entrance, which was enhanced by construction of the Shrape breakwater in 1936/37. Ebb and flood tidal flow is confined to separate channels, but the ebb flow has shifted westward as a result of the construction of the breakwater. Dominant transport of sand is thus out of the harbour except along the extreme west bank, where the flood current dominates and net transport is inward (Bunce, Gibbs, Goldsmith, Jones and Spence, 1987; Posford Duvivier, 1994; Carter, 1997; Webber, 1969, 1978; Pieda, 1994). Measurement of tidal currents in the adjacent area of the central Solent indicate westward flow at high water, thus ebb currents at the harbour entrance are deflected westward and sediment transport pathways shift accordingly (Bunce et al., 1987; Price and Townend, 2000).

Examination of hydrographic charts dating back to 1856 indicate that some cyclic variations of outer estuary bed morphology may have occurred prior to construction of the breakwater, but subsequently it has been very stable (Bunce et al., 1987; Webber, 1969; Carter, 1997). This can be attributed to net offshore transport of sediment, which maintains stable channel configuration and prevents siltation even in recently dredged berths (ABP Research and Consultancy, 1994; Webber, 1969). Small sand and gravel banks exist where dominant ebb and flood flows crossover; these are probably not sediment sinks but temporary accumulation zones for sediment subject to net offshore transport (Webber 1969). In the Medina estuary upstream of Cowes, bankside erosion of marginal mudflats began to replace a longer-term tendency for channel accretion in the 1980s. Banks further offshore in the central Solent, such as Prince Consort Shoal and Bramble Bank, are probable sediment sinks (Dyer 1980) in a confluence zone receiving both wave and tidally transported sediment (Velegrakis, 2000; Bray, Carter and Hooke, 1995). Prince Consort Shoal was probably previously supplied by fine sediment flushed out of the Medina, but quantities have been significantly reduced by breakwater construction and periodic maintenance dredging (Isle of Wight Development Board and Cowes Harbour Commissioners, 1990). In SCOPAC, 2014.

Historical chart analysis, a review of estuary processes and morphometric analysis on the estuary (ABPmer, 2007) suggests that accretion of fine material has continually occurred since 1856 (albeit at a relatively slow rate) but the man-made interventions, mostly between the 1920s and 1950s, probably caused a temporary change to the system. This changed the hydrodynamics, inducing additional flows at the lower states of the tides (particularly ebb) which have scoured the low water channel. This scour has mainly been at the edges, removing the finer fractions of sediments to leave the coarser gravels as bed armouring thus reducing the effect depth-wise. This temporary change appears to have worked through the system up to the area around Island Harbour and the net accretionary regime has re-established down estuary. The rates of future accumulation are, however, likely to be lower than those before the construction of the Shrape breakwater due to its effect on reducing the supply of sediment into the system. The Shrape breakwater has contributed (along with coastal protection works) to reduce the overall supply of sediment to the estuary, compared to 1856 but since the 1980s the estuary has had a net accretionary trend, particularly over the intertidal. Rates of change are small, being measured in millimetres per year. There has been a net reduction in surface area (at high water) due to coastal squeeze, predominantly from embankments and reclamation.

Since the 1940s the area of saltmarsh has reduced by 10.3 ha as a consequence of direct reclamation, capital dredging or impoundment such as at Island Harbour as well as from natural processes. A reduction in saltmarsh has occurred throughout the Solent Area and therefore a proportion of the natural change may reflect regional trends rather than local developments. The rate of erosion has slowed considerably in recent years. Upstream of Dodnor, the net accretionary trend has been continuous but may be reduced for a period in the future as the effects of the developments continues to work its way up the estuary, unless the effect has decayed sufficiently not to cause a significant change relative to the accretion and erosion thresholds.

View north from Newport along the Medina Estuary towards Cowes and East Cowes at the Estuary mouth (Isle of Wight Council).

Dredging is periodically undertaken for navigation purposes at Yarmouth Harbour (MacMillan, 1956; Turton, 1982; Western Yar Liaison Committee, 1998; ABP, 2003), Cowes Harbour and Newport Harbour. In all cases dredged volumes are small and predominantly comprise muds and silts. At Cowes Harbour, regular dredging was necessary to offset siltation prior to construction of the breakwater in 1936/37, but subsequent sediment removal comprising maintenance dredging of the main channel, deepening of access channels and creation of new berths, has been modest (Webber, 1969). An approximate equilibrium between loss from this source and gain from flood tide sediment input may prevail. Maintenance dredging of approximately 4,000 tonnes a^{-1} is undertaken in the Medina estuary upstream of Cowes Harbour to maintain the channel to Newport Harbour (Newport Harbour Master, 1991). It is reported that routine dredging began in the early 1900s but reliable historical data is lacking. For the most part, the main channel upstream to Newport is self-scouring. In SCOPAC, 2014.

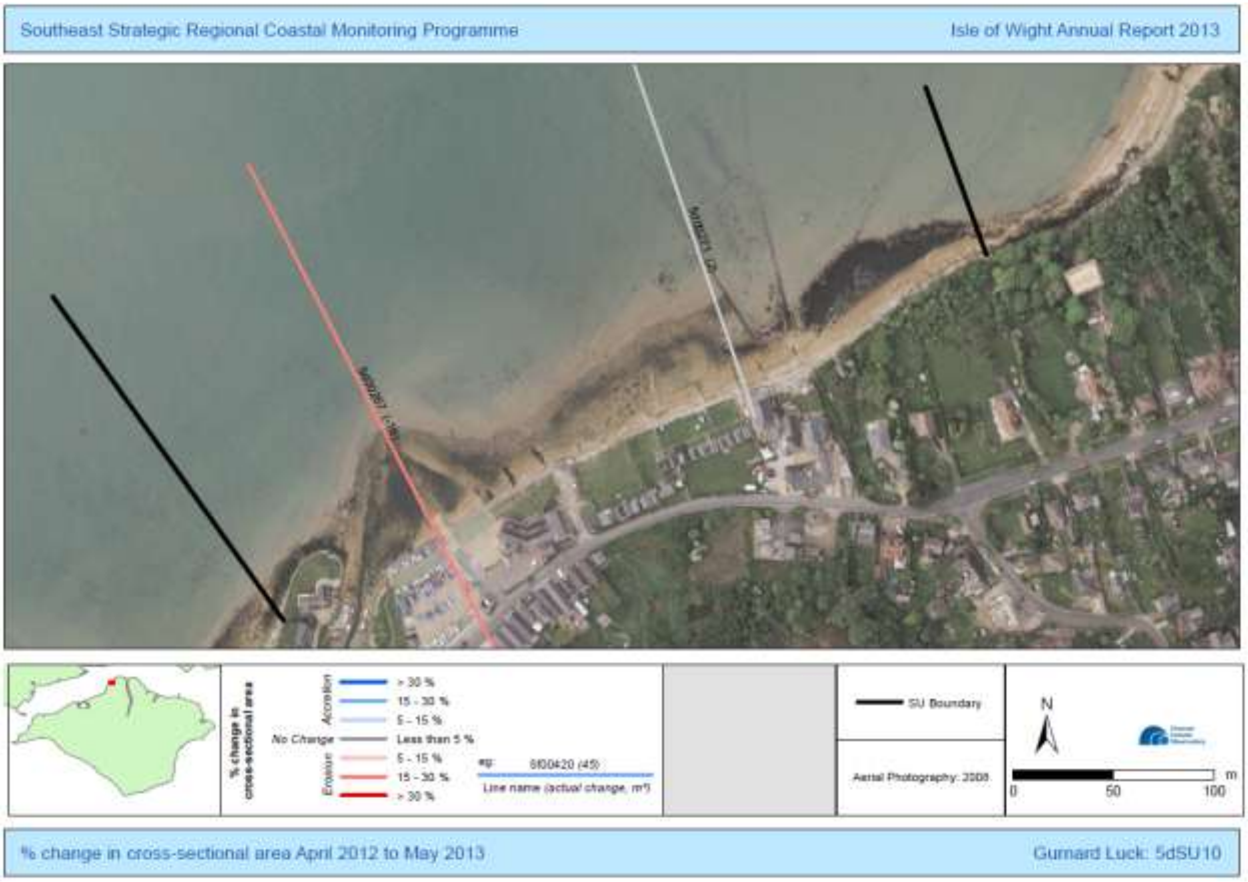
Newport Harbour, looking north, 2012

Buildings surrounding Newport Harbour, 2012

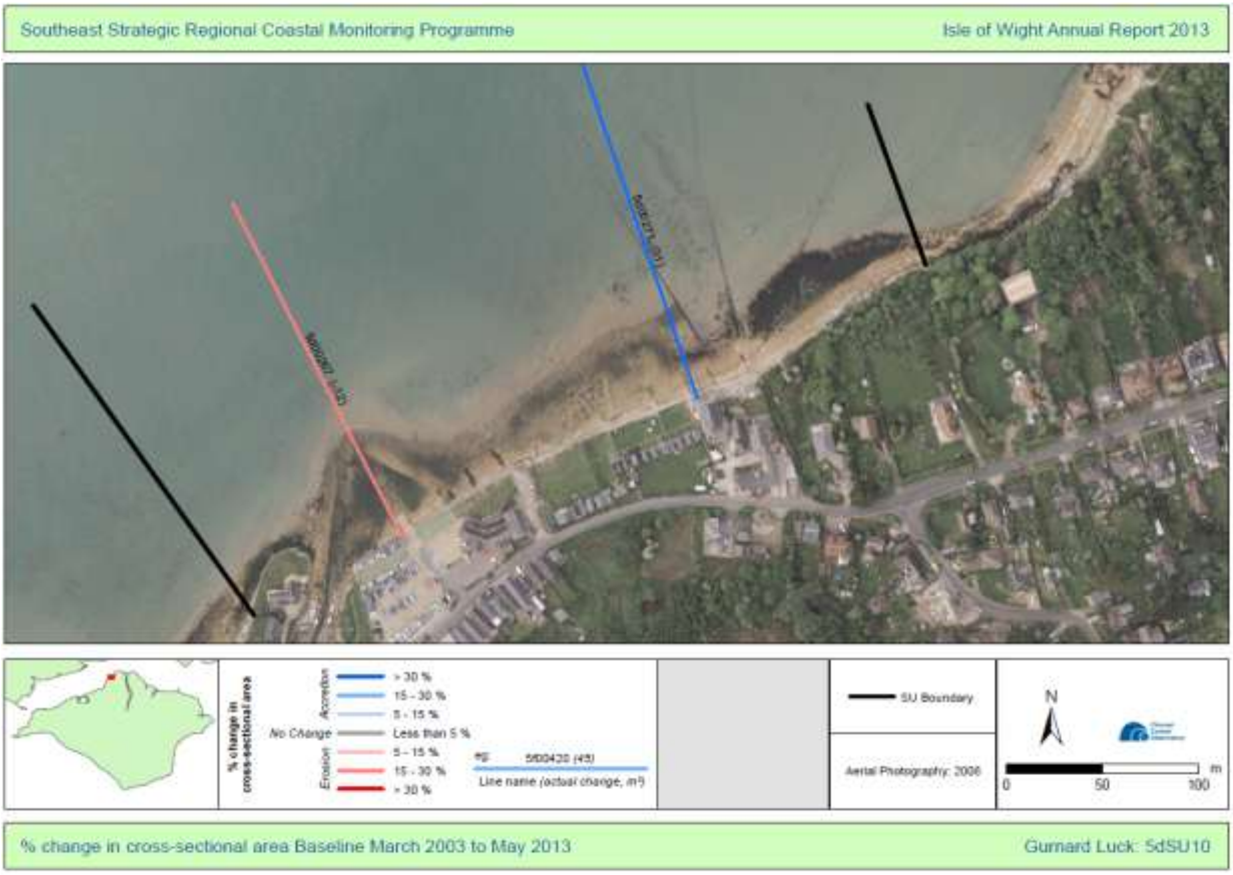
Results of the Strategic Regional Coastal Monitoring Programme:
(Maps and text ref. Channel Coast Observatory, 2013, Isle of Wight Annual Report):

5dSU10 (NEW 4): Gurnard Luck

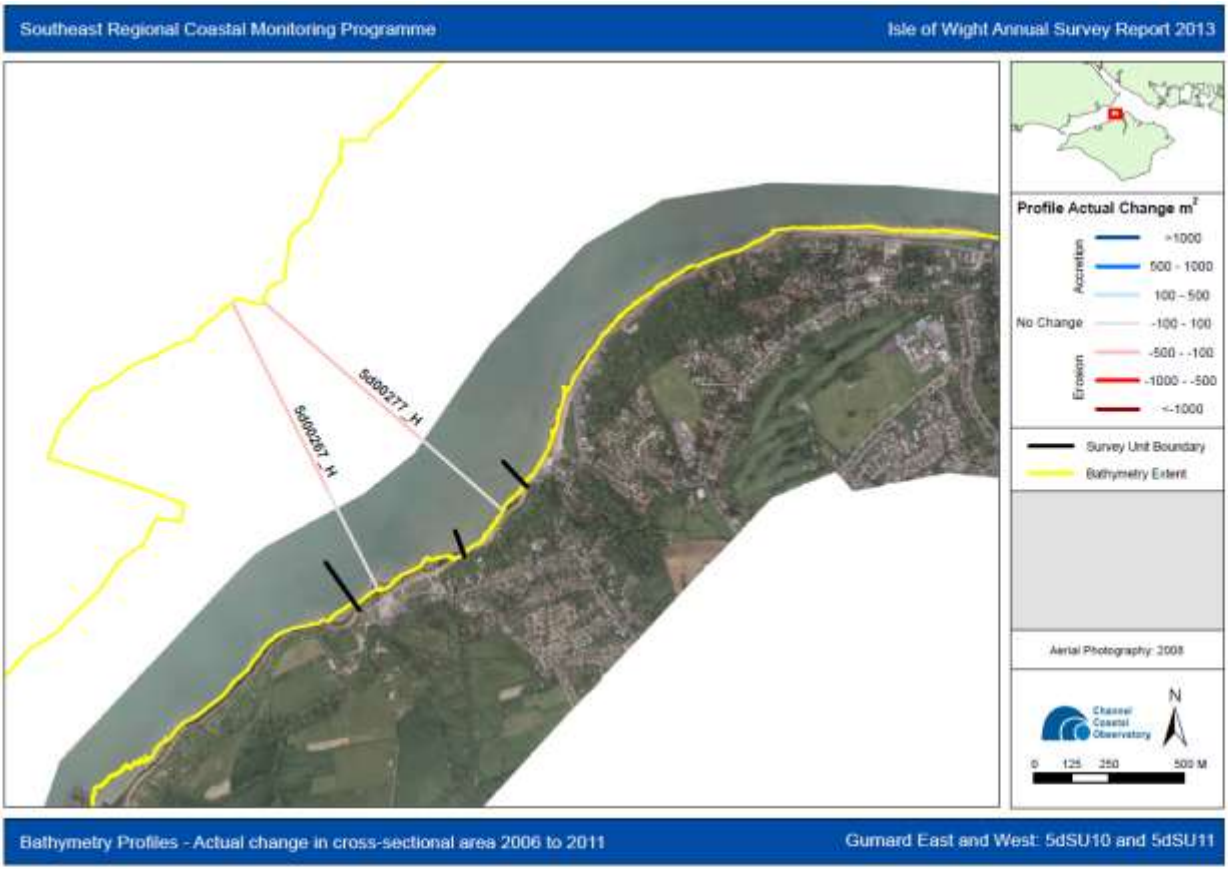
- *Spring 2012 to Spring 2013: Profile 5d00271 is generally stable apart from profile 5d00267 which shows a change of -21%. This change is observed in the upper beach only, by the sea wall.*
- *Baseline Spring 2003 to Spring 2013: Profile 5d00267 has shown a -12m2 change in cross-sectional area (CSA) over the longer term; much of this change can be attributed to the change during 2012-2013. In contrast profile 5d00271 has shown an increase in CSA of 31m2 over the longer term, with a 0.3m sediment accretion in the middle of the profile.*



Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



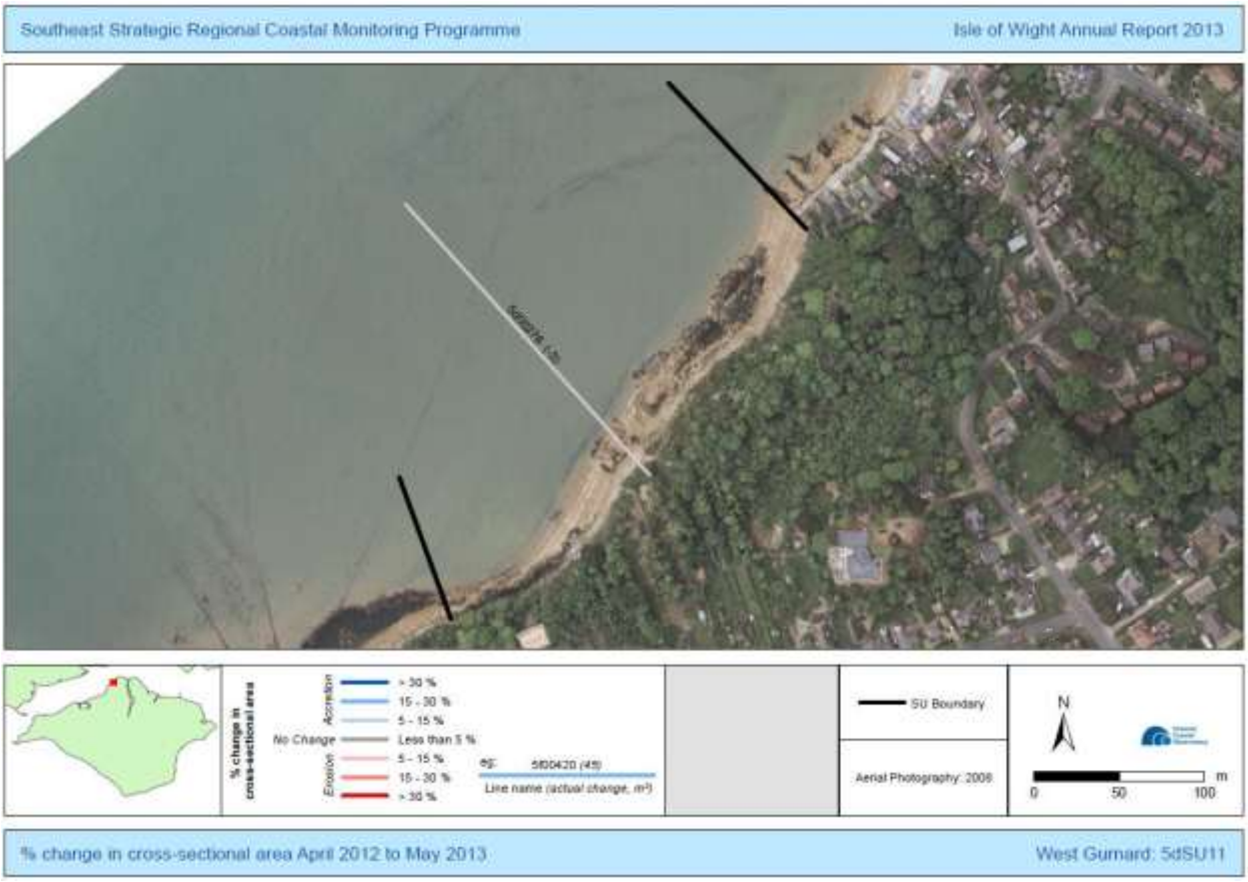
10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



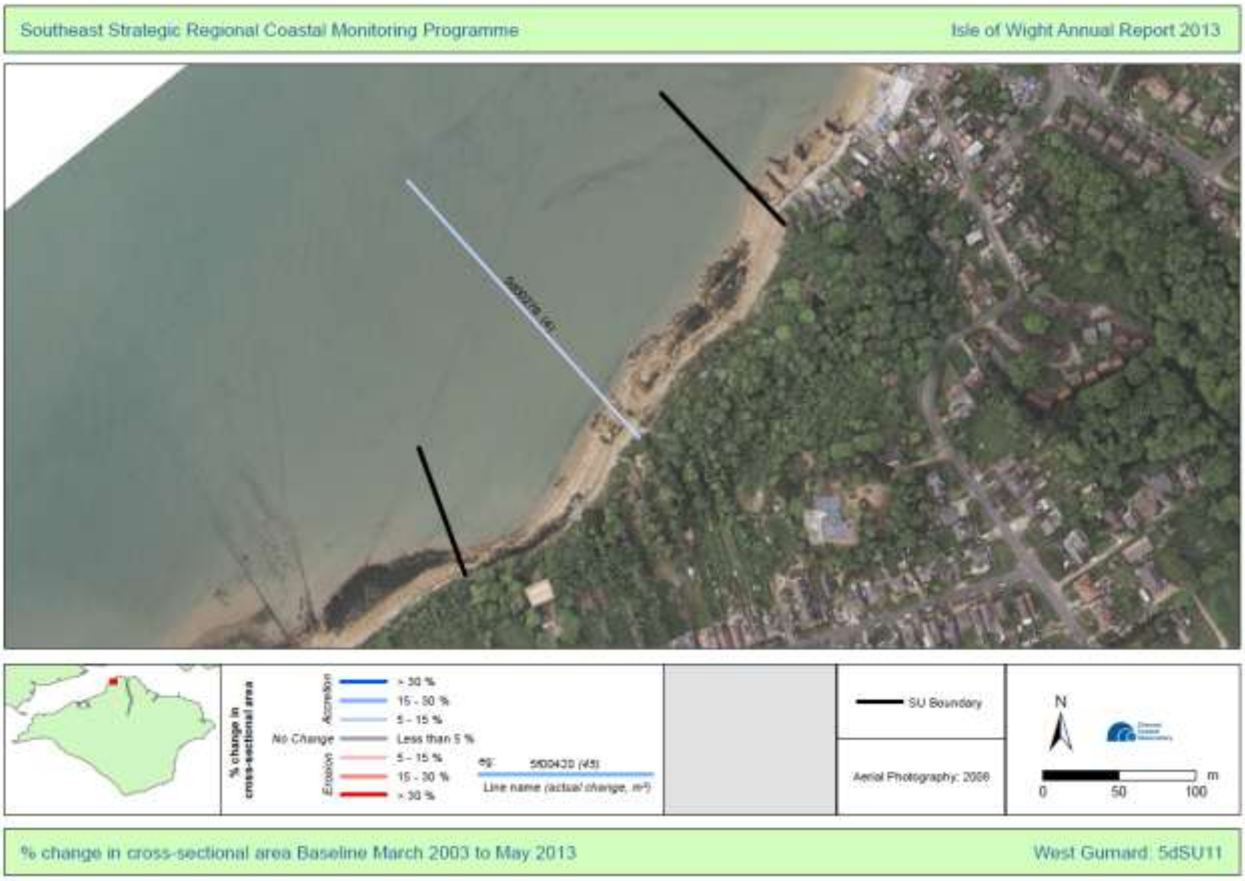
5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

5dSU11 (NEW 5): West Gurnard

- *Spring 2012 to Spring 2013: The profile in this management unit shows minor erosion.*
- *Baseline Spring 2003 to Spring 2013: In the longer term minor accretion is evident along the entire profile length.*



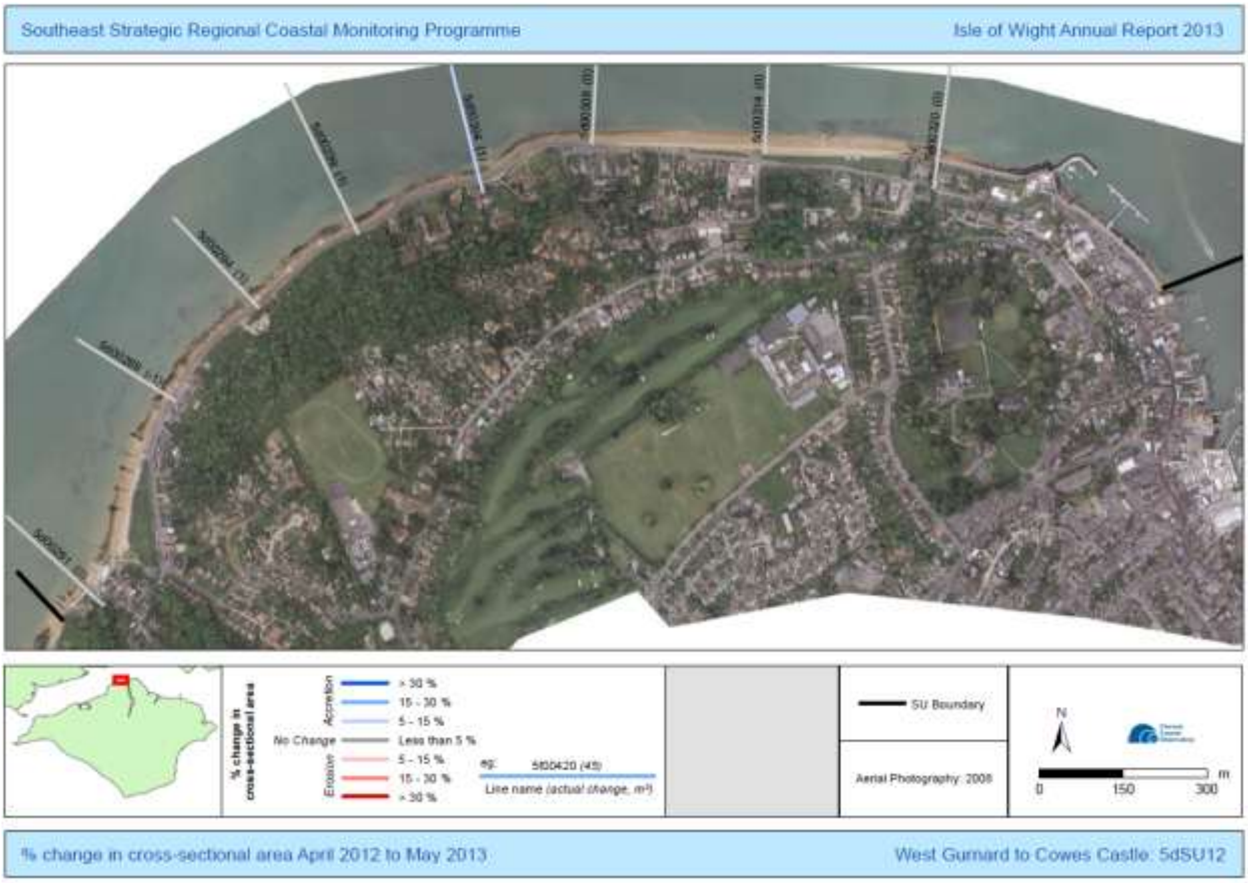
Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



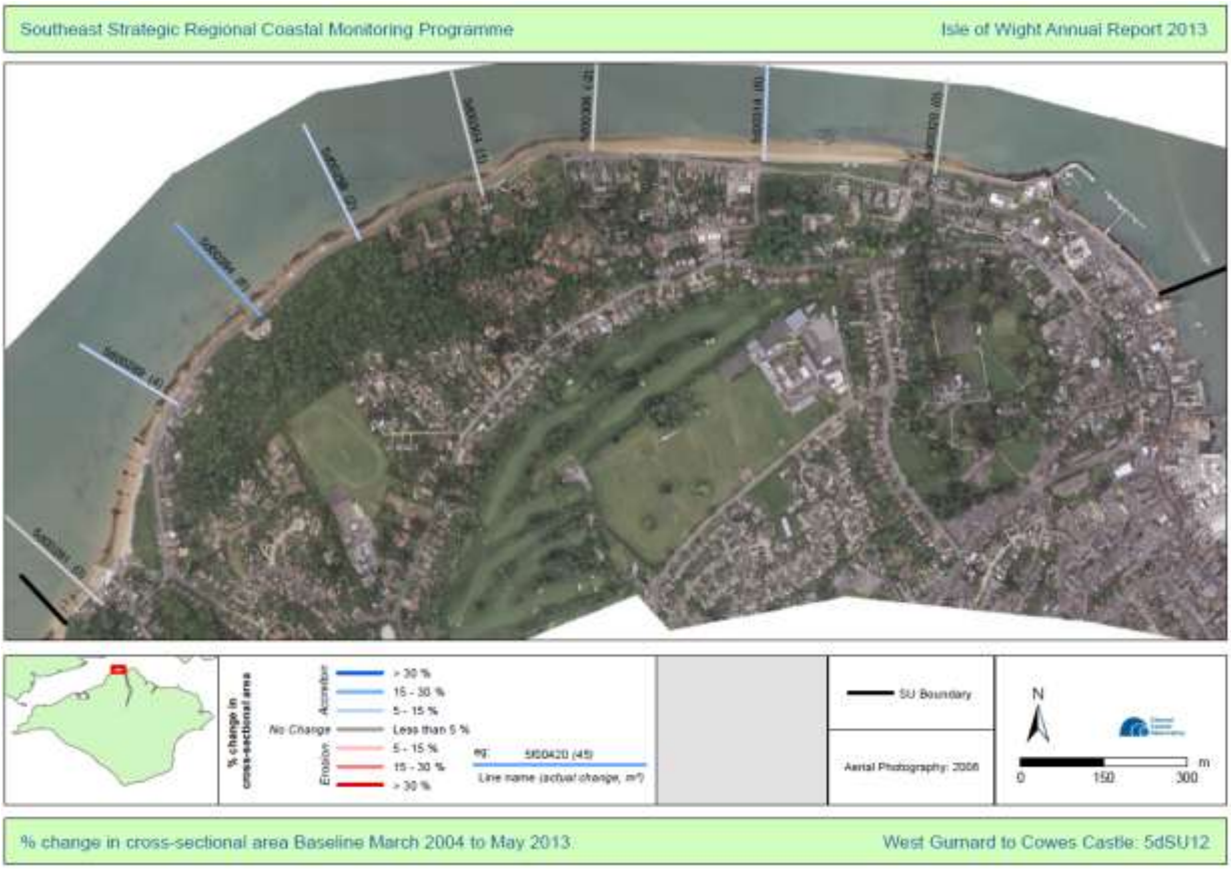
10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)

5dSU12 (NEW 11-13): West Gurnard to Cowes Castle

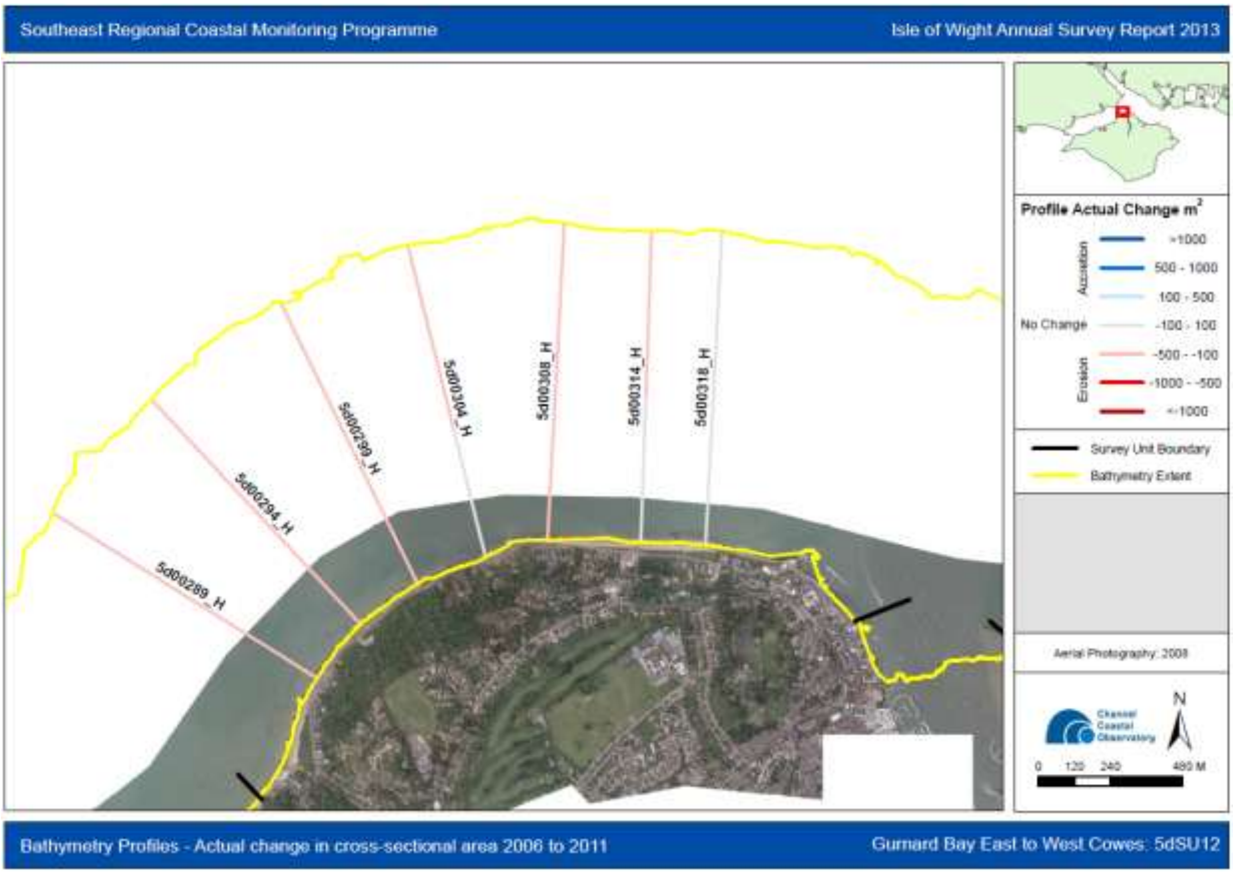
- *Spring 2012 to Spring 2013: All profiles in this unit show little change over the shorter timescale.*
- *Baseline Spring 2004 to Spring 2013: Most profiles in this survey unit have shown little change or minor accretion over the longer timescale. There has been minor erosion, less than 0.5m, to the top end of profile 5d00308.*



Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



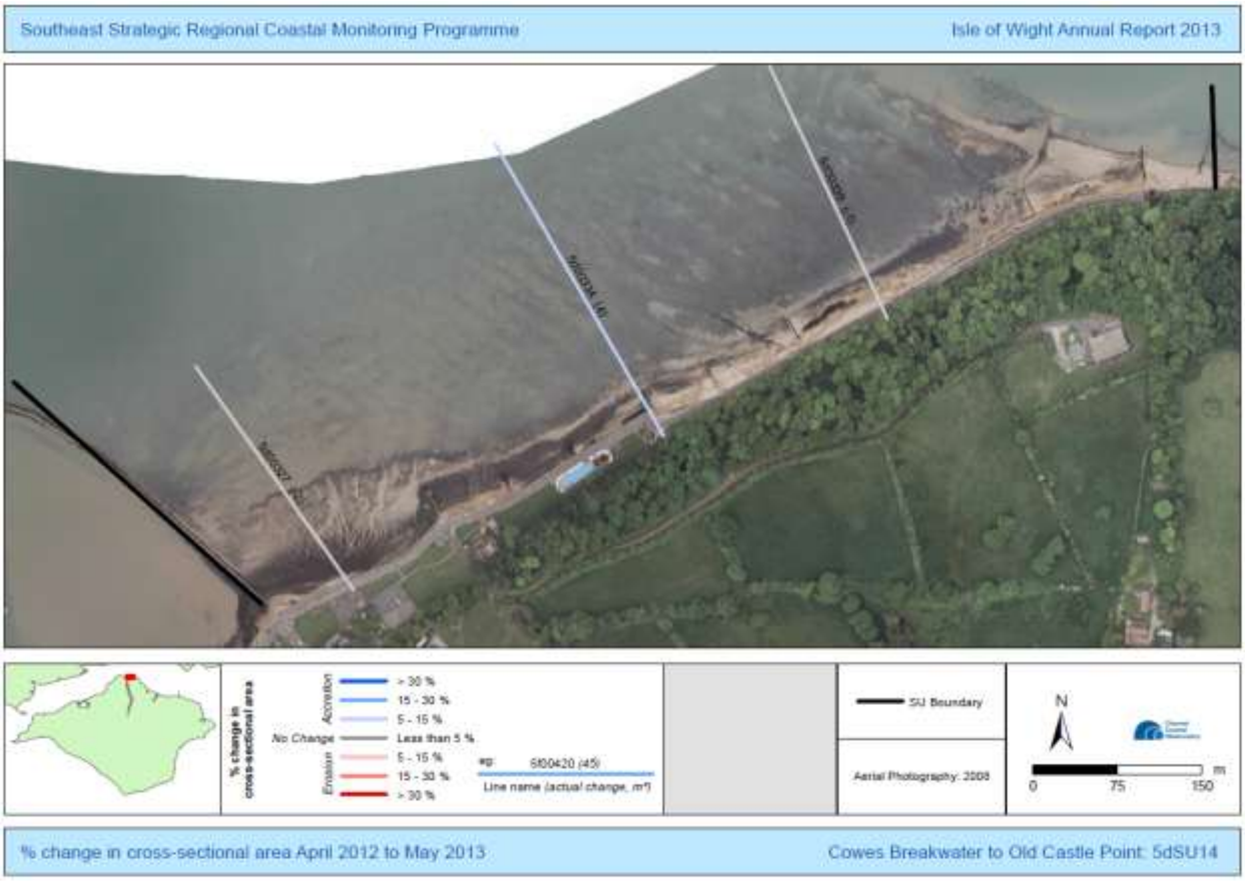
10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



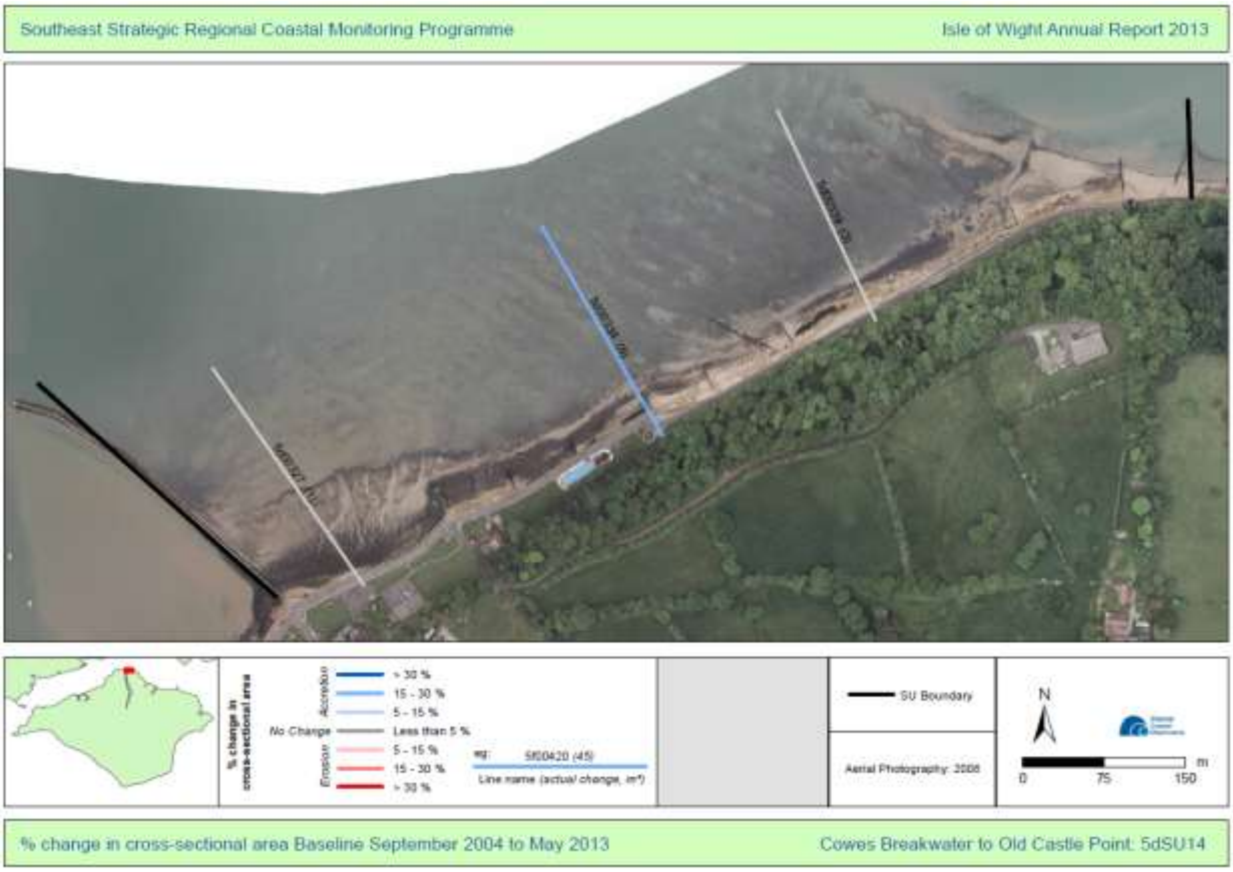
5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

5dSU14 (NEW15): Cowes Breakwater to Old Castle Point, East Cowes

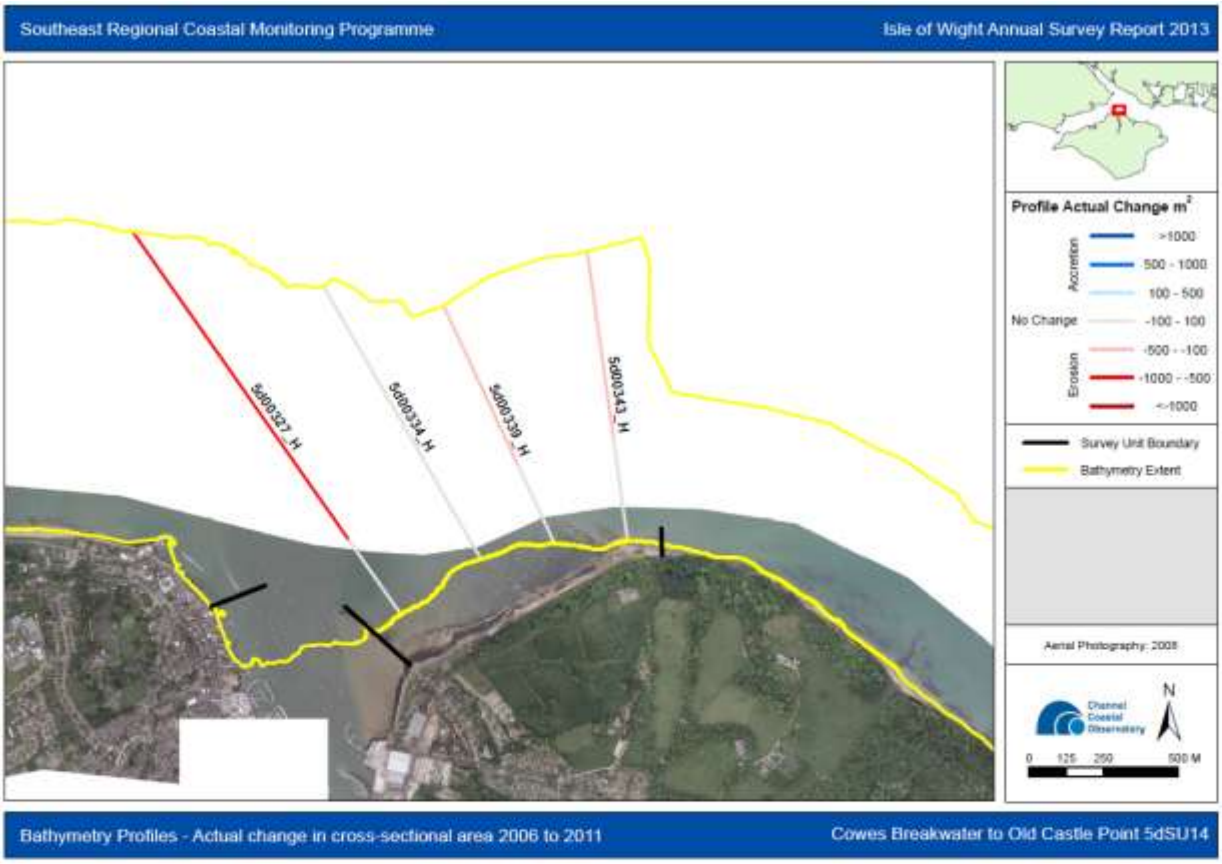
- *Spring 2012 to Spring 2013: Over the past year all profiles in this unit show less than 5m2 change in cross-sectional area. Profile 5d00334 shows 0.8m accretion to the top end of the profile by the sea wall.*
- *Baseline Summer 2004 to Spring 2013: Over the longer timescale, since 2004, the majority of profiles have remained stable with all profiles showing some minor accretion.*



Annual percentage change in cross-sectional area of beach profiles, from 2012-2013 (CCO, 2013)



10-year percentage change in cross-sectional area of beach profiles, from 2003-2013 (CCO, 2013)



5-year change in the cross-sectional area of bathymetry profiles, from 2006-2011 (CCO, 2013)

Additionally, Hydrographic Surveys of the Media Estuary up to Newport Harbour have been undertaken for navigational purposes in 2007 and 2012 (for the Isle of Wight Council).

Shoreline Movement:
North of the small valley occupied by Gurnard Marsh, a partly active wooded coastal slope, located on Oligocene clays, marls and interbedded limestones, up to 35m in height is protected by revetments and sea walls, currently in generally poor condition. The slope continues east to West Coves, but to the east of Gurnard slipway, it becomes less steep, and is protected at its toe by seawalls and an esplanade. Slope morphology comprises numerous bench-like irregularities, which indicate intermittent past and active seepage erosion and the presence of relic deep-seated and shallow landslides together with associated debris (Posford Duvivier, 2000; Isle of Wight Centre for the Coastal Environment, 2000, Hutchinson and Bromhead, 2002; Moore and McInnes, 2002, Hodges 2002). Although an average rate of cliffline recession of 1.5 to 3.0m/yr between approximately 1850-1950 is suggested by Hutchinson (1965), present conditions do not support such rapid recession of the entire cliff. It could be that the rates quoted relate to local areas where formerly inactive landslides have rapidly reactivated upslope.

Between Egypt Point and West Cowes the upper coastal slopes exhibit evidence of instability, but the toe has been protected by an esplanade and sea wall since 1894, so no contemporary sediment supply occurs (Hydraulics Research, 1977a; Hutchinson, 1965; Halcrow, 1997; Posford Duvivier, 2000; McInnes 2008) so long as it maintains its function. A low shoreface erosion rate of 1,300m^3/yr (Posford Duvivier, 1999) is a function of protection from high-energy waves. It should be noted that increases in winter rainfall (effective precipitation) that are likely to result from future climate change could have serious implications as it would raise groundwater levels, potentially causing more widespread reactivation of the coastal slope along this frontage (Halcrow Maritime et al, 2001).

Predictions of Shoreline Evolution:
Futurecoast (2002) estimated that without defences, the toes of the coastal slopes would be likely to be eroded at slow to moderate rates. Over 30 to 100 years, this could remove support and destabilise the relict landslides on the slopes above. The frontage from Gurnard to the Royal Yacht Squadron is most exposed to wave attack and also supports the steepest slopes, suggesting that it may be the most vulnerable to future re-activation.

The morphology of the active cliffs at Thorness may provide an analogy for the type of morphology that could ultimately form, although a lengthy time period of 50 to 100 years could be required for such a transition. The full re-activation process could involve rapid but intermittent inland migration of the active cliff scarp by up to 200m. It should be noted that although the full re-activation process could involve relatively long timescales the initial ground movements could occur quite rapidly following the onset of toe erosion. Areas affected would be highly localised and related to the distribution of relict landslides on the slopes. Although toe erosion would prepare the slopes for instability, the re-activation events themselves would most likely be triggered by high groundwater levels.

Although the toe of coastal slope is protected in some areas, with present management practices landsliding processes could still be re-activated due to rainfall increasing the pore water pressure in the cliffs. Present re-activations are concentrated around Gurnard Bay, so this area may be the most sensitive to this factor.

The Medina Estuary appears to be capable of continuing to accrete fine sediments and the saltmarsh has been relatively stable since the 1980s, Since this is a valley type estuary with relatively steeply sloping margins the saltmarsh is likely to be sensitive to future climate change and sea-level rise unless vertical accretion can compensate (Halcrow Maritime et al, 2001).

Erosion rates and detailed **predictions of future shoreline change** (including the **'No Active Intervention'** and **'With Present Management' scenarios**) were developed by the Isle of Wight Shoreline Management Plan in 2010. This forms the best available co-ordinated information for this frontage, so this information is provided in full in Appendices A and B of this report –please see below (re. units IW55 to IW59, and IW1).

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Appendix A: Coastal erosion rates, from the Isle of Wight Shoreline Management Plan 2, 2010

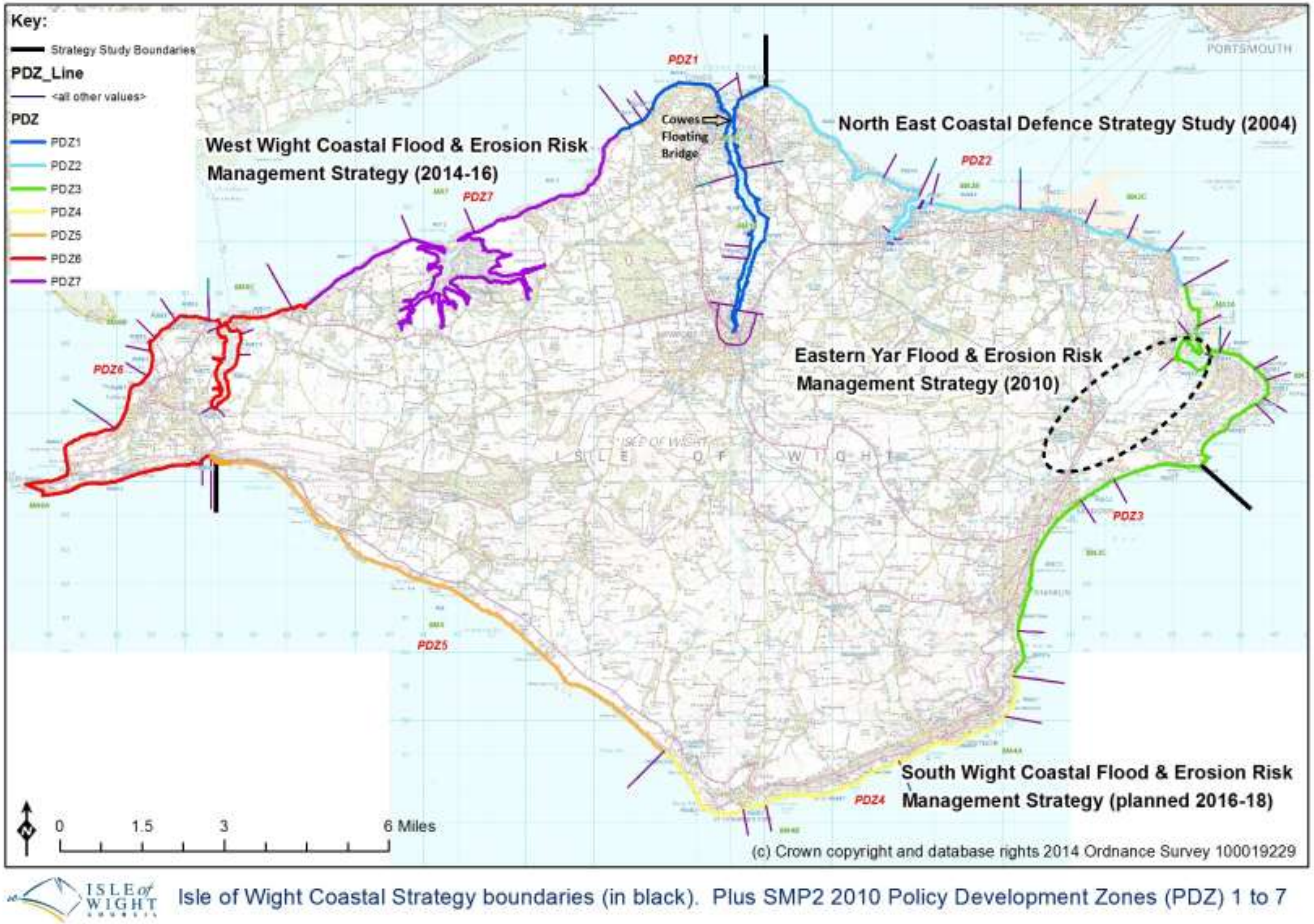
Introduction

The Isle of Wight Shoreline Management Plan 2 (2010) reviewed a wide range of data to define current and potential rates of coastal erosion and cliff retreat along the Isle of Wight coast using the best available information. It also provided a range of scenarios of future coastal change along the coastline. Appendices A and B of this report provide a copy of this information. Further information from the SMP is available at www.coastalwight.gov.uk/smp.

Appendices A & B organise the information using categories developed for the SMP2:

- Firstly, '**Policy Development Zones**' (PDZ). Three PDZs cover the coastline considered by the West Wight Strategy, numbers 1, 6 & 7. A map of these zones is shown below.

- Secondly, a numbered set of units, running clockwise around the coast, 1 to 59. A map of these '**IW' units** is also provided below, for reference.



Map showing the 'Policy Development Zones' used in the Isle of Wight SMP2, 2010 (see PDZ6 in red, PDZ7 in purple, & PDZ1 in dark blue).

*Map showing the location of the **'IW' units (in purple)** used in the Appendix below.*

*Nb. the map also shows the location of the SMP2 **Policy Units 'e.g. PU1A.1' (in blue)**.*

Appendix A1 -Potential Baseline Erosion Rates, from Isle of Wight SMP2, 2010

The SMP reviewed a wide range of data to define the current and potential rates of coastal erosion and cliff retreat along the Isle of Wight coast using the best available information. Full details can be found in Appendix C3 of SMP2 (2010). Future erosion rates were predicted using Walkden & Dickson formula (2008) and allow for future sea level rise –the full methodology is explained in the SMP2 Appendix. Predicted sea level rise rates of 4mm/yr (to 2025), 8.5mm/yr (to 2055), 12mm/yr (to 2085) then 15mm/yr (to 2105) were used, in accordance with SMP national guidance by Defra. These rates equate to 7cm of sea level rise (above the 2009 baseline) by 2025, 32cm by 2055 and 98cm by 2105.

The IW numbering units refer to lengths of coast for which future behaviour is described and mapped in the SMP2 Appendices (used to gather information for policy development). These are not the SMP2 policy units, which were subsequently developed by the SMP process.

Potential total erosion over the next 100 years is shown, however it is important to note that this is an estimate that is based on an undefended coastline.

The erosion rates were then applied following the predicted failure date of each individual element of the defences to create the erosion distances and descriptions provided in Appendix C3 of SMP2 (the 'Baseline scenarios of future change') -also provided as Appendix B of this West Wight Strategy report. Therefore Appendix B will show reduced erosion totals in some locations compared to the overview provided here.

Potential coastal erosion rates (all figures in metres/year), clockwise:-

PDZ 6 –West Wight

Numbering in SMP2 Appendices (2010) (no. & name, clockwise)		Historical Rate	Current to 2025	2025 to 2055	2055 to 2085	2085 to 2105	Potential 100 year erosion (if undefended) -total in metres	Notes
IW41	**Freshwater Bay**	0.30	0.35	0.46	0.53	0.58	48	
IW42	**Tennyson Down & The Needles**	0.25	0.29	0.38	0.44	0.48	40	
IW43	**Alum Bay**	0.30	0.35	0.46	0.53	0.58	48	
IW44	**Headon Warren**	0.30	0.35	0.46	0.53	0.58	48	
IW45	**Totland & Colwell**	0.50	0.58	0.76	0.88	0.96	80	Potential slope failure and landslip in this area.
IW46	**Central Colwell Bay**	0.50	0.58	0.76	0.88	0.96	80	
IW47	**Fort Albert**	0.50	0.58	0.76	0.88	0.96	80	
IW48	**Fort Victoria Country Park**	0.30	0.35	0.46	0.53	0.58	48	
IW49	**Fort Victoria & Norton**	0.30	0.35	0.46	0.53	0.58	48	
IW50	**Yarmouth Estuary**	0.10	0.12	0.15	0.18	0.19	16	
IW51	**Yarmouth Town & Bouldnor**	0.30	0.35	0.46	0.53	0.58	48	

PDZ 7 –North-west coastline

Numbering in SMP2 Appendices (2010) *(area and name,*	Historical Rate	Current to 2025	2025 to 2055	2055 to 2085	2085 to 2105	Potential 100 year erosion (if	Notes

clockwise)							**undefended) -total in metres**	
52	**Bouldnor Copse & Hamstead**	0.30	0.35	0.46	0.53	0.58	48	
53	**Newtown Estuary -western spit**	0.60	0.69	0.91	1.06	1.15	96	
	Newtown Estuary -eastern spit	0.62	0.72	0.94	1.10	1.19	99	
	Newtown Estuary -inside eastern spit	0.20	0.23	0.30	0.35	0.38	32	
54	**Thorness Bay (& cliffs west to meet Newtown gravel spit)**	0.40	0.46	0.61	0.71	0.77	64	

PDZ 1 –Cowes & Medina Estuary

Numbering in SMP2 Appendices (2010) *(area and name, clockwise)*		**Historical Rate**	**Current to 2025**	**2025 to 2055**	**2055 to 2085**	**2085 to 2105**	**Potential 100 year erosion (if undefended) - total in metres**	**Notes**
IW55	**Gurnard Luck**	0.30	0.35	0.46	0.53	0.58	48	
IW56	**Gurnard & Cowes Esplanade**	0.30	0.35	0.46	0.53	0.58	48	Coastal erosion could trigger potential landslide reactivation (approx. 2m/yr slope retreat); see Appendix C3 for details of the zone at risk.
IW57	**Cowes Parade & Harbour**	0.30	0.35	0.46	0.53	0.58	48	
IW58	**Medina Estuary**	0.10	0.12	0.15	0.18	0.19	16	
IW59	**East Cowes Outer Harbour**	0.10	0.12	0.15	0.18	0.19	16	
		NE Strategy Study Morphodynamic Unit No.		**Current to 2055**	**2055 to 2085**	**2085 to 2105**	**Potential 100 year erosion (if undefended)**	**Plus potential slope reactivation triggered by coastal erosion**
IW1	**East Cowes Esplanade**	1		0.26	0.31	0.34	29	n/a
		2		0.26	0.31	0.34	29	Plus 65m potential slope reactivation at end of epoch 1

Notes:

i) Erosion rates have been determined from monitoring data and examination of historical records and have been calculated to take account of sea level rise. –see Appendix C3 of SMP2 (2010) for details.

ii) The IW numbering units refer to lengths of coast described in Appendix C of SMP2 (2010). These are not SMP2 policy units.

Appendix A2 –Unconstrained scenario of coastal change, from Isle of Wight SMP2, 2010

The Isle of Wight Shoreline Management Plan 2010 also provided an overview of future coastal change along the coastline.

The **'unconstrained' scenario** provides a vision of how the coast could evolve if not controlled by man-made structures such as coastal defences. This is a key step in understanding the 'natural' response of the coast.

PDZ 6 –West Wight; Unconstrained scenario:
The Western Yar valley is vulnerable to tidal inundation if the beach and seawall in Freshwater Bay is overtopped and breaches. It is uncertain whether a breach would seal naturally, or whether the Western Yar valley would flood such that the land to the west would become an island separated by tidal flows between the West Solent and Freshwater Bay. Without defences cliff recession of the Chalk headland will continue with the small quantities of flints eroded from the northern facing cliffs comprising the main inputs of fresh gravels to the Alum Bay beach. Although at Headon Warren the upper cliff has been relatively stable over recent decades, it will be subject to reactivation of landsliding in the longer-term due to coastal erosion and groundwater. This could potentially occur at some point within the next century, although the presence of a considerable volume of debris material from previous failures provides a degree of protection at the cliff toe. Within Totland and Colwell Bays the unprotected frontage would erode rapidly, although the enhanced sediment supply arising would only partly enhance beach volumes because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades. The cliffs between Fort Albert and Sconce Point would continue to recede through mudsliding, with the fresh material largely transported offshore in suspension. From Sconce Point to Norton continuing foreshore erosion may in the long term cut into the relict coastal slope eventually triggering formation of low eroding cliffs over 30 to 50 years. This process is likely to be slow due to the low wave energy. Norton Spit is depleted and would be likely over the forthcoming 30 years to become subject to landward migration such that it would increasingly recurve into the estuary and possibly breach. This process may be slowed by sediment inputs released from updrift as recession processes within cliffs re-activate. However, the spit could migrate and breach before this potential sediment supply becomes fully active. Any breach in the spit could allow greater wave penetration into the Western Yar estuary. The Yarmouth shoreline is likely to retreat at slow to moderate rates as the foreshore is narrow and provides limited protection. Immediately east of Yarmouth there is the possibility that shore erosion could cut through into the lowland valley of Thorley Brook to produce a small new tidal inlet. This could potentially link to the Western Yar estuary leaving the town of Yarmouth as an island at high tide.

PDZ 7 –North-west coastline; Unconstrained scenario:
The trend for narrowing of the foreshore suggests that debris and cliff toe erosion will continue or intensify in the future and the cliffs remain unstable and actively eroding. Increases in sediment supply to beaches due to the acceleration of freely eroding cliffs would be unlikely to generate substantial protective beaches because most of the cliff materials are clay and mechanisms exist for seaward removal of these sediment grades. Instead, there may be very local increases in beach accumulation at Hamstead Duver and in Thorness Bay.

A breach in the eastern Newtown spit would be unlikely to seal naturally due to limited sediment supply, possibly resulting from the proximity of a local drift reversal and divide. Instead it is likely that the breach would enlarge in the short-term and the spit breakdown further as sea level rises. The corresponding western spit is rather more stable because it is sustained by a modest sediment supply from the cliffs to the west. It would be likely to remain static or slowly migrate into the harbour inlet. The effect of these changes would primarily be to permit increased wave penetration into the harbour with implications for the erosion of saltmarshes and mudflats.

PDZ 1 –Cowes & the Medina Estuary; Unconstrained scenario:
Without defences, the toes of the coastal slopes would be likely to be eroded at variable slow to moderate rates throughout the coastal areas of the PDZ dependent on the underlying landslide morphology and weak coastal slopes. This could remove support and destabilise the relic landslides on the slopes above along the Cowes-Gurnard frontage. The northern shore of the Isle of Wight is more sheltered than the south coast, however locally the frontage from Gurnard to the Royal Yacht Squadron is the most exposed to wave attack and also supports the steepest slopes, suggesting that it may be the most vulnerable to future re-activation. An adequate supply of sediment is important to maintaining the wildlife habitats of the Medina Estuary and although past work has identified that the estuary may be ‘sediment starved’ the estuary appears to be capable of continuing to accrete fine sediments in the upper reaches which appears to be getting sandier. As a consequence there has been a change in the invertebrate fauna to reflect this and a change in the birds feeding there. The rate of saltmarsh erosion has slowed considerably in recent years. Since this is a valley type estuary with relatively steeply sloping margins the saltmarsh is likely to be sensitive to future sea-level rise and coastal squeeze unless vertical accretion can compensate.

Appendix B: Baseline Scenarios of future shoreline change, from Isle of Wight SMP2, 2010

- **No Active Intervention scenario**
- **With Present Management scenario**

The Isle of Wight Shoreline Management Plan 2 (2010) provided a range of scenarios of future coastal change and examined their impacts.

Following on from the information provided in Appendix A above, Appendix B now provides a copy of the 'No Active Intervention' scenario and the continuing 'With Present Management' scenario of future shoreline change (including erosion rates and totals), as defined for the SMP in 2010.

A full introduction to these scenarios and the methodology for this work is provided in full in the Shoreline Management Plan, Appendix C3 (2010), available here: http://www.coastalwight.gov.uk/smp/FINAL_SMP_for_web/pdf_Appendices/AppendixC/Appendix_C3_BaselineScenarios_Dec10_Final.pdf

Please note: The unit numbering provided corresponds to the Map provided in Appendix A (the introduction to Appendix A) of this West Wight Strategy report.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
IW41 ***Name: FRESHWATER BAY*** ***From: Central Freshwater Bay, to the limits of the coastal defences.***	**No Active Intervention**	*Short description of predicted defence failure*	Freshwater Bay is a small low-lying embayment flanked by high Chalk cliffs, with 309m of coastal defences in the centre of the Bay preventing breaching of the barrier behind the beach and averting risk of a tidal connection developing between the West Yar estuary and Freshwater Bay. Defences generally consist of a reinforced concrete bull-nosed seawall with steel sheet-piled toe. Sections of the wall will fail in 10-15 and 15-25 years time.	Any remaining sections of seawall will be increasingly outflanked by erosion from the seawall breaches and fail at the start of this epoch. For the majority of the epoch, there will be no defences.	No defences.
		Description of cliff erosion/ reactivation	Freshwater Bay is a small low-lying embayment surrounded by high Chalk cliffs, formed where coastal recession has truncated a narrow valley, and a seawall in the centre of the bay protects the flat land of the Western Yar Estuary behind. The Western Yar is effectively an estuary whose freshwater catchment has been destroyed by historic coastal erosion. Without flood protection works the river would be open to the sea at both ends, and there is the potential for large scale inundation of properties in the town of Freshwater behind from the north and south. With no further maintenance or intervention, the coastal defences at Freshwater are predicted to fail from year 10 onwards, allowing erosion to begin at approx. 0.35m/yr (up to 3.5m in this epoch following defence failure) through the narrow barrier behind.	By year 20 undermining and breach of the seawall is expected, which may allow occasional sea flooding of headwaters of Western Yar in storm conditions. From years 20-50 the remaining sections of seawall will have fail and erosion at approx. 0.46m/yr advance through the barrier behind (approx. 14m during this epoch, or 16.5m since year 1) which will breach the barrier and lead to regular marine inundation and potential undermining of adjacent valley-side properties and flooding of upper Western Yar valley. Roads behind the bay and areas along Afton Road and School Green Road will be at risk.	From years 50-100 ongoing sea level rise and tidal inundation has the potential to separate the western headland of Freshwater, Tennyson Down, Totland and Colwell (west of the Western Yar valley) as a separate island from the rest of the Isle of Wight.
		Description of beach evolution	A shingle beach has accumulated within Freshwater Bay, a medium to steep, storm beach of flint cobbles with massive chalky accretions at western end of the Bay. Swell waves approach this coastline with minimal refraction, creating a substantial reflective beach that affords significant cliff toe erosion within the perimeter of the bay. However, a near-vertical cliff profile is likely to be maintained. The Strategic Monitoring Programme reveals that the western section of the beach has shown	A tidal breach will overtop and destabilise the beach at Freshwater Bay, encouraging lowering of beach levels and potential opening of a channel in front of any breach. It is uncertain whether a breach would seal naturally, temporarily, or whether the whole Western Yar valley could flood to lead to regular tidal flows occurring between the West Solent and Freshwater Bay.	Marine inundation of the Western Yar valley linking Freshwater and Yarmouth will destabilise any areas of remaining beach cobbles around Freshwater Bay, although beach materials may still be supplied into the inlet from erosion of Tennyson Down cliffs.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			significant erosion from 2003-2009 while the eastern section has remained stable. Over years 0-20, gradual lowering of beach levels due to sea level rise and increased storminess may expose the seawall increasingly to wave attack and undermining, although adjacent cliff erosion to the west will supply some flints and cobbles into the embayment. The groynes in the bay have already reached the end of their life at the start of the epoch, which will encourage transport of material to the eastern end of the bay and further contribute to undermining of the walls		
	With present management	*Short description of predicted defence failure*	309m of seawall protecting the town of Freshwater and the upper reaches of the Western Yar from marine inundation would be maintained and replaced.	Seawalls protecting the town of Freshwater and the upper reaches of the Western Yar from marine inundation would be maintained and replaced. Overtopping, especially towards the end of the epoch, has the potential to weaken the structure and the narrow land barrier behind.	Seawalls protecting the town of Freshwater and the upper reaches of the Western Yar from marine inundation would be maintained and replaced. More frequent overtopping will occur, generating flood risk to the coastal road behind the defences and properties.
		Description of cliff erosion/ reactivation	With maintenance of the current defences at Freshwater Bay at their current standard of protection, the present beach configuration would be maintained and flooding of the Western Yar valley from the south would be prevented.	With maintenance of the current defences at Freshwater Bay, the present beach configuration would be maintained and significant flooding of the Western Yar valley from the south would be prevented. Flood risk due to overtopping or tidal inundation from the north could still remain.	This scenario would maintain the existing flood protection from Freshwater Bay, but the risk and frequency of flooding, especially overtopping, would increase with rising sea levels, as would the risk of tidal inundation from the north (from Yarmouth).
		Description of beach evolution	Maintenance of the seawalls is not expected to have a significant effect on existing coastal processes. Foreshore narrowing may begin to occur, but the width of the beach could be maintained due to the pronounced embayment of the Bay retaining flints and cobbles released from Chalk cliff erosion to the west.	Foreshore narrowing is likely to occur in front of the defences, but beach levels may be maintained by additional beach feeding from neighbouring cliff erosion within the perimeter of the bay and from Tennyson Down.	Foreshore narrowing or beach lowering may occur due to sea level rise and increasing storminess, although beach levels could be maintained by additional beach feeding from neighbouring cliff erosion.
IW42 ***Name:*** **TENNYSON**	**No Active Intervention**	*Short description of predicted defence failure*	7.3km length of high, near vertical Chalk cliffs surrounding Tennyson Down which is open and undeveloped, including the Needles rocks at the western tip of the Isle of Wight.	No defences	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
DOWN & THE NEEDLES **The Chalk headland from Freshwater Bay to the southern edge of Alum Bay, including the Needles**			No defences. Fragments of masonry and concrete structures in the west of Freshwater Bay are not performing a significant coastal defence function.		
		Description of cliff erosion/ reactivation	Very steeply northward dipping Chalk sea cliffs developed by erosion of the Purbeck–Needles–Culver Chalk ridge. The Chalk cliffs of the Tennyson Down headland (up to 147m high) exert an important control on wider shoreline evolution, forming the resistant western tip of the Isle of Wight and providing shelter from dominant south-westerly wave climate to the north-western coast of the Island from the Needles and Cliff End, and to the northern and southern shores of the Solent. The cliffs adopt a simple linear form and fail mainly by rock falls of variable magnitude following over-steepening of the profile by toe erosion. Flint nodule bands present within the cliffs are released by erosion, but otherwise most cliff erosion products are removed in suspension by wave action. Cliff recession will continue at an average of approx. 0.29m/yr over the next 20 years (resulting in up to 6m of cliff top retreat). Along Tennyson Down large tension cracks will continue to appear landward of the cliff top, indicative of incipient large-scale toppling failures perhaps involving cliff top losses of 5-15m within single events.	Cliff retreat will continue, at approx. 0.38m/yr, causing a further 11m of cliff retreat over thirty years, or 17m in total since year 1. The recession process will be episodic with major cliff falls and long intervening periods of little activity. Erosion follows a cycle of basal undercutting, localised cliff falls that generate temporary accumulations of scree at the cliff toe, sub-aerial weathering whilst marine erosion removes the debris at the toe, allowing further undercutting to begin.	Episodic cliff retreat will take place at up to approx. 0.44m/yr then 0.48m/yr, as sea level rise attacks the base of the unprotected Chalk cliffs. Recession of approx. 23m over fifty years is anticipated, or 40m in total since year 1.
		Description of beach evolution	The narrow shoreline has a rocky foreshore with flint cobbles, with semi- continuous feed from fresh Chalk cliff fall debris, which will continue in future epochs. The cliffs are fronted by variable accumulations of Chalk debris according to recent cliff-falls and generally descend directly to deep water (without a significant shore platform), with high energy wave attack on the southern face allowing break-down of cliff fall debris more rapidly than on the northern face.	Sediment supply from fresh Chalk cliff fall debris will continue and increase, supplying flints and gravels to the beaches of Scratchells Bay, .Freshwater Bay and Alum Bay.	Sediment supply from fresh Chalk cliff fall debris is likely to increase as sea level rise and wave attack at the cliff base increases the rate of undermining and erosion of the cliffs. Retreat of the headland may create new ‘Needles’ stacks, as some of the previous stacks erode and topple, leaving a sequence of the base of former sea stacks just underwater (a hazard to

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			The Needles marks a key sediment divide with sediment transport moving north-east and south-east along this peninsula to the northern and southern coasts of the Isle of Wight. Therefore there are no adjacent units which influence the episodic cliff retreat characterising this unit in future epochs. The cliffs on the south side of Tennyson Down and West High Down will continue to supply small quantities of flints to the foreshore of Scratchells Bay where an inaccessible shingle beach has accumulated, and some of which may enter Freshwater Bay or Compton Bay to the west. Erosion of flints from the northern side of the headland will supply small quantities of flints which are the main input of fresh gravels to Alum Bay beach (in the unit to the north). The headland controls the direction of tidal flows exiting from Hurst Narrows such that it influences the configuration of seaward parts of the Shingles Bank.		shipping).
	With present management	*Short description of predicted defence failure*	No defences	No defences	No defences
		Description of cliff erosion/ reactivation	See 'No Active Intervention' scenario above. The Needles marks a key sediment divide with sediment transport moving north-east and south-east along this peninsula to the northern and southern coasts of the Isle of Wight. Therefore there are no adjacent units which can influence the episodic cliff retreat characterising this unit.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.
		Description of beach evolution	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.
IW43	**No Active Intervention**	*Short description*	No defences occur along this 559m length of naturally evolving cliffs, with the exception of two	No defences	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
Name: ALUM BAY **Alum Bay beach, backed by cliffs**		*of predicted defence failure*	small structures -a concrete and sheet-piled structure at the base of the Chairlift and some limited rock armour at the base of timber access steps, both of which will fail during this first epoch.		
		Description of cliff erosion/ reactivation	Alum Bay is a west-facing bay cut into soft Palaeocene and Eocene sand and clay sediments. The geological strata dip steeply northward and overlie the older Chalk. Composed of interbedded cycles of clay, silt and sand the 60m high cliffs form generally steep profiles that erode readily by rock fall, gullying, translational slides and occasionally mudsliding (immediately north of the Chalk. The extremely limited outcrops and rapid variations create the famous multi-coloured cliffs and sands of Alum Bay, giving rise to the holiday park located on the cliff top. Over the next 20 years, increased marine erosion and cliff face weathering is likely to cause cliff retreat at approx. 0.35m/yr (or 7m in total).	Cliff retreat will continue, at an average of approx. 0.46m/yr, although local variation will occur through the steeply dipping clay silt and sand cliffs, as adjacent failing units undermine each other.	Erosion will continue and increase to rates of approx. 0.53m/yr then 0.58m/yr, creating cliff top retreat of approx. 27m between years 50-100, or 48m in total since year 1.
		Description of beach evolution	A steep and relatively narrow shingle beach provides partial protection at the cliff toe. Flint nodules within the Chalk cliffs to the west will be released by erosion and supplied to the beach in Alum Bay. Alum Bay, Totland Bay and Colwell Bay to the North each behaves as a relatively independent pocket beach, principally fed by sediment inputs from erosion of the local cliffs. Sands, clays and occasional grit and pebble horizons are supplied to the foreshore by cliff falls, flows and mudslide, but much of the material yielded is too fine to remain on beaches and is transported seaward. Limited littoral drift is to the north, towards Headon Warren and Totland Bay, although foreshores linking the bays are rocky.	Significant sediments will be released by erosion and retreat of the cliffs, although increased beach steepening of the rocky shore is likely to occur.	Active cliff erosion will increase sediment supply to the local beach, and increase flint sediment inputs from the short section of eroding Chalk to the west.
	With present management	*Short description of predicted*	No defences occur along this 559m length of naturally evolving cliffs, with the exception of two small structures -a concrete and sheet-piled	No defences	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		defence failure	structure at the base of the Chairlift and some limited rock armour at the base of timber access steps, both of which will fail during this first epoch. These structures are provided for access and do not play a significant role in coastal protection, therefore their future maintenance cannot be assumed.		
		Description of cliff erosion/ reactivation	See 'No active intervention' scenario above.	See 'No active intervention' scenario above.	See 'No active intervention' scenario above.
		Description of beach evolution	See 'No active intervention' scenario above.	See 'No active intervention' scenario above.	See 'No active intervention' scenario above.
IW44 ***Name:*** **HEADON WARREN** **From: Alum Bay (northern edge)** **To: south of Widdick Chine, Totland Bay**	**No Active Intervention**	*Short description of predicted defence failure*	No defences along this 1954m frontage of active and undeveloped coastal slopes.	No defences	No defences
		Description of cliff erosion/ reactivation	Northward of Alum Bay, at Headon Warren, the topography rises considerably to a headland of 120m fronted by a series of complex landslips and partially active scarps forming coastal slopes within a near-horizontal interbedded sequence of clays, sands and thin limestones, facing west and northwards. The cliff toe is sensitive to marine erosion and overall recession rates can be rapid. A wide multiple bench and scarp morphology has developed and failures occur both by mudsliding over the benches and periodic deep-seated failures of backing scarps. The soft limestones are of significance as they break down into boulders that afford some short-term protection to the cliff toes and have resulted in emergence of Hatherwood Point as a local headland. Retreat events are episodic and are interspersed between prolonged inactive periods at the cliff top, during which detached blocks are	Marine erosion will continue to cause toe erosion of the coastal slopes at approx. 0.46m/yr, which together with cliff face weathering will promote conditions of instability, therefore the cliffs will continue to erode episodically through landsliding behaviour. Retreat of 14m is likely to occur during this epoch, or 21m in total since year 1. Cliff top retreat at the southern edge of Totland (at the northern boundary of this unit) is likely to endanger cliff top properties –see the unit below for more information.	At Headon Warren the upper cliff will become subject to re-activation of landsliding in the longer-term future. This could potentially occur at some point within the next century, although debris material from previous failures will provide a degree of protection at the cliff toe. Erosion will continue at a rate of approx. 0.53m/yr followed by 0.58m/yr, causing coastal retreat of approx. 27m during this fifty year epoch, or approx. 48m in total over 100 years. Cliff top retreat at the southern edge of Totland (at the northern boundary of this unit) is likely to endanger cliff top properties –see the unit below for more information.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			transported down to the shore on the lower sloped. Episodic seaward movement of landslide lobes can temporarily advance the shoreline. Coastal retreat at an average of 0.35m/yr is anticipated (or a total of 7m retreat over 20 years).		
		Description of beach evolution	A wide range of sediment grades will be supplied to the shore by coastal slope failure, although fine sands, silts and clays are susceptible to rapid suspended transport offshore. Limited coarse sands and gravels contribute to beach volume. Limestone boulder aprons at the shoreline significantly will interfere with drift, although some sands and gravels drift north-eastwards into Totland Bay.	The narrow, rocky shore will continue to be supplied by local erosion and increasing slumping of the coastal slopes. The unconstrained shoreline will continue to evolve naturally.	Sea level rise may result in gradual narrowing of the rocky foreshore, although larger scale activation of slumping and landsliding is likely to increase sediment supply to the shore periodically. Episodic seaward movement of landslide lobes may temporarily advance the shoreline and interrupt the limited sediment transport to the north-east.
	With present management	*Short description of predicted defence failure*	No defences	No defences	No defences
		Description of cliff erosion/ reactivation	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.
		Description of beach evolution	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.
IW45 ***Name:*** **TOTLAND & COLWELL** **From:** **Totland Bay (from south**	**No Active Intervention**	*Short description of predicted defence failure*	1973m of seawalls, promenades and cliff drainage schemes help to stabilise the reactivating developed coastal cliffs in Totland Bay and southern Colwell Bay. The solid defences commence at Widdick Chine, Totland, and extend northwards continuously into Colwell Bay. The defences comprise sequence of concrete seawalls with steel sheet-piled toes, often with wave return and stepped concrete apron. Residual life of the seawalls along the	Any sections of seawall remaining between the breaches will fail at the start of this epoch, after which time, the frontage will be undefended.	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
of Widdick Chine) **To:** **Colwell Bay (Sea View Road)**			frontage is often 15-25 years, but in central Totland Bay there are sections which are showing cracking and rapid deterioration which may fail in as little as 5-7 years and 10-15 years. Timber groynes will provide some additional protection along the frontage for 8-12 years or 10-20 years, dependent on condition. North of Totland Pier to Warden Point a small area of rock groynes and some rock armouring are present (residual life 15-25 years). The northernmost defences in Colwell Bay comprise a timber boarded breastwork with rock fill behind and limestone/gravel infill providing support to the base of the coastal slope (residual life 15-25 years).		
		Description of cliff erosion/ reactivation	Totland Bay and Colwell Bay are two north-eastward facing embayments backed by eroding soft rock cliffs and occupied by narrow pocket beaches of sand and shingle. The cliff line comprises partially vegetated cliffs of weak sands and clays, some of which are characterised by hydrogeologically-driven slumping failures; the cliff height reduces from 30m-25m in Totland Bay to 5m towards central Colwell. Warden Point, a local headland that is defined by the presence of resistant limestone foreshore reefs, separates the bays. The cliffs of Totland and southern Colwell Bays presently form relatively steep, partly vegetated slopes following protection of their toes by defences. Although the intention has been to stabilise the cliffs, in many places this has not been achieved fully because significant landsliding has occurred within the slopes above the seawalls, resulting in some cliff top recession, which will be subject to rapid retreat after the seawalls fail in 15-25 years, and some sections will be exposed when sections of the seawall within Totland Bay continue to deteriorate and may fail in 5-7 years and 10-15	Complete destruction of the remaining sections of seawall along this frontage at the start of the epoch will result in reactivation of cliff instability and undermining of the weak sand and clay cliffs along the whole frontage. The erosion rates of approx. 0.76m/yr during this epoch continue retreat at the cliff top, assuming the form of the cliffs remains similar. The undefended coastal cliffs in northern Colwell Bay provide a useful example of the behaviour that can be anticipated. Further cliff recession of 23m is therefore likely to occur during this thirty year epoch from 20-50 years, resulting in 26m to 32m of erosion in total since year 1. Cliff recession will pose risks to cliff top development, particularly in the south of the bay near the limit of the coastal defences.	Complete reactivation of coastal slopes with episodic landsliding and ongoing retreat of the sea cliff line into developed cliff top frontages. Cliff top properties will be affected during this epoch. Retreat rates of approx. 0.88m/yr then 0.96m/yr will result in approx. 46m of erosion from 50-100 years, or approx. 72-78m in total over 100 years.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			years. Prior to seawall failure, slumps will occur onto the seawall. Following seawall breach, erosion at 0.58m/yr will lead to between 3m and 9m of coastal retreat over the next 20 years dependent on when the different sections of seawall fail. By the end of epoch 1 or early in epoch 2 any stabilised cliff foot sediments will be lost and there will be a reversion to 'natural' cliff line retreat and reactivation of cliff instability providing sediment input.		
		Description of beach evolution	Gently sloping sandy (and in parts clay) foreshore. Beaches have suffered losses of sediment and lowering and narrowing over the past century, and deep water often extends to the toes of the seawalls. The Strategic Monitoring Programme records that in the shorter term, from 2004-2009, the beaches in this unit are generally stable or accreting, although there is erosion in the centre of Totland Bay (south of the Pier). Through the first epoch the frontage will be characterised by a gradual steepening in beach levels leading to increased exposure of the sheet-piled toes to the seawalls along this frontage. There will be no direct sediment inputs into this frontage whilst the seawalls remain. Once erosion commences after seawall breech and failure, additional sediment input may benefit adjacent areas. Totland Bay and Colwell Bay behaves as a relatively independent pocket beaches, principally fed by sediment inputs from erosion of the local cliffs, with some sediment feed from Headon Warren to Totland Bay. Much of the material yielded is too fine to remain on beaches and is transported seaward. Limited littoral drift is to the north.	Toe erosion of the exposed cliffs will promote conditions of instability, exacerbated by generally declining beach levels. Increases in sediment supply to the foreshore will result, but this is unlikely to enhance beach volumes significantly because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades.	Increasing rates of cliff retreat will supply increasing quantities of sediments to the shore as sea level rises, although this may not be sufficient to counter trends of declining beach levels.
	With present management	*Short description*	The seawalls, groynes and slope drainage will be maintained and rebuilt at their current standards.	The defences will continue to be maintained and rebuilt.	The defences will continue to be maintained and rebuilt at a similar

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		of predicted defence failure			standard, although are likely to be insufficient to prevent cliff slumping and reactivation.
		Description of cliff erosion/ reactivation	Maintenance and replacement of the seawalls and defences will prevent widespread erosion and reactivation of the cliff line. Smaller scale slumps will occasionally deposit material from the cliff onto the seawall and beach. At the southern end of the unit, ongoing erosion and undefended cliff retreat over the next twenty years is likely to cause retreat of approx. 7m retreat adjacent to the line of the maintained defences. At the northern end of the unit, coastal retreat of approx. 12m will occur over the next twenty years, offsetting the coastline from the defended to undefended coast.	Widespread reactivation of the cliff line will be prevented, but the cliffs will become increasingly vulnerable to slumping and some areas of reactivation may occur. Overtopping of the seawall is likely to become more frequent towards the end of the epoch. With present management practices continuing, the defences will reduce the frequency of landsliding events within the backing sea cliffs, but are unlikely to completely eliminate instability where high groundwater levels are a factor. Periodic slope failures will therefore still occur. The fronting beaches will continue to narrow along defended frontages resulting in increasing exposure of defences to wave energy. In combination, these potentially increasing stresses from landward and seaward could significantly reduce stability of the structural defences and consequently trigger further landslides within the sea cliffs, leading to cliff top retreat and increasing damage to the structures. It is likely that shoreline stability cannot be sustained at these locations with current management practices so that significantly improved defences or an alternative management approach would be required in the short to medium term (20 to 50 years). At the southern end of the defences continued cliff retreat of a further approx. 14m is likely to occur (approx. 21m in total since year 1). Coastal slope failure will place properties at risk at the southern limit of the current defence line.	Cliff toe erosion and widespread reactivation of the cliff line will be minimised by the seawall and defences, but increasing winter rainfall and frequent overtopping of the seawalls will have an increasingly adverse impact on cliff stability. At the southern end of the defences continued cliff retreat of a further approx. 27m is likely to occur (approx. 48m in total since year 1). Coastal slope failure is likely to affect cliff top properties. At the northern end of the unit, coastal retreat of a further approx. 46m will increase the offset of the coastline to a total of approx. 80m from the defended to undefended coast.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
				At the northern end of the unit, coastal retreat of a further approx. 23m will increase the offset of the coastline to a total of approx. 34m from the defended to undefended coast.	
		Description of beach evolution	If defences are maintained, there will no freely eroding cliffs along the frontage and no direct sediment inputs to the beaches (with the exception of minor slumps of the coastal slope, which would not provide any significant sediment input). The rate of sediment movement northwards along this frontage is very slow. Continuing to 'hold the line' will not change the existing situation. Low beach levels and foreshore narrowing are likely. This frontage will benefit from small sediment inputs from the south-west, but sediment transport will be hindered by groynes and may be prevented completely by Warden Point.	The fronting beaches will continue to narrow along defended frontages resulting in increasing exposure of defences to wave energy.	Foreshore narrowing will continue in front of the defences and low beach levels expose the weakened defences. This frontage may benefit from increased sediment inputs derived from slope failure along Headon Warren to the south-west, but sediment transport will be hindered by groynes and may be prevented completely by Warden Point.
IW46 ***Name:*** **CENTRAL COLWELL BAY** **From: Colwell (Sea View Road)** **To: the southern end of Fort Albert coastal**	**No Active Intervention**	*Short description of predicted defence failure*	757m frontage which is generally undefended, with some development along the cliff top. A field of timber groynes with rock stubs have now been rendered ineffective through cliff retreat.	No defences	No defences
		Description of cliff erosion/ reactivation	Colwell Bay is characterised by eroding low clay cliffs (15-25m) showing consistently rapid retreat. Coastal slopes in clays and sands at 20-30^0 are prone to slumping and shallow slides. The unprotected cliffs of central and northern Colwell Bay are composed of soft permeable strata overlying impermeable clays in a classic landslide-generating sequence. Rapid seepage erosion, simple landslides and occasional deeper-seated failures are the main recession mechanisms. A wider degradation zone and	Ongoing recession of the soft cliffs will affect cliff top developments. Further cliff recession of 23m is likely to occur during this thirty year epoch from 20-50 years, resulting in 34m of erosion in total since year 1.	Rates of coastal retreat will increase due to the impact of sea level rise and wave attack. Retreat rates of approx. 0.88m/yr then 0.96m/yr will result in approx. 46m of erosion from 50-100 years, or approx. 80m in total over 100 years. Loss of the headland protection of Fort Albert in the unit to the north would increase erosion in Colwell Bay.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
defences			increased propensity for mudsliding is evident closer to Fort Albert. **T**he presently active cliffs will continue to erode rapidly, at an average rate of approx. 0.58m/yr, resulting in 12m of cliff retreat over the next 20 years. Episodes and areas of even faster retreat may also occur.		
		Description of beach evolution	Gently sloping sandy beach is backed by eroding cliffs. Colwell Bays behaves as a relatively independent pocket beach, receiving sediment inputs from erosion of the local cliffs within the bay. Much of the material yielded is too fine to remain on beaches and is transported seaward. Beaches have suffered losses of sediment and lowering and narrowing over the past century, although the Strategic Monitoring Programme records that from 2004-2009 the beaches in this unit are generally stable. The presently active cliffs will continue to erode rapidly resulting in ongoing sediment supply to the foreshore, but this is unlikely to enhance beach volumes significantly because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades.	Local cliff retreat will continue to input fine sediments to the beach, but beach levels may still fall, reinforcing wave attack and cliff retreat. Sediment supplies from the renewal of erosion and retreat of the cliffs of Totland Bay and southern Colwell Bay (in the unit to the south) is likely to supplement local sediment input.	Increased sediment supply from local cliff recession will continue to input fine sediments to the beach, but beach levels could still fall if the majority of sediments are lost offshore, or due to the impact of sea level rise. Increased sediment supplies from the erosion and retreat of the cliffs of Totland Bay and southern Colwell Bay (in the unit to the south) will supplement local sediment input and supply beach materials.
	With present management	*Short description of predicted defence failure*	Undefended retreating cliff, fronted by several timber groynes currently detached from the cliff toe. These structures are redundant; therefore present management is essentially the same as the 'No Active Intervention' scenario.	No defences	No defences.
		Description of cliff erosion/ reactivation	The frontage will continue to evolve as outlined in the 'No Active Intervention' scenario outlined above. **T**he presently active cliffs will continue to erode rapidly, at an average rate of approx. 0.58m/yr, resulting in 12m of cliff retreat over the next 20 years. Episodes and areas of even faster retreat may also occur. The cliffs along this frontage	Ongoing recession of the soft cliffs will affect cliff top developments. Further cliff recession of 23m is likely to occur during this thirty year epoch from 20-50 years, resulting in 34m of erosion in total since year 1. At the southern and northern ends of the unit, coastal retreat will increase outflanking	Rates of coastal retreat will increase due to the impact of sea level rise and wave attack. Retreat rates of approx. 0.88m/yr then 0.96m/yr will result in approx. 46m of erosion from 50-100 years, or approx. 80m in total over 100 years. At the southern and northern ends of this unit, further coastal retreat of up to 46m

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			may also erode more rapidly as they will be further starved of sediments due to maintenance of the updrift defences in Totland and particularly in southern Colwell Bay. The enhanced sediment supply arising from erosion of the cliffs within this unit would only partly enhance beach volumes because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades. At the southern and northern limits of the unit, coastal retreat of approx. 12m over the next twenty years will offset the coastline and outflank the adjoining seawall and rock revetment.	of the adjoining defences to a total of approx. 34m.	will increase the outflanking of adjacent defences to a total of approx. 80m.
		Description of beach evolution	The presently active cliffs will continue to erode rapidly resulting in ongoing sediment supply to the foreshore, but this is unlikely to enhance beach volumes significantly because most of the cliff materials are sand and clay and mechanisms exist for rapid removal seaward of these sediment grades.	Local cliff retreat will continue to input fine sediments to the beach, but beach levels may still fall, reinforcing wave attack and cliff retreat. Continued maintenance of the seawalls in Totland and Colwell Bay to the south will prevent erosion and littoral drift input of sediment into this frontage.	Increased sediment supply from local cliff recession will continue to input fine sediments to the beach, but beach levels could still fall if the majority of sediments are lost offshore, or due to the impact of sea level rise. Continued maintenance and replacement of the seawalls in Totland and Colwell Bay to the south will prevent erosion and littoral drift input of sediment into this frontage.
IW47 ***Name:* FORT ALBERT** **From: southern to northern end of coastal defences around Fort Albert (Cliff End)**	**No Active Intervention**	*Short description of predicted defence failure*	Fort Albert at Cliff End (at the northern end of Colwell Bay) is an 809m defended frontage between two undefended units, protecting a prominent and distinctive headland characterised by residential development at the top and base of the weak coastal cliffs. An access road slopes steeply down the 25m high coastal slopes. Fort Albert is protected by lengths of (from south to north): masonry seawall (5-7 year residual life), rock armour (15-25 years residual life), steel sheet piling around the Fort itself (26-60 years residual life) and concrete seawall in the north (10-15 years residual life). Although the majority of defences will fail towards the end of the first epoch, the steel and concrete walls around the Fort itself are in a good condition and will remain	The concrete structure of Fort Albert could fail early in this epoch (with no further maintenance).	No defences.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			for approx. into epoch 2. Sections of the cliffs at Fort Albert have been artificially drained.		
		Description of cliff erosion/ reactivation	Fort Albert (Grade II* Listed Building) was built in 1856 and is located on the end of a promontory, and has now been converted into apartments. Coastal slopes in clays and sands at 20-30^0 are prone to slumping and shallow slides. Just to the south of Fort Albert frontage, a wider degradation zone and increased propensity for mudsliding occurs in the northern Colwell Bay cliffs. In this epoch there will be a gradual deterioration in the condition of the seawalls and steel sheet-piled defences leaving rock armour as the only form of protection later in the epoch, although Fort Albert itself is unlikely to be affected during this epoch. This will expose the shoreline and subsequently the foot of the coastal slopes to erosion at a rate of 0.58m/yr, resulting in approx. 3m to 9m of erosion in the first epoch, dependent on when the defences failed.	These processes will continue with the complete break-up of the remaining sections of seawall, promoted by wave attack and by undermining of the sheet-piled toe, with displacement of much of the rock armourstone, and potential loss of the Fort itself. Collapse of the walls and reversion to a natural soft cliff would be a major change, with potential destabilisation of the coastal slope and impacts on the adjacent coastline to the north and south which, to a degree, have been controlled by this prominent headland. Erosion of the foot of the coastal slopes will continue at approx. 0.76m/yr during this epoch, with further cliff recession of approx. 23m likely to occur during this thirty year epoch from 20-60 years (or 26m to 32m of erosion in total since year 1). Fort Albert itself could be affected from year 26 onwards when erosion could begin, but the structure may last into the third epoch.	Areas of the cliff top properties near the margins of the former defences would be at risk first over 100 years, due to the retreat of the top of the cliff as the cliff maintains its slope while its toe erodes, and erosion encroaches in from the undefended coast to the north and south. Erosion at approx. 0.88m/yr then 0.96m/yr will cause a further retreat of approx. 46m over years 50-100 (up to 78m over 100 years). Loss of the headland protection of Fort Albert would increase erosion in Colwell Bay.
		Description of beach evolution	Gently sloping sandy beach. The Strategic Monitoring Programme records that from 2004-2009 the beach to the south of the Fort Albert defences is relatively stable whilst the beach to the north of the Fort (in front of the seawall) has shown significant erosion, although shorter term variability also occurs. The north of the Fort is likely to see beach lowering and gradual exposure of the piled toe before the defences fail. Breaches in the seawall will begin to supply impounded sediment into the short frontage.	Failure of the defences and erosion of the stabilised platform at the base of the cliff, followed by cliff foot erosion, will supply some beach sediments into this unit, although these may be lost offshore and into the adjacent unit by weak northwards drift.	Cliff erosion will supply sediments to the local shoreline, but may not be sufficient to retain an effective beach. The base of the cliff is likely to be subject to wave attack.
	With present management	*Short description of predicted*	The 809m defended frontage around Fort Albert will be maintained, with seawalls and rock revetment repaired and replaced at a similar	Defences will be maintained and replaced, but are likely to be exposed by low beach levels.	Defences will be maintained and replaced, but will become increasingly vulnerable to sea level rise.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		defence failure	standard to at present.		
		Description of cliff erosion/ reactivation	Maintenance of the seawalls and defences will preserve the distinctive headland of Fort Albert and prevent active cliff toe erosion. Slumps of the weak cliffs are likely to occur behind the rock revetment in the south. Outflanking will occur at the southern and northern margins of the defences where erosion continues and the cliff lines begin to increasingly curve back away from the cliff toe defences (these zones already mark transitions to a more active coastal slope). Outflanking of up to approx. 12m is anticipated to the south, and approx. 7m in the north.	Cliff toe erosion will be prevented and will minimise but may not eliminate further slumps and reactivations within the soft rock coastal slopes behind the defences. Outflanking will increase at the southern and northern margins of the defences, where continued erosion will begin to cut back into the margins of the coastal slopes behind the defences as the adjacent coastal slopes are increasingly active. Outflanking of a further approx. 23m in the south during this epoch would take the total setback there to approx. 34m, and an additional 14m in the north would take the total step back there to approximately 21m.	Cliff toe erosion will be prevented but the coastal slope may destabilise due to encroaching coastal slope erosion from the north and south and increased winter rainfall raising ground water levels. Outflanking will increase at the southern and northern margins of the defences, where continued erosion will increasingly cut back into the margins of the coastal slopes behind the defences. Erosion of a further approx. 46m in the south during this epoch would take the total setback there to approx. 80m, and an additional 27m in the north would take the total step back there to approximately 48m.
		Description of beach evolution	Foreshore narrowing and lowering in front of the defences would be expected to continue. The frontage will be reliant on sediment supply from the eroding cliffs of Colwell Bay in the unit to the south. Weak littoral drift to the north-east occurs.	Foreshore narrowing and lowering in front of the defences will continue. Low beach levels will increase the vulnerability and exposure of the seawalls and revetment, which may also be vulnerable to episodes of overtopping. The frontage would be reliant on sediment supply from the eroding cliffs of Colwell Bay in the unit to the south, and the seawalls maintained in the south of Colwell Bay will prevent additional sediment supply during this epoch.	Foreshore narrowing and lowering in front of the defences would be expected to continue. Sea level rise, low beach levels, declining slope stability due to winter rainfall, adjacent erosion destabilising the coast slopes, more frequent wave attack and overtopping of the defences may trigger slope failures and supply limited quantities of sediment to the shore, but the principal control on the shoreline will be the sediment supply from Colwell Bay to the south and the offset caused by outflanking, which may trap potential sediment supply into the unit.
IW48 ***Name:* FORT VICTORIA COUNTRY PARK** **From:**	**No Active Intervention**	*Short description of predicted defence failure*	No defences. 742m length of undefended wooded and undeveloped coastal cliff and coastal slopes.	No defences	No defences
		Description of cliff erosion/ reactivation	Coastal slopes in clays and sands at 20-30^0 prone to slumping and shallow slides, rising to a 38m low headland inland of the frontage. Eroding soft rock cliffs and foreshore debris	In some areas the soft clays at the cliff toe appear to be eroded faster than the rate of supply of material from mudslides, thus lower slopes can be oversteepened and	Increased rates of erosion, slope failure and retreat will occur, at approx. 0.53m/yr then 0.58m/yr, leading to a further 27m of retreat during this epoch (or approx. 48m

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
northern end of Fort Albert coastal defences **To: Fort Victoria**			lobes are continuous from Fort Albert to Fort Victoria. The clayey materials of the cliffs degrade by mudsliding and simple translational slides, creating a shallow actively retreating coastal slope. The cliffs between Fort Albert and Fort Victoria (Sconce Point) will continue to recede through mudsliding and toe erosion, with trees slumping forward onto the foreshore on the beach south of Fort Victoria. Erosion at an average of approx. 0.35m/yr will cause 7m of coastal retreat over the next 20 years.	controlled by shallow failures. Aggressive toe erosion is leading to progressive reactivation of relict landslides upslope, so that the scale of landsliding is likely to increase in future as the full slope becomes active. Coastal erosion at approx. 0.46m/yr will lead to a further 14m of retreat during this epoch, or 21m in total since year 1.	coastal retreat in total over 100 years). North of Fort Albert extensive reactivation of the coastal slope can be expected promoting rapid cliff retreat.
		Description of beach evolution	Gently sloping sandy beach with scatterings of small boulders. The Strategic Monitoring Programme records that from 2003-2009 the beach to the south of Fort Victoria has shown areas of accretion and erosion, with no overall dominant trend. Input of sediment from active cliff erosion along this frontage during this epoch will supply predominantly clays with some sands and soft limestones to the shoreline, with small quantities of gravel. Strong tidal currents are effective in removing clayey debris that accumulates at the cliff toe with fresh material largely from being transported offshore in suspension. This coast is more sheltered from wave erosion than areas to the west, but is swept by rapid tidal currents of Hurst Narrows so relatively little beach material will accumulate. Sediment drift operates from west to east, but is weak due to limited fetches and shortages of shoreline sediments. Small to moderate quantities of fine sediments yielded by erosion of cliffs between Cliff End and Sconce Point are likely to be transported eastwards in suspension and potentially be available for transport into the Western Yar estuary.	Input of sediment from active cliff erosion during this epoch is expected to increase as erosion rates increase cliff stability declines. Fine sediments will be transported offshore or transferred north-eastwards, although some debris from cliff failures will contribute to local beach levels.	Input of sediment from active cliff erosion during this epoch is expected to increase through this epoch as the coastal slopes destabilise and cliff toe erosion triggers more frequent failures. Fine sediments will be transported offshore or transferred north-eastwards, although some debris from cliff failures will contribute to local beach levels.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
	With present management	*Short description of predicted defence failure*	No defences	No defences	No defences
		Description of cliff erosion/ reactivation	With present management practices continuing, the cliff behaviour described above under the 'No Active Intervention' scenario above will continue to occur. During this epoch approx. 7m of retreat adjacent to the defended coastal cliff at Fort Albert at the southern limit of the frontage will increase offset of the cliff top and cliff toe. At the northern limit of the unit the transition from undefended to defended coast at Fort Victoria is on flat grassy ground and a short stretch of timber structures provides some transition the hard defences, but the current offset of approx. 5m at the southern end of the hard seawall and defences may increase by 7m to approx. 12m by the end of this epoch.	See 'No active intervention' scenario above. Outflanking or offset of the cliff top and cliff toe at fort Albert will increase by approx. 14m during this epoch to 21m in total, creating a curved cliff profile linking the defended and undefended sections. At Fort Victoria, outflanking a further 14m may occur, increasing the step-back of the low coast to approx. 26m.	See 'No active intervention' scenario above. Outflanking or offset of the cliff top and cliff toe at fort Albert will increase by approx. 27m during this epoch to 48m in total, as erosion encroaches from the north of the adjacent defended frontage. At Fort Victoria, outflanking a further 27m may occur, increasing the step-back of the low coast to approx. 53m.
		Description of beach evolution	See 'No active intervention' scenario above. Due to the weak north-easterly drift, the majority of sediment along this frontage will derive from local cliff erosion and slope retreat within the unit, therefore will be largely unaffected by the seawalls maintained to the south-east.	See 'No active intervention' scenario above. Maintaining the promontory of Fort Albert will reduce additional sediment that may have been supplied into this unit during this epoch as the stabilised coast reactivated and small quantities of impounded sediment were released, but locally derived sediment will supply the beaches.	See 'No active intervention' scenario above.
IW49 ***Name:* FORT VICTORIA & NORTON** **From: Western edge**	**No Active Intervention**	*Short description of predicted defence failure*	1088m frontage backed by a ribbon of development and local coastal access road through gentle wooded coastal slopes, lower in profile than the unit to the south-west. A patchwork of ageing defences and short groynes are present along the majority of the shoreline. In summary, at the southern limit, low timber breastwork will fail in 5-7 years, and moving	Remaining sections of un-maintained seawall will fail at the start of this epoch, leaving the frontage undefended and exposed to erosion.	No defences.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
of Fort Victoria **To: Norton Spit**			north-eastwards around Sconce Point a series of continuous concrete and masonry seawalls will fail in approximately 5-7 years or 15-25 years. Moving east a short undefended section is protected by a shingle ridge, giving way to rock-filled gabions with short residual lives (some as little as 1-3 years). These rock structures front the most vulnerable section of the adjacent local coastal access road and ground movement in the gentle slopes is affecting the road surface. A more robust seawall fronts Norton Grange, with a residual life of 15-25 years. Destruction of groynes is anticipated throughout the frontage		
		Description of cliff erosion/ reactivation	Fort Victoria is an L-shaped defensive structure which marks a relatively abrupt change in coastal orientation from north-eastwards to eastwards towards Yarmouth. In the west the coastline is flat and grassy, giving way to the east to a shallow coastal slope in clays where much of the frontage is heavily wooded. Further east the land is low lying and gives way to a dune frontage at Norton Spit. As the coastal defences deteriorate and collapse over the next 20 years due to wave attack and undermining, erosion at approx. 0.35m/yr will be triggered in the breaches, with up to 5m of erosion occurring at the first locations of defence failure, with the majority of the frontage exposed to erosion by the end of the epoch, or soon after. In the adjacent unit to the east, a breakwater has been built eastward from the tip of Norton Spit to protect Yarmouth Harbour and the Western Yar estuary entrance.	From Sconce Point to Norton continuing foreshore erosion may in the long term cut into the relict coastal slope eventually triggering formation of low eroding cliffs over 30 to 50 years. This process is likely to be slow due to the low wave energy. Erosion at 0.46m/yr will cause coastal retreat of approx. 14m during this epoch, or up to 19 since year 1, resulting in the erosion of property and recreation beach, and further destabilising the local access road.	Continued erosion is likely to trigger some slope movements with erosion rates of approx. 0.53m/yr then 0.58m/yr resulting in an additional 27m of coastal retreat affecting additional properties (or retreat of approx. 46m in total over 100 years).
		Description of beach evolution	A narrow sand and shingle foreshore is exposed during mean low water in front of the coastal defences. A relatively wide shingle beach exists towards Norton, with deeper water fronting the Norton Grange seawall to the east. The Strategic Monitoring Programme records that the	Sediments will be supplied to the local beaches by renewed coastal retreat through the flat ground and gentle coastal slopes. Failure of the costal defences around Sconce Point (Fort Victoria) may allow increased northwards transmission of	Increased rates of sediment will be supplied by erosion, and may remain on the local beach or be transported eastwards towards North Spit and Yarmouth.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			beaches around Fort Victoria have been stable overall from 2003-2009, with the exception being some accretion near the eastern edge of the unit. Where defences remain during the first epoch, the upper shore would be held static by the structures, but slow rates of foreshore lowering and narrowing would continue due to sediment starvation. Weak littoral drift generally operates north eastward along the whole coast, but coast protection structures severely restrict drift transport at Fort Victoria. Local sediment input from the stabilised coastal platform and coastal slopes will increase as sections of the seawall fail over the next 20 years. From Fort Victoria to Yarmouth Harbour entrance the drift direction is presumed to be eastward, but beach levels are low and transported volumes are extremely limited, although the eastwards alignment of Norton Spit indicates that historically net drift has been eastward.	sediment from the actively eroding cliffs of Fort Victoria Country park to the south. Renewed erosion of this frontage may release shingle material into the system and could have a beneficial effect on Norton Spit to the east.	Tidal breach and marine inundation from the south coast to the north coast of the Island along the Western Yar valley could significantly affect the sediment regime within this adjacent frontage in the longer term.
	With present management	*Short description of predicted defence failure*	The series of seawall, groynes and gabions and timber revetment fronting Fort Victoria and Norton will be maintained and renewed.	The series of seawall, groynes and gabions and timber revetment fronting Fort Victoria and Norton will be maintained and renewed. There will be a risk of overtopping of defences, particularly later in the epoch.	The series of seawall, groynes and gabions and timber revetment fronting Fort Victoria and Norton will be maintained and renewed. Increased overtopping of the defences is likely to occur, increasing the risk of slope weakening behind the defences and breaching.
		Description of cliff erosion/ reactivation	Maintaining the line of defences will prevent renewal of erosion right along the frontage, but erosion and retreat can still occur at the undefended section in the centre of the unit, although this may be minimised by the presence of the shingle beach. Damage to the coastal access road is evidence of some slope movement occurring behind the current defences, and further damage to the road is likely.	Maintaining the line of defences will prevent renewal of erosion right along the frontage. Ground movements in the gentle coastal slope are affecting the road and may cause breaches of the fronting defences to occur, rendering the current gabions insufficient to prevent coastal change, although they could be reconstructed.	Maintaining the line of defences will prevent renewal of erosion right along the frontage, although some slope movements may still occur, but not to the scale of adjacent units to the south-west. At Fort Victoria, outflanking a further 27m may occur, increasing the step-back of the low coast to approx. 53m. Erosion of the undefended section in the centre of the

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			At the southern limit of the unit the transition from undefended to defended coast at Fort Victoria is on flat grassy ground and a short stretch of timber structures provides some transition the hard defences, but the current offset of approx. 5m at the southern end of the hard seawall and defences may increase by 7m to approx. 12m by the end of this epoch. Erosion of the undefended section in the centre of the unit may occur at approx. 0.35m/yr (outflanking adjacent defences by up to 7m over 20 years).	South of Fort Victoria, outflanking a further 14m may occur, increasing the step-back of the low coast to approx. 26m. Erosion of the undefended section in the centre of the unit may occur at approx. 0.46m/yr, causing outflanking of up to 21m by the end of this epoch.	unit may continue at approx. 0.53m/yr then 0.58m/yr, causing outflanking of up to 48m by the end of this epoch, which may extend eastwards if the sections of rock gabions are insufficient to prevent coastal reactivation.
		Description of beach evolution	Foreshore narrowing is likely to occur in front of the maintained seawalls and defences. The upper shore would be held static by the structures, but slow rates of foreshore lowering and narrowing would continue due to sediment starvation. Coast protection structures severely restrict drift transport from the south at Fort Victoria.	Foreshore narrowing is likely to occur in front of the maintained seawalls and defences. A small amount of fine sediment may be supplied by the erosion breach in the centre of the frontage but beach levels are expected to be low, exposing the defences to wave attach and occasional overtopping.	More frequent overtopping of defences with rising sea level together with low beach levels will increase the likelihood of breaches in the coastal defences, which were not designed to be sufficient for the coastal processes operating during this epoch.
IW50 ***Name:*** **YARMOUTH ESTUARY** **Western Yar Estuary, from Norton Spit to Yarmouth Castle**	**No Active Intervention**	*Short description of predicted defence failure*	Yarmouth Harbour is located at the mouth of the Western Yar Estuary. To the west of the harbour, Norton Spit is a natural feature which has been stabilised by timber breastwork and extended by a rock armour breakwater to provide shelter to the harbour behind (the harbour channel opens to the Solent at the far eastern end of the breakwater). Without maintenance, the stabilisation of the spit and breakwater are due to fail in 10-20 years time. To the east of the harbour, around the western edges of the town of Yarmouth (from the Castle to the Thorley Brook) a series of seawalls (masonry and concrete) and revetments (rock armour and gabions) have residual lives of 15-25 years, with the exception of two sections of steel sheet piling within the ferry terminal which will last for 26-60 years. Within the Yar Estuary scattered short lengths of wall and embankments will last for a maximum of 15-25 years.	Failure of the remaining (outflanked) sections of steel sheet piling around the ferry terminal is likely. No defences present along the majority of the frontage.	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			Defences are critical to the functioning of the commercial harbour and marina, which provides cross-Solent ferry services vital to the communities of the West Wight.		
		Summary of flood and erosion risk	The Western Yar Estuary is protected by a narrow sand and gravel spit extending east from Norton. The town of Yarmouth and ferry terminal were originally built upon a shorter former counterpart spit on the low-lying eastern bank. Yarmouth Castle is a Scheduled Monument. The defences and a large number of residential and non-residential properties are low-lying and vulnerable to flooding. A swing bridge carries the main road from Newport to West Wight across the Estuary mouth. The Western Yar Estuary runs inland 3km almost due south from Yarmouth towards Freshwater, with approx. 9.1km of frontage within the breakwater and estuary. There are extensive mudflats, marshes and reed beds. The Estuary almost dries at low water and effectively ends at the tide flaps under the Causeway bridge, beyond which there are reed beds. *Norton Spit & breakwater:* Norton Spit has retreated landward over the past century and is stabilised with a breakwater extension which provide protection from wave attack to the Western Yar outer estuary, but without maintenance, these structures may fail in 10-15 or 10-20 years time. Norton Spit is depleted and would be likely over the forthcoming 30 years to become subject to landward migration such that it would increasingly recurve into the estuary and possibly breach. This process may be slowed by sediment inputs released from updrift as recession processes within cliffs re-activate. However, the spit could migrate and breach before this potential sediment supply becomes fully active. Any breach in the spit could allow greater wave penetration into the Western Yar estuary and wave heights attacking the frontage	Loss of remaining coastal defences on the frontage is likely, alongside increasing inundation of low lying areas of Yarmouth town as a result of rising sea levels. Later in this epoch there is the risk of tidal breach through Freshwater Bay at the southern end of the estuary causing marine inundation from both ends of the Western Yar.	Increasing rise in sea levels may leave parts of the frontage under standing water at high water. Widespread inundation of the Western Yar estuary and adjacent land will occur regularly. Damage to properties, the main public highway and services will occur. Tidal breach through Freshwater Bay and marine inundation along the valley could potentially create a separate island of the West Wight peninsula, and both main road links across the valley will be lost or compromised by erosion and flooding.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			will increase. *Yarmouth Town & Harbour:* There is very significant and increasing risk to the western areas of the town of Yarmouth from increasing levels and frequency of tidal flooding. Tidal flooding already occurs at occasionally, inundating the ferry terminal, marshalling area and roads leading to the town square. In addition to the risk of marine inundation, some areas will become exposed to erosion. With no further maintenance or intervention the sea walls surrounding the town and harbour are expected fail in 15-25 years time, with some limited sections fronting the ferry terminal lasting longer, well into the second epoch. Following seawall collapse erosion will occur. An indicative erosion rate of 0.12m/yr increasing due to the impacts of sea level rise to 0.15, 0.18 and 0.19m/yr in future epochs is illustrated on the No Active Intervention mapping, due to the relative shelter of the inlet. Progressive erosion following failure of the hard defences in the vicinity of the harbour mouth is shown, but in essence, by the end of the first epoch (0-20 years) or early in the second epoch (20-50 years) the defences and sheltering structures protecting the mouth of the estuary are expected to have failed, opening up the estuary behind to wave attack, combined with widespread increasing flood risk. The ferry terminal would be unsafe should sections of the sea wall collapse from 15 years onwards through the second epoch. *Thorley Brook:* The low-lying valley of Thorley Brook runs parallel to the shore on the landward side of Yarmouth town. It will be increasingly inundated from the main estuary following failure of a seawall between the two in 15-25 years, increasing the risk of tidal flooding to parts of the south and east of the town.		
		Summary of	Morphology of the mouth of the Western Yar	There is potential impact on the tidal prism	There is potential impact on the tidal prism

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		estuary response	estuary indicates littoral drift towards the inlet on both sides, forming Norton Spit in the west (fronted by a sloping beach in fine sand), and very weak net westward drift over the sector to the immediate east of the inlet mouth (in contrast to the general pattern of eastward drift along the north-west coast of the Isle of Wight. The dominant flow in the Yar Estuary is during the ebb tide and it has been estimated that its sediment carrying potential is five times that of the flood. Fluvial transport from the Western Yar catchment is negligible with predominantly marine clays having partially infilled the estuary, although dominant flushing effect of the ebb current rapidly removes fine-grained sediments previously transported into the mouth. It is reported that sand can be transported into Yarmouth Harbour by strong northerly gales. The entrance to the Western Yar has been dredged on several occasions to maintain a navigable channel for car ferries. There is potential impact on the tidal prism and dynamics of the whole estuary due to changes to the estuary entrance following collapse of the breakwater. Since this is a coastal plain type estuary with relatively steeply sloping margins saltmarsh within the estuary is likely to be sensitive to future climate change and sea-level rise unless vertical accretion can compensate.	and dynamics of the whole estuary due to changes to the estuary entrance following collapse of the breakwater and increased inundation of Thorley Brook. Increased sands and sediments may be transported into the estuary mouth once it is opened to wave attack.	and dynamics of the whole estuary due to changes to the estuary entrance following collapse of the breakwater. Tidal breach through Freshwater Bay and marine inundation along the valley could alter the tidal regime around Yarmouth Harbour.
	With present management	*Short description of predicted defence failure*	Seawalls around Yarmouth town and Estuary would be maintained and replaced at their current standard.	Seawalls around Yarmouth town and Estuary would be maintained and replaced at their current standard.	Seawalls around Yarmouth town and Estuary would be maintained and replaced at their current standard.
		Summary of flood and erosion risk and estuary	Full details can be found under the 'No Active Intervention' scenario described above. Maintenance of the existing breakwater and	Maintenance of the existing breakwater and seawalls would prevent wave attack within the Estuary, but would not reduce high and increasing risk of flooding to Yarmouth Town	The breakwater and seawalls will continue to prevent wave attack within the Estuary, but would not reduce the regular inundation of Yarmouth Town centre by

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		response	seawalls would maintain the present form and operation of the Estuary and prevent wave attack within the Estuary, but would not reduce the present and increasing risk of flooding to Yarmouth Town centre, where defences levels are already overtopped.	centre. Rising sea levels and marine inundation may also impact upon saltmarshes within the estuary. Maintenance of the seawall barrier at Freshwater Bay will prevent tidal inundation of the Estuary from the south and maintain the operation of the Estuary in its current form, leading into the Solent on the north coast of the Isle of Wight.	tidal flooding. The breakwater will prevent wave attack within the Estuary but rising sea levels are likely to affect the morphology and environments within the Estuary. The seawall barrier at Freshwater Bay will continue to prevent tidal inundation of the Estuary from the south and maintain the operation of the Estuary in its current form, leading into the Solent on the north coast of the Isle of Wight.
IW51 ***Name:*** **YARMOUTH TOWN & BOULDNOR** **From: Yarmouth Castle** **To: Port La Salle**	**No Active Intervention**	*Short description of predicted defence failure*	1946m unit fronting the seaward face of the town Yarmouth and coastal development eastwards to Port La Salle, including a section supporting the main coastal road (from Newport to West Wight). Around Yarmouth Castle (a Scheduled Monument) stone walls and buttresses form their own coastal defence. Between the Pier and Yarmouth Common there is a mixture of vertical stone or concrete walls front residential properties. From Yarmouth to Bouldnor a series of seawalls have residual lives (without any further maintenance) of 15-25 years in general. Some sections of recent wall and steel sheet piles are in better condition and will last into the second epoch (which runs from 20-50 years), and there are also short sections will fail first, in 10-15 years. It is important to note that the central section (where the main road is supported on an embankment adjacent to the coast) is in poor condition and could fail in 5-10 years. Along the Port la Salle frontage development is protected by (west to east): steel sheet-piling (generally 26-60 years residual life), rock armour (10-20 years residual life) and concrete wall (15-25 years residual life) and gabions (6-10 years residual life).	Any remaining sections of defences will be outflanked and are likely to be lost during this epoch.	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		Description of cliff erosion/ reactivation	There is current and increasing significant flood risk in west of this unit affecting the centre of the town of Yarmouth. In addition to the flood risk, the shoreline is likely to retreat at moderate rates of erosion as the foreshore is narrow and provides limited protection. The majority of defences along the frontage will deteriorate and fail during the first epoch (over the next 20 years), with breaches in the seawall leading to more widespread failure and commencement of erosion at approx. 0.35m/yr. This will result in up to 5m of coastal erosion by year 20 in the areas where the defences failed first. Areas of the developed coastal slope are subject to small-scale instability problems. At Port La Salle slope instability would put houses at risk. The principal road A3055 runs along the top of the coastal embankment at Bouldnor within this unit. Collapse of the seawalls and reversion to a natural soft cliff would be a major change, but would not be detrimental to adjacent management units.	The problems along this frontage will be exacerbated by sea level rise. Flood risk in the west of the town increases and the stability of the coastal slopes will be significantly reduced, resulting in upslope movements impacting on the public highway and adjacent properties. Coastal erosion at approx. 0.46m/yr will create approx. 14m of coastal retreat during this epoch, or up to 19m in places since year 1. As erosion of the shoreline continues over years 20-50 through the coastal road, there is increasing potential for a breach through the foreshore just east of Yarmouth, enabling the creation of a small tidal inlet at Thorley Brook. The low-lying valley of Thorley Brook runs parallel to the shore just inland of the town of Yarmouth, extending eastwards from the Western Yar Estuary. If a breach occurs, shoreline sediments could become entrained by tidal currents generated at the new inlet and become flushed seaward. Loss of A3054 road (which is the main link between West Wight and Newport) and also the coastal footpath link would result. Traffic would be seriously disrupted following any breach event.	There is likely to be regular flooding affecting properties and significant slope instability problems along the whole gently sloping peninsula on which Yarmouth is built, and in Port la Salle to the east. Coastal erosion at approx. 0.53m/yr then 0.58m/yr will create approx. 27m of coastal retreat during this epoch, or up to 46m in places since year 1. Immediately east of Yarmouth there is the possibility that shore erosion over the forthcoming 50 to 100 years could cut through into the lowland valley of Thorley Brook to produce a small new tidal inlet. This potential link to the Western Yar estuary would leave the town of Yarmouth as an island at high tide.
		Description of beach evolution	Weak littoral drift generally operates north eastward along the north-west coast of the Isle of Wight, with the exception of local reversals on the eastern entrances to inlets. Littoral drift is from both sides towards the inlet of the Western Yar, although this is a very localised and minor reversal in the east. A littoral transport divergence is difficult to locate because of the small volume and rate of sediment movement and is likely to be a partial, and probably transient, boundary. East of the harbour mouth and the solid structural defences there is a medium to gentle	Renewed erosion along the majority of the frontage will supply sediments to the local foreshore and may be transported to the units to the east by the weak north-eastwards littoral drift system.	Increasing rates of erosion along the entire frontage will supply sediments to the local foreshore and may be transported to the units to the east by the weak north-eastwards littoral drift system. Tidal breach and marine inundation from the south coast to the north coast of the Island along the Western Yar valley could significantly affect the sediment regime within this adjacent frontage in the longer term.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			sloping sand, shingle and boulder beach on a clay sub-base fronting the George Hotel. Historically the foreshore at Yarmouth has lowered and narrowed in front of seawall defences, and foreshore narrowing is likely to continue to occur whilst the defences remain in place during the first epoch. In the shorter term, the Strategic Monitoring Programme records that from 2003-2009 the beaches fronting Yarmouth town showed slight accretion, but to the east the beaches were stable overall, with slight erosion in front of the central section of the vulnerable Bouldnor road. There will be no direct sediment input into the frontage until breaches in the seawall allow erosion to commence later in the epoch.		
	With present management	*Short description of predicted defence failure*	2km of continuous seawalls and defences fronting the seaward face of the town Yarmouth and coastal development eastwards to Port La Salle will be maintained and replaced (at current standards of protection) if current management practices continue.	The seawalls and defences fronting the unit will be maintained and replaced.	The seawalls and defences fronting the unit will be maintained and replaced.
		Description of cliff erosion/ reactivation	The maintenance of the defence line will prevent renewal of erosion and retreat along the coastline, but will not prevent tidal flooding in the west of Yarmouth. The eastern end of the defence line at Port la Salle marks the transition to an undefended eroding cliff line, so step-back or offset of the coast will occur at the eastern edge of the unit by up to 7m if the current defence gabions are maintained in their current position.	Maintenance of the seawalls will prevent erosion and a marine breach through to Thorley Brook would therefore be prevented, but the defences themselves would become increasingly exposed to wave action and overtopping, especially towards the end of the epoch. Tidal flooding will remain a significant risk. At the eastern end of the defence line outflanking of the defences by a further 14m may occur during this epoch (or up to 21m in total since year 1).	The seawalls will prevent erosion and a marine breach through to Thorley Brook, although overtopping of the maintained defences will become more frequent during this epoch. Tidal flooding will be an increasing risk. At the eastern end of the defence line outflanking of the defences by a further 27m may occur during this epoch (or up to 48m in total since year 1).
		Description of beach evolution	Foreshore narrowing in front of the defences is likely to occur due to limited sediment supply.	Foreshore narrowing in front of the defences is likely to continue due to very limited sediment supply.	Foreshore narrowing will continue as renewal of erosion prevents further sediment supply and sea levels rise. The presence of the Western Yar Estuary is

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
					likely to prevent significant sediment supply along the shoreline from the west.
IW52 ***Name:*** **BOULDNOR COPSE & HAMSTEAD** **From: Port La Salle** **To: Hamstead Point, Newtown Bay**	**No Active Intervention**	*Short description of predicted defence failure*	4.2km frontage of slumping coastal slopes and cliffs. No defences.	No defences.	No defences.
		Description of cliff erosion/ reactivation	Cliffs developed within the predominantly clayey strata of the Bouldnor Formation (Solent Group) rise from beach level at Bouldnor village to 61m at Bouldnor Cliff and 35m at Hamstead Cliff before declining steadily east to the Newtown Harbour inlet. The coastal slope exhibits complex morphology and degrades by mudslides, relatively shallow multiple translational slides and infrequent deep-seated rotational slides. Erosion of the cliff-toe and cliff-foot debris will continue or intensify in the future such that the cliffs are likely to remain unstable and actively eroding. Erosion at approx. 0.35m/yr will create approx. 7m of cliff top retreat over years 0-20. Cliff top recession process often involves high-magnitude low-frequency failures that can result in loss of between 5 and 25m within single events associated with intense mudsliding downslope.	Continued instability and rapid mudsliding is seasonal and controlled by precipitation, groundwater availability and porewater pressures as well as toe erosion and wave attack causing slope steepening and destabilisation. Erosion at approx. 0.46/yr will create an additional approx. 14m of cliff top retreat over years 20-50 (or 21m in total since year 1).	Increased erosion and higher winter rainfall are expected to promote a significant increase in coastal landsliding activity at Cranmore and Hamstead. Erosion at approx. 0.53m/yr then 0.58m/yr will create an additional approx. 27m of cliff top retreat over years 50-100 (or 48m in total since year 1).
		Description of beach evolution	The coast between Bouldnor and Newtown Harbour is characterised by sediment inputs from local coastal erosion (sediment input from updrift is negligible). A gently sloping foreshore in clay deposits with a thin covering of sand and some fine to medium shingle is present. Weak littoral drift operates north eastward along the coast. The upper foreshore has retreated in accordance with cliff recession along the majority of this frontage, but mean low water appears to have moved back more rapidly so that the foreshore has narrowed.	Increases in sediment supply to beaches due to the acceleration of freely eroding cliffs would be unlikely to generate substantial protective beaches because most of the cliff materials are clay and mechanisms exist for seaward removal of these sediment grades. Instead, there may be very local increases in beach accumulation at Hamstead Duver (the western spit at Newtown, in the adjacent unit to the east).	Large quantities of primarily fine sediments are contributed to the West Solent by cliff erosion within this frontage. This constitutes the major direct input of fresh sediments to the Solent and may be of critical importance to its sediment budget and maintenance of intertidal features.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			The high eroding cliffs in this unit and near Thorness Bay to the north-east are important sources of fresh fine grained sediment within the Solent. Coarser sediments will drift predominantly eastwards along the foreshore and contribute to spits and to embayments defined by minor headlands. Cliff recession yields significant sediment volumes, but much is clay and silt so only a small proportion of total cliff input is stable on the beach. Wide, low gradient mixed sediment inter-tidal zones are characteristic. Drift is not continuous along this unit, but is intercepted periodically by lobes of landslide debris that surge across the beach from the cliffs above. Obstructions are removed gradually by marine erosion so as to permit a long term drift. Sediment accumulates against the western side of such lobes with scour to the east, a combination indicative of eastward drift. At Bouldnor Cliff, mudslides converge to form a major mudslide lobe that extends periodically across the foreshore during surging phases and suffers marine erosion thereafter. Old boulder arcs on the foreshore are the residue of previous mudslides.	Renewal of erosion along the Yarmouth and Bouldnor frontage in the unit to the east could supply some limited sediments into this frontage, but erosion of the low Yarmouth coastline provides negligible sediments in comparison with the high eroding cliffs in this unit.	
	With present management	*Short description of predicted defence failure*	No defences	No defences	No defences
		Description of cliff erosion/ reactivation	See 'No Active Intervention' scenario above for details. With present management practices continuing in adjacent frontages, the western edge of this unit will continue to mark the transition from defended to undefended coast, so step-back or offset of the coast by up to 7m will occur if the	See 'No Active Intervention' scenario above for details. At the western edge of the unit the adjacent defence line may be outflanked by a further 14m during this epoch (or up to 21m in total since year 1).	See 'No Active Intervention' scenario above for details. At the western edge of the unit the adjacent defences may be outflanked by a further 27m during this epoch (or up to 48m in total since year 1).

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			current defence gabions are maintained in their current position.		
		Description of beach evolution	See 'No Active Intervention' scenario above for details. The coast between Bouldnor and Newtown Harbour is characterised by sediment inputs from local coastal erosion. Sediment input from updrift is negligible, and this trend would continue when seawalls are maintained along the Yarmouth frontage to the west preventing the renewal of erosion.	See 'No Active Intervention' scenario above for details.	See 'No Active Intervention' scenario above for details.
IW53 ***Name:*** **NEWTOWN ESTUARY** **Newtown Estuary & spits, from Hamstead Point to Brickfield Farm House**	**No Active Intervention**	*Short description of predicted defence failure*	Newtown Estuary is a significant undefended, undeveloped and naturally evolving inlet. Within Newtown Estuary, the vast majority of the frontage (amounting to a length of 28km) is undefended, but a few scattered short sections of masonry wall and timber breastwork at Shalfleet Quay, Newtown Quay (saltworks) and on the upper reaches of Shalfleet Lake have residual lives of a maximum 15-25 years, generally less. Two entrance spits perform a natural coastal defence function, sheltering the branches of the Estuary behind forming a natural harbour.	No defences	No defences
		Summary of flood and erosion risk	Newtown Estuary occupies a low-lying valley complex, with narrow twin gravel spits protecting five main diverging branches of the estuary behind, extending over 3km inland. Habitats of saltmarsh and mudflats are bordered by Oak woodlands, and the villages of Newtown (much of which is a Scheduled Monument), Porchfield and Shalfleet. Heights of tidal inundation into the Estuary behind will gradually increase. Weak littoral drift generally operates north eastward along the whole coast with the	Increased erosion of neighbouring cliffs may feed additional sediments into the system, potentially replenishing the spits, however increased wave action and storm frequency could also promote even faster retreat and assist breaching and failure in the east and also in the west spit, opening up the Estuary to increased wave action, particularly the eastern side and the vulnerable saltmarsh and mudflat habitats. Erosion or retreat of the gravel western spit may continue at approx. 0.91m/yr for years 20-50 (resulting in up to 27m of potential	Rising sea levels will mean that significant amounts of the frontage could be under standing water throughout the year.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			exception of local reversals on the eastern entrances to inlets. Littoral drift is from both sides towards the inlet of Newtown Harbour. The eastern spit is relatively depleted compared to the western spit. The western spit at Newtown (Hamstead Duver) has retreated and recurved partially into the harbour. A relict spit is located behind the active one. The western spit is rather more stable than the eastern spit because it is sustained by a modest sediment supply from the cliffs to the west (the eastward alignment of this spit providing clear evidence of long term eastward drift). It would be likely to remain static, or slowly migrate into the harbour inlet. A historical retreat rate of 0.6m/yr (BRANCH project) for the western spit will translate to 0.69m/yr potential retreat over years 0-20 (14m in total). The eastern spit at Newtown entrance has a history of sediment depletion and has receded landwards. High tides overtop the eastern spit and may form a small new inlet subject to tidal flows at high water. Breaches in the eastern Newtown Spit will be unlikely to seal naturally due to limited sediment supply, possibly resulting from the proximity of the local drift reversal and divide. The eastern spit may continue to roll back south eastwards away from the prevailing wave direction, but is likely to submerge when it reaches the deeper water channel behind. The gravel spit climbs eastwards into low land rising to 11m in height near Brickfield Farm House; active is erosion occurring on both the outside and inside of the spit, providing fine sediments into solution. Historical retreat at 0.62m/yr (BRANCH project) for the gravel section of the eastern spit will translate to 0.72m/yr potential erosion or retreat over years 0-20 (approx. 14m in total). Erosion of the low peninsula forming the eastern section of the harbour arm will	additional retreat, or 41m since year 1). Any remaining sections of the eastern gravel spit could recede at 0.94m/yr (resulting in up to 28m of additional retreat over years 20-50, or 43m since year 1). Rising sea levels will open the whole frontage to more aggressive wave attack leading to extensive flooding of the National Nature Reserve and increased salt penetration on adjacent farmland with impacts on the bordering woodlands. Tidal flood risk may inundate the road link to Newtown village from the south (near Fleetlands Farm), the channel approaching Porchfield and cross the Porchfield-Shalfleet road at Clamerkin Bridge. .	

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			continue at the rate of the adjacent coast in this and future epochs (approx. 0.46m/yr over years 0-20 along the outside of the arm, with slower erosion rates on the sheltered inside of the arm). The effect of erosion or retreat of the spits will primarily be to permit increased wave penetration into the harbour with implications for the erosion of saltmarshes and mudflats.		
		Summary of estuary response	The estuarine processes are expected to continue in a similar pattern in future epochs. At Newtown Estuary sediment mobility is greatest at the harbour entrance, with fine silt and clay accumulating as mudflats and marsh sediments within the inner estuary. The bed of the main channel is composed of coarse pebbles and ebb tidal currents exceeding $0.5ms^{-1}$ can result in offshore flushing of coarse sediments, fed by gravel driven by wave action along the spits flanking the harbour entrance. A proportion of the sediment stored in inter-tidal flats and saltmarsh is presumed to derive from input by the small rivers discharging into Newtown Harbour. Most input however, is likely to have been transported by the flood tide, and originate from cliff, platform and shoreface erosion of suspended sediment from the adjacent open coastline. Supply of both gravels and suspended sediments may increase over the next 20 years and particularly through future epochs.	The functioning and morphology of the Harbour would be affected by the retreat or loss of the entrance spits, with wave penetration into the harbour increasing the potential for erosion on previously sheltered frontages and the potential opening of a second entrance channel through a breach in the eastern spit. Additional sediment may be supplied by erosion of the Bouldnor cliffs to the east of Newtown Harbour, although there is significant sediment lost offshore.	The functioning and morphology of the Harbour would be affected by the loss of sheltered caused by the significant widening of the entrance channel through loss of the entrance spits, or recurving or roll back into the estuary. Sediment supply from the east may increase from erosion of Bouldnor cliffs, although there is significant sediment lost offshore.
	With present management	*Short description of predicted defence failure*	Maintenance of the short sections of defences within the harbour would not have an overall impact on the behaviour of the system as a whole, or mitigate the increasing flood risk around the Estuary.	No defences	No defences
		Summary of flood and erosion risk	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.
		Summary of estuary response	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
IW54 ***Name:*** **THORNESS BAY** **From: Newtown Bay** **To: Gurnard Bay**	**No Active Intervention**	*Short description of predicted defence failure*	6.1km stretch of undefended, relatively undeveloped slumping coastal slopes and cliffs.	No defences	No defences
		Description of cliff erosion/ reactivation	East of Newtown Harbour there are simple low cliffs developed in clays of the Bouldnor Formation. Abundant landslide debris and fallen trees on the beach indicate rapid recession. Topography rises rapidly eastwards to a height of 57m near Burnt Wood and Thorness Bay Holiday Park with corresponding change in cliff landslide activity. There is a wide degradation zone characterised by shallow multiple translational landsliding and transport of debris in mudslides that form lobes across the foreshore. Thorness Bay is a small low lying valley floor. The cliffs between the Thorness and Gurnard rise to 28m and comprise clays and marls of the Bouldnor formation overlying Bembridge limestone at beach level. Mudslides and shallow translational slides create debris accumulations on the foreshore. The limestones outcrop as foreshore reefs forming Gurnard Ledge, also undergoing erosion. The landform assemblage is comparable to that at Bouldnor and Burnt Wood, but smaller in scale. Erosion of the cliff toe and debris is likely to continue or intensify into the future such that the cliffs are likely to remain unstable and actively eroding. Erosion at a rate of approx. 0.46m/yr will result in 9m or cliff retreat over the next 20 years.	Erosion and slope reactivation of the coastal cliffs will continue, at a rate of approx. 0.61m/yr, resulting in an additional 18m of cliff top recession (or 27m in total since year 1). Tidal flood risk extends up to 900m inland in two adjacent inlet zones, crossing the Porchfield to Northwood road. Retreat within low-lying Thorness Bay could form a small intertidal area controlled by the topography, similar in scale to the present King's Quay inlet on the north-east coast. The tidal prisms would be small and marginal in stability and potentially subject to episodes of periodic closure and breaching.	Increased coastal erosion and slope reactivation will continue, at a rate of approx. 0.71 then 0.77m/yr, resulting in an additional approx. 37m of cliff top recession from years 50-100 (or 64m retreat in total over 100 years).
		Description of beach evolution	There is a mixed, mud, sand and boulder foreshore that becomes increasingly wide to the east of Newtown. The foreshore is interrupted periodically by lobes of landslide debris that surge across the beach from the cliffs above. Weak littoral drift operates north eastward along the coast.	Increases in sediment supply to beaches due to the acceleration of freely eroding cliffs would be unlikely to generate substantial protective beaches because most of the cliff materials are clay and mechanisms exist for seaward removal of these sediment grades. Instead, there may	Large quantities of primarily fine sediments are contributed to the West Solent by cliff erosion. This constitutes the major direct input of fresh sediments to the Solent and may be of critical importance to its sediment budget and maintenance of intertidal features.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			Sediment supplied to the foreshore (predominantly from local cliff erosion) is clay, with some gravels. Erosion of in-situ gravel-bearing deposits exposed on the foreshore also contributes sediment to the beach. Cliff recession yields significant sediment volumes, but much is clay and silt so only a small proportion of total cliff input is stable on the beach. The high eroding cliffs are an important source of fresh fine grained sediment within the Solent. Net north-eastward drift between Brickfield Farm and Gurnard is indicated by eastward deflection of stream mouths by small, mixed sediment bars at Thorness and Gurnard. Drift is fed by local cliff erosion. A considerable quantity of gravel is stored on the upper and mid foreshore within Thorness Bay, where it has formed a barrier across the stream and its low marshy valley. Gurnard Ledge functions as a partial impediment to drift tending to assist coarse sediment retention within Thorness bay, causing depletion of the beaches to its northeast.	be very local increases in beach accumulation in Thorness Bay.	
	With present management	*Short description of predicted defence failure*	No defences	No defences	No defences
		Description of cliff erosion/ reactivation	See 'No Active Intervention' scenario above. At the eastern end of the unit, the cliffs fall in height to the promontory of Gurnard Luck. Differential erosion from the undefended to defended coast may create an offset of approx. 9m over 20 years.	See 'No Active Intervention' scenario above. At the eastern end of the unit the offset from the undefended to defended coast may increase by approx. 18m to 27m in total over 50 years.	See 'No Active Intervention' scenario above. At the eastern end of the unit the offset from the undefended to defended coast may increase by approx. 37m to 64m in total over 50 years.
		Description of beach evolution	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.	See 'No Active Intervention' scenario above.
IW55	**No Active**	*Short*	574m length of masonry and concrete walls and	No defences	No defences

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
***Name:* GURNARD LUCK** **Marsh Road, Gurnard** **From: Marsh Cottage promontory** **To: Lower Church Road junction**	**Intervention**	*description of predicted defence failure*	timber breastwork bordering the low-lying developed area of Gurnard Luck, surrounding the outlet of the small river in the west of the frontage. Collapses in the ageing sea defences are already occurring, and sections of the repaired frontage are expected to fail in 5-7 years (the section in the centre of the bay), 10-15 years, 10-20 years and 15-25 years, so by the end of the first epoch (year 20) the majority of defences will have failed, with initial breaches extending to expose the majority of the frontage to erosion.		
		Description of cliff erosion/ reactivation	Low lying dunes backed by marshland, with the coastal strip either side of the coastal road developed with improved chalets and residential buildings. Formerly a bar extending across what was a small coastal inlet with a marsh behind. Moving east vegetated and developed clay slopes are prone to instability, continuing into the adjacent unit. Gurnard Luck suffers from regular flooding from a complex combination of both fluvial and coastal sources. Over the next 20 years there will be total undermining and collapse of all existing coastal defences. Increased erosion of coastal land will occur as well as increased susceptibility for sea flooding in extreme conditions. Erosion at up to approx. 0.35m/yr could retreat the coast by up to 5m (approx.) in the first areas of defence failure. Coastal overtopping waters flow away from the frontage, past a row of properties over Marsh Road then descends into a low-lying marsh. During coastal flood events, this marsh can store flood waters for whole storms unless the surge level is about 30cm above the lowest point in the defence, then total inundation occurs to match sea surge level.	Total loss of all remaining defences and regular flooding as a result of sea level rise will occur. Tidal flood risk extends up to 1.5km inland following the route of Gurnard Luck stream to Ruffin's Copse. Erosion, slope failure and retreat of the cliffs in the east will occur, on the margins of a larger potential landslide reactivation. Erosion at approx. 0.46m/yr will retreat the coast by a further 14m (or up to 19m since year 1).	Coastal retreat and flooding will continue. The whole Gurnard Luck frontage could be under standing water at high water. Increased erosion, slope failure and retreat of the cliffs in the east will increase the likelihood of larger-scale landslide reactivation (discussed in the Gurnard & Cowes Esplanade unit). Erosion at approx. 0.53m/yr then 0.58m/yr will potentially retreat the coast by a further 27m (or up to 46m since year 1). Retreat within Gurnard Bay could form a small intertidal area controlled by the topography similar in scale to the present King's Quay inlet on the north-east coast. The tidal prisms would be small and marginal in stability and potentially subject to periodic closure and breaching episodes.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			Gurnard Luck stream drains through this unit and exits to the sea after passing through flapped culverts under a road bridge. The Luck can only drain during low tide conditions, and excess waters overflow into the Marsh. The Marsh quickly fills during fluvial events; however it does provide a valuable source of storage. The flap gates are likely to stick in a closed position after 10-20 years of no maintenance. After the gates fail, Gurnard Luck stream will divert and flow over Marsh Road to the east of the bridge and exit to the sea at a low point in the defences, flooding Marsh Road properties.		
		Description of beach evolution	A shingle, sand and cobble beach fronts the defence line. Weak littoral drift operates north eastward along the coast. The Strategic Monitoring Programme records that from 2003-2009 overall the beach fronting Gurnard Luck was stable in the south-west, but showed moderate accretion in the north-east. There is currently no significant direct sediment input to the frontage, although limited sediment will be supplied following sea wall breach and erosion commencing. However, the low-lying frontage will not contribute significantly to sediment supply, in comparison with retreat of surrounding cliff lines.	Erosion will supply the formerly stabilised sediments to the beach within this unit, and sediment supply from the south-west may increase as slope retreat and reactivation occurs in adjacent units, dependent to the profile of failures or debris lobes controlling longshore sediment transport.	Increasing rates of erosion due to sea level rise and wave attack will continue to supply formerly stabilised sediments to the beach within this unit. Sediment supply by littoral drift from the south-west may increase as slope retreat and reactivation increases in adjacent units, dependent to the profile of failures, embayments or debris lobes controlling the patterns of longshore sediment transport.
	With present management	*Short description of predicted defence failure*	The series of masonry and concrete walls and timber breastwork would be maintained and replaced at their current standard, if current management practices continue.	The series of masonry and concrete walls and timber breastwork would be maintained and replaced.	The series of masonry and concrete walls and timber breastwork would be maintained and replaced.
		Description of cliff erosion/ reactivation	Maintenance of the line of coastal defences will prevent breach and erosion of the frontage commencing, but will not reduce the significant flood risk in the area without improvements in the standard of protection. Overtopping of the defences will continue.	Erosion of the frontage will be prevented, but this scenario still has a high residual risk of flood inundation and impact on people and property, including possible loss of life during extreme flood events when the flood defences would be increasingly overtopped.	Frequent flooding will continue with regular overtopping of the defences and marine inundation. At the western and eastern ends of the end of the unit the offset from the

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			At the western and eastern ends of this unit, retreat at the transition from the defended to undefended coast would create offsets of approx. 9m in the west and 7m in the east over 20 years.	At the western and eastern ends of the end of the unit the offset from the undefended to defended coast may increase by approx. 18m in the west (to 27m in total over 50 years) and 14m in the east (to 21m in total over 50 years).	undefended to defended coast may increase by a further 37m in the west (to approx. 64m in total over 100 years) and a further 27m in the east (to 48m in total over 100 years).
		Description of beach evolution	Foreshore narrowing will occur in front of the defences as the beaches are starved of local sediment supply as erosion and retreat of the beach is prevented.	Foreshore narrowing is likely in front of the defences as sea levels rise, although additional sediment could be supplied by littoral drift from the south-west.	Foreshore narrowing and low beach levels are likely to increasingly expose the defences to wave attack, as the beaches are starved of local sediment supply. Potential increase in sediment supply by littoral drift from the south-west may mitigate some of this trend for narrowing or loss of beach materials.
IW56 ***Name:*** **GURNARD & COWES ESPLANADE** **From: Gurnard Bay** **To: the Royal Yacht Squadron, West Cowes**	**No Active Intervention**	*Short description of predicted defence failure*	2.7km frontage of weak coastal slopes underlying the towns of Cowes and Gurnard, with continuous seawalls, with the exception of Gurnard Cliff in the east of the unit. At Gurnard Cliff, the wooded and developed coastal slope is undefended, with minor fragmented exceptions such as a groyne with a residual life of 15-25 years. From Gurnard north-eastwards around Egypt Point and eastwards to Cowes (along an Esplanade road) a continuous series of concrete seawalls have residual lives of 15-25 years (10-15 years in the south of Gurnard). The seawall from Gurnard to south of Egypt Point is fronted by short groynes which are expected to fail in 10-20 years. Groynes are generally absent west of Egypt Point.	Remaining sections of seawalls will fail at the start of this epoch, after which, there will be no defences.	No defences.
		Description of cliff erosion/ reactivation	In Cowes and Gurnard the coastal slopes rise to approx. 30-35m in a slope risk zone (before plateauing at approx. 40-45m over the Cowes peninsula). This mainly urban residential area is at risk from erosion and significant landslide reactivation. Many of the existing seawalls will collapse in 15-25 years, allowing erosion to	The toes of the coastal slopes will be eroded at rates of approx. 0.46m/yr (allowing approx. 14m of retreat during this epoch, or up to 16m since year 1). *Gurnard Cliff:* This epoch will see reactivation of the whole of the coastal	Rates of coastal erosion will increase to approx. 0.53 then 0.58m/yr as sea level rises, resulting in a further 27m of retreat during this epoch (or approx. 43m over 100 years). *Gurnard Cliff:* Complete re-activation of

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			commence at approx. 0.35m/yr (with approx. 2m of initial erosion possible by the end of the epoch). Beach steepening, scour and potentially ground movement may accelerate deterioration and collapse of the defences. A few properties are also at risk from flooding. At Gurnard Cliff partly-active wooded clay coastal slopes rises up to 35m in height. The coastal slope continues eastwards to West Coves, but to the east of Gurnard slipway, it becomes less steep, and is protected at its toe by continuous seawalls and an esplanade. The coastal slopes above the shoreline retain relict landslides. Slope morphology reveals numerous irregularities, indicating past and active seepage erosion and the presence of relic deep-seated and shallow landslides. At Gurnard Bay and from Egypt Point east to Cowes the coastal slopes are heavily developed, separated by an unstable wooded area, where evidence of ground movement is evident in the esplanade road and at joints in the seawall. The seawall and esplanade road are overtopped and inundated at extreme high tide events. *Gurnard Cliff:* Gurnard Cliff is characterised by active deep-seated landslides developed within the Bembridge and Osborne Marls. Coastal mudslides have resulted in undermining and recession of the cliff top, active settlement of the cliffs and translational movement of debris to the foreshore and mudslide lobes. Poor drainage, increased rainfall, beach steepening and increased toe erosion will promote active landsliding and could result in rapid retrogression upslope towards cliff top development. At the foot of the active slope, cliff toe erosion and retreat may outflank the adjacent defences at Gurnard Luck to the west and Gurnard Bay to the east by up to 7m before those defence structures fail towards the end of the epoch.	slope, posing a risk to properties above on Solent View Road. Erosion could trigger landslide reactivation, therefore a wider potential reactivation zone is shown on the maps of the 'No Active Intervention' scenario. *Gurnard to Cowes:* Increased scour on the foreshore is likely to encourage instability on the Princes' Esplanade frontage where the landslide extends out to sea under the seawall. Failure of the seawall will affect the public highway, adjacent properties and public open space. By the end of the epoch erosion and increasingly frequent marine inundation would be likely to have promoted increased instability through loss of toe support of the coastal slope behind. Over 30 to 100 years, toe erosion will remove support and destabilise the relict landslides on the slopes above. The frontage from Gurnard to the Royal Yacht Squadron is most exposed to wave attack and also supports the steepest slopes, suggesting that it may be the most vulnerable to future re-activation. Although the full slope re-activation process could involve relatively long timescales the initial ground movements could occur quite rapidly following the onset of toe erosion. Erosion could trigger landslide reactivation at 2m/yr, therefore a wider potential reactivation zone is shown on the maps of the 'No Active Intervention' scenario. Marine inundation of the esplanades will occur at high water events causing flood risk.	the coastal cliffs and slopes below Solent View Road. Erosion could trigger landslide reactivation, therefore a wider potential reactivation zone is shown on the maps of the 'No Active Intervention' scenario. Gurnard-Cowes: Coastal erosion at the toe of the coastal slope could trigger landslide reactivation at 2m/yr, therefore a wider potential reactivation zone is shown on the maps of the 'No Active Intervention' scenario. Complete reactivation of the coastal slope between Egypt Point and the Royal Yacht Squadron may occur. The morphology of the active cliffs at Thorness may provide an analogy for the type of morphology that could ultimately form, although a lengthy time period of 50 to 100 years could be required for such a transition. The full re-activation process could involve rapid but intermittent inland migration of the active cliff scarp by up to 200m. It should be noted that although the full re-activation process could involve relatively long timescales the initial ground movements could occur quite rapidly following the onset of toe erosion. Areas affected would be highly localised and related to the distribution of relict landslides on the slopes. Although toe erosion would prepare the slopes for instability, the re-activation events themselves would most likely be triggered by high groundwater levels.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			Gurnard to Cowes: To the east the low lying shoreline is backed by a marginally stable slope composed of degraded coastal slopes and deep-seated coastal landslides. Seawalls are expected to deteriorate and fail in 15-25 years, with significant opening of joints with displacement of wall sections due to slope instability between Gurnard and Egypt Point, allowing erosion to commence. From Gurnard to Egypt point the esplanade shows signs of ground movement and between Egypt Point and West Cowes the upper coastal slopes exhibit evidence of instability. Although the full slope re-activation process could involve relatively long timescales the initial ground movements could occur quite rapidly following the onset of toe erosion. Overtopping and marine inundation of the esplanades will occur more frequently, with flood risk to seafront properties in the east of the frontage.		
		Description of beach evolution	At Gurnard Cliff a beach of shingle, sand, and limestone boulders is present but areas of soft clay are exposed within the thin foreshore sediments. From Gurnard to Cowes (where some seawalls have been in place since 1894) no contemporary sediment supply occurs directly into the frontage. From Gurnard Bay eastwards beaches comprise sandy gravels becoming coarse gravel and cobbles under the seawall, and are very depleted around Egypt Point, but widen eastwards to Cowes. From Egypt Point eastwards a significant raised shingle storm beach is present at a higher level in front of the Queens Road esplanade and Green, and shingle can be pushed back onto the gentle slopes behind. The Strategic Monitoring Programme records that from 2003-2009 the narrow beaches fronting Gurnard and Cowes Esplanades were relatively stable (showing no consistent trend in change in cross-sectional	Erosion of the entire frontage and re-activation of cliff recession will supply predominantly fine sediments to the Solent. Weak net eastwards littoral drift will supply limited sediments into the area so beach levels are likely to remain low.	Faster rates of erosion of the toe of the coastal slopes and slope reactivation could supply increased quantities of sediment directly to the local beaches, and littoral drift from the south west may increase as slopes reactivate and retreat along the north-west coast of the Isle of Wight. However, slope reactivation and failure may encroach onto the foreshore and divert sediment offshore.

Location	Scenario		Predicted change for: Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			area). Weak net eastwards littoral drift occurs along the depleted beach from Gurnard around Egypt Point. Concrete rubble groynes at Egypt Point selectively intercept sediments, but quantities are small because of the presence of protection structures and a lack of available material. Foreshore narrowing and lowering of beach levels is likely to continue over the next 20 years, until failure of the seawalls opens up breaches (and eventually the entire frontage) to erosion at the end of this epoch or soon after, supplying limited sediments directly to the narrow and depleted foreshores. Littoral drift into the unit from the south-west is limited.		
	With present management	*Short description of predicted defence failure*	At Gurnard Cliff, the coastal slope would remain undefended at the cliff toe. From Gurnard to Cowes the existing coast protection would be sustained by maintaining and replacing the existing seawalls at their current standard without improvement.	At Gurnard Cliff, the coastal slope would remain undefended at the cliff toe. From Gurnard to Cowes the concrete seawalls and groynes would be maintained and replaced at their former standard of effectiveness.	At Gurnard Cliff, the coastal slope would remain undefended at the cliff toe. From Gurnard to Cowes the concrete seawalls and groynes would be maintained at their former standard of effectiveness.
		Description of cliff erosion/ reactivation	At Gurnard Cliff, significant slope reactivation and retreat would continue in line with the 'No Active Intervention' scenario outlined above, with cliff toe erosion and retreat outflanking the adjacent defences at Gurnard Luck to the west and Gurnard Bay to the east (by approx. 7m by the end of the epoch). From Gurnard to Cowes, maintenance of the seawalls will prevent exposure and erosion of the toe of the coastal slopes, minimising landslide reactivation. The seawalls would continue to be overtopped with increasing regularity, and may be destabilised by ground movement. Flood risk to properties in the east of the frontage will remain	With present management practices continuing, landsliding processes could still be re-activated due to rainfall increasing the pore water pressure in the cliffs. The seawalls would prevent erosion but (in their current form) will be overtopped regularly which may destabilise the slopes behind. Flood risk to seafront properties in the east of the frontage will remain and increase.	Very frequent, serious overtopping will occur, inundating roads and infrastructure. Tidal flood risk to seafront properties between Queens Road and the esplanade will increase. Overtopping along large sections of the frontage may assist in saturating and destabilising the coastal slopes at risk of landslide reactivation. Seawalls maintained at current standards will not be sufficient to prevent risk of significant reactivation of landsliding within the coastal slopes, as the seawalls will be overtopped, subject wave attack and may be destabilised by underlying ground movement. Slope failure could be triggered by high groundwater levels so

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			and increase.		ground conditions will worsen with predicted increases in winter rainfall. Maintenance of the seawalls will however significantly reduce the risk of landslide reactivation by continuing to prevent coastal slope toe erosion and undermining.
		Description of beach evolution	Foreshore narrowing and lowering of beach levels will occur in front of the seawalls, exposing them to wave attack. There will be no direct sediment input into the frontage and littoral drift into the unit from the south-west is limited.	Foreshore narrowing and lowering of beach levels will continue in front of the seawalls, exposing them to wave attack and undermining. There will be no direct sediment input into the frontage (unless significant landslide reactivation occurs) and littoral drift into the unit from the south-west is likely to remain limited.	Foreshore narrowing and lowering of beach levels will continue in front of the seawalls, exposing them to wave attack and undermining. Increased slope failure at adjacent Gurnard Cliff may supply some additional sediments to the area, but this is not likely to be sufficient to counteract the lowering trend along the length of this frontage.
IW57 ***Name:*** **COWES PARADE & HARBOUR** **West Cowes** **From: the Royal Yacht Squadron** **To: Floating Bridge**	**No Active Intervention**	*Short description of predicted defence failure*	2278m defended frontage along Cowes Parade and Cowes town centre. A masonry wall fronts Cowes Parade which will fail in 15-25 years. Moving southwards a series of short sections of concrete and masonry seawalls and steel sheet piles protect individual properties along the waterfront. Unmaintained, the sections of seawall will generally fail in 15-25 years, and the steel sheet piling in 26-60 years. This unit forms the western mouth of the Medina Estuary. For most of the frontage vertical walls rise from the silt of the river bed. Low-lying coastal land on both sides of the Medina Estuary is heavily developed. The defences and parts of the town are low-lying and vulnerable to flooding. Defences maintain the channel to allow commercial operation of the harbour and estuary. The southern limit of this frontage is the key transport link of the Floating Bridge (or Chain Ferry) vehicle and passenger river crossing.	Collapse and of remaining sections of seawall is likely early in this epoch, followed by deterioration and failure of areas of steel sheet piling through the epoch as these areas are isolated or outflanked.	No defences along the majority of the frontage. Steel sheet piling in front of Shepards Wharf marina is expected to last for 30-70 years.
		Description of cliff	This urban area is at risk from both coastal flooding and erosion. This stretch of coast is	Rising sea levels will significantly increase flood risk with increasing numbers of	Rising sea levels will significantly increase flood risk, with flooding of East Cowes and

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		erosion/ reactivation	intensively used and many properties have their own slipways with a variety of defence types, and heights with varying conditions. The average defence height is currently about 2.4m though some places are as low as 2.2mOD. With no further intervention or maintenance the patchwork of defence structures will breach, erosion will set in and flooding will increase. Erosion at 0.35m/yr may result in scattered patches of recent erosion by the end of the epoch. There is flood risk to a large number of properties on the High Street south of the Parade and the shoreline assets running along to the floating bridge.	properties and businesses at risk, including along the High Street and the lower sections of St. Mary's Road and Cross Street. Erosion will continue at approx. 0.46m/yr where defences have failed, with a total of approx. 14m retreat possible during this epoch. However, patterns of shoreline change will be controlled by remaining hard defence points along the frontage.	Cowes town centres on most tides. Erosion of exposed frontages will continue at approx. 0.53m/yr then 0.58m/yr, with a further approx.27m of shoreline retreat possible during this epoch. However, the most significant risk to the frontage will be extensive tidal flooding.
		Description of beach evolution	There will be no direct sediment input into this frontage until defences start to fail later in the epoch, and defences generally rise from the silt of the river bed with no fronting beach sediments. Very limited sediment may be released following seawall breaches. Cowes Harbour entrance represents a drift convergence boundary, although very small quantities of sediment moved by littoral transport, together with the Shrape breakwater retaining sediments to the north, makes this little more than a notional feature.	The wave climate at the mouth of the Medina is relatively moderate; therefore, the initial impact is likely to be an increase in the frequency of flooding as a result of sea level rise and increasing adverse weather conditions. However, breach and failure of the Shrape Breakwater (running offshore from East Cowes) will allow increased wave penetration into the estuary and exposure of the shoreline of this unit to wave attack. Failure of the Shrape Breakwater will also release quantities of stored sediment into the harbour mouth and entrance channel, and could divert or weaken the tidal regime across a wider entrance to the estuary. Sediment levels along this frontage are expected to remain negligible, with limited sediment input from patchy erosion following defence failure.	Continued erosion will supply limited quantities of sediment to the shoreline; however sediment levels along this frontage are expected to remain negligible, with fine sediments removed by the tidal flows of the Medina Estuary.
	With present management	*Short description of predicted defence failure*	The present patchwork of concrete and masonry seawalls and steel sheet piles could be maintained at their current standards of effectiveness. The majority of defences along this frontage are privately owned.	Concrete and masonry seawalls and steel sheet piles will be maintained and replaced at their current standards.	Concrete and masonry seawalls and steel sheet piles will be maintained and replaced at their current standards.
		Description	Maintaining the existing sea walls without	Maintaining the existing sea walls without	Rising sea levels will result in extensive

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		of cliff erosion/ reactivation	improving the current standard of protection will prevent shoreline change due to erosion but will not reduce the current and future levels of flood risk. Tidal inundation already affects Cowes High Street, and the flood risk zone will expand in future epochs and the area will be at high flood risk.	improving the current standard of protection will prevent shoreline change due to erosion but will not reduce the high flood risk. Overtopping and tidal flooding of the High Street and roads behind will become increasingly frequent, with large numbers of residential commercial and industrial properties affected. Maintaining the shoreline in its current position will help to preserve the harbour entrance channel and retain the commercial operation of the estuary and the important cross-Solent ferry links.	tidal flooding overtopping the defence structures and inundating the low-lying centre of the town. Increasing numbers of residential commercial and industrial properties will be affected. The seawalls will continue to prevent erosion from changing the shoreline position, but the frequency of flooding may effectively trigger the abandonment of areas. Maintaining the shoreline in its current position will help to preserve the harbour entrance channel and retain the commercial operation of the estuary, although the cross-Solent ferry links are located in the flood risk zones.
		Description of beach evolution	No significant change in the shoreline is anticipated if present management practices continue. Continuing the use of vertical walls in this location is acceptable because of the low energy wave climate.	No significant change in the shoreline is anticipated if present management practices continue. There would be no sediment inputs into the frontage from local erosion or significant inputs from adjacent units.	No significant change in the coastal regime is anticipated if present management practices continue. There would be no sediment inputs into the frontage from local erosion.
IW58 ***Name:*** **MEDINA ESTUARY** **Upstream of the Cowes Floating Bridge**	**No Active Intervention**	*Short description of predicted defence failure*	The Medina Estuary is 6.8km in length from Newport to Cowes, and is long relative to the mouth width (of 500m narrowing quickly to 100m). At the northern end of this unit (just south of the Floating Bridge) lie approx. 1.5km lengths of defences fronting Cowes and East Cowes (generally marine industries benefitting from the waterfront location). Defences are a mixture of seawalls with residual lives from 5 to 35 years, and steel sheet piling with residual lives of up to 30-70 years. Significant amounts of the frontage of West Cowes will deteriorate and the defences fail during this first epoch. In East Cowes, the majority of defences will last into the second epoch, with the central sections below Yarborough Road are the first expected to fail at	The remaining lengths of defended frontage along East Cowes and Island Harbour are likely to deteriorate and fail through this epoch. The rest of the Estuary banks will be undefended during this epoch.	It is likely that there will be no defences remaining (although fragments of isolated steel sheet piles could remain at East Cowes and Island Harbour).

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			the end of epoch 1. The central reaches of the Estuary are generally undefended, with the exception of the Stag Lane and Dodnor Land frontages of the west bank (concrete walls and steel sheet piling generally failing in 10-15 years or less (with very short sections lasting longer) and at Island Harbour (an inlet on the east bank, with outer banks failing from 5-7 years, but inner seawall and embankment lasting 25-35 years and beyond) and some other short fragments. The central section of the western bank is therefore likely to be largely undefended by the end of this epoch (20 years). Around Newport Harbour and Little London approx. 750m of both banks of the river are protected by masonry and concrete seawalls and steel sheet piles generally expected to fail in 10-15 years or 18-26 years respectively. By the end of epoch 1 (0-20 years) or early in epoch 2 (20-50 years), the defences surrounding and containing Newport Harbour will have failed, affecting property and infrastructure.		
		Summary of flood and erosion risk	The Medina Estuary extends 6.8km from its tidal limit at Newport Harbour northwards to Cowes and East Cowes. It lies in a wide shallow valley with a gentle incline on either side. At low water a single, relatively wide but shallow channel remains. The lower reaches and mouth are lined by docks, boatyards and marinas. There are narrow intertidal mudflats on either side of the middle and upper estuary, largely bordered by agricultural land and woods and the upper estuary forms the developed area of Newport Harbour. Upstream of the Floating Bridge, the Medina Estuary narrows and is sheltered from wave attack.	Flood risk remains the main risk to the developed areas and habitats of the Medina Estuary. The frequency of inundation and flood levels are likely to increase, as remaining sections of defence are increasingly overtopped and the scale of property damage increases, particularly affecting commercial properties and marine industries.	Sea level rise of approx. 98cm from 2009 to 2105 will result in increased tidal flood frequency and increasing depth of tidal flooding. Regular inundation of significant areas of Cowes, East Cowes, waterside developments along the estuary margins, Island Harbour, Newport Harbour will occur.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			There is significant flood risk to approximately 1.5km of commercial and residential properties lining each bank of the Medina fronting Cowes and East Cowes, just upstream of the Floating Bridge. There is also flood risk at Folly Lane, Island Harbour, Stag Lane and to a number of commercial and residential properties surrounding Little London and Newport Harbour (which is already inundated, alongside adjacent infrastructure, at extreme high tide events). Within the estuary erosion of the banks and saltmarshes is variable, but occurs predominantly within the middle and upper reaches of the Estuary.		
		Summary of estuary response	The Medina Estuary inlet operates as a natural littoral transport boundary as its dominant ebb tidal flow generates net offshore flushing of incoming shoreline sediments, although there is very little incoming littoral drift due to widespread shoreline stabilisation and drift interception. The Shrape breakwater limits the amount of suspended sediment entering the Estuary and shifts the ebb tidal flow westward into the centre of the inlet. These patterns of behaviour may begin to alter in later epochs as defences fail and potential sediment supply from neighbouring coastlines increases. The majority of intertidal sediments along the length of the Medina are cohesive and consist of a wide range of sediment sizes, with the majority silt, followed by fine sand, and some clays and gravel. In Cowes Harbour the main channel is generally composed of silt to sandy silt, changing to gravel through the constriction of the Floating Bridge. Fluvial sources of sediment are considered to be relatively insignificant and are likely to continue to contribute little to the coastlines on either side of the mouth. The entrances to the Western Yar and Medina estuaries have been dredged on several occasions to maintain navigable channels for car ferries. The hydrodynamics of	The sediment supply into the mouth of the Medina could increase as defences fail along the Cowes-Gurnard and East Cowes frontages, supplying additional sediment to the shoreline and into the weak sediment transport system. Sediment input from the east will also increase on the failure of the Shrape breakwater, potentially releasing stored sediments. The tidal flows of the Medina will redistribute this sediment, dependent on the balance between the quantity and type of sediment supply and current strength.	The sediment supply into the mouth of the Medina is likely to increase as coastal erosion and potential slope reactivation and failure occurs on the coastlines adjacent to the mouth of the Estuary. The tidal flows of the Medina will redistribute this sediment, dependent on the balance between the quantity and type (size) of sediment supplied and current strength as the morphology of the Estuary reverts increasingly to its natural form.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			the Medina Estuary are similar to those of the Solent with a double high water feature. It has a tidal range of 4.2m.		
	With present management	*Short description of predicted defence failure*	The seawalls and steel sheet piling protecting and constraining the estuary frontages along Cowes, East Cowes, sections of the central estuary, Island Harbour and Newport Harbour will be maintained at their current standards of effectiveness. The majority of the central Estuary will remain undefended.	The seawalls and steel sheet piling protecting the developed frontages will be maintained and replaced. The majority of the central Estuary will remain undefended.	The seawalls and steel sheet piling protecting the developed frontages will be maintained and replaced. The majority of the central Estuary will remain undefended.
		Summary of flood and erosion risk	Maintenance of the defences will hold the shoreline in its present position and prevent collapse and undermining of the borders of the estuary, maintaining commercial harbours and operations at Cowes and Newport. However, there would continue to be significant flood risk to approximately 1.5km of commercial and residential properties lining each bank of the Medina fronting Cowes and East Cowes, just upstream of the Floating Bridge. There is also flood risk at Folly Lane, Island Harbour, Stag Lane and to a number of commercial and residential properties surrounding Little London and Newport Harbour. The risk of overtopping is dependent on the variable crest heights of current defences, which do not form a continuous line or consistent standard of protection. Within the estuary erosion of the banks is variable, but occurs predominantly within the middle and upper reaches of the Estuary while defences remain near the Estuary mouth.	Maintenance of the defences will hold the shoreline in its present position and prevent collapse and undermining of the borders of the estuary, maintaining a navigable and commercial channel through Cowes and East Cowes into the central and upper Estuary. Defences at East Cowes and Island Harbour will also be renewed and replaced under this scenario, maintaining access to and use of the shoreline. Flood risk remains the main risk to the developed frontages of the Medina Estuary. The frequency of inundation and flood levels are likely to increase as sections of defence are increasingly overtopped and the scale of property damage increases, particularly affecting commercial properties and marine industries.	Sea level rise of approx. 98cm from 2009 to 2105 will result in increased tidal flood frequency and increasing depth of tidal flooding. Regular inundation of significant areas of Cowes, East Cowes, waterside developments along the estuary margins, Island Harbour, Newport Harbour is likely as the majority of defence levels are likely to be insufficient as they were not designed to protect against the prevailing conditions on a 50-100 year timescale.
		Summary of estuary response	The Medina Estuary inlet operates as a natural littoral transport boundary as its dominant ebb tidal flow generates net offshore flushing of incoming shoreline sediments, although there is very little incoming littoral drift due to widespread	The maintenance of the defences within the Estuary and particularly in adjacent units will continue to prevent erosion and supply of littoral drift sediment from converging in the estuary mouth.	The maintenance and replacement of the defences within the Estuary, the Shrape breakwater and particularly in adjacent units will continue to control and minimise sediment input and supply, assisting the

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			shoreline stabilisation and drift interception. The Shrape breakwater limits the amount of suspended sediment entering the Estuary and shifts the ebb tidal flow westward into the centre of the inlet. The maintenance of the defences within the Estuary and particularly in adjacent units (Gurnard and Cowes Esplanade, Cowes Parade and Harbour and East Cowes Esplanade) will continue this pattern of behaviour, preventing the commencement of erosion input to the local weak littoral drift system and starving the Estuary mouth of sediments from neighbouring shorelines. Fluvial sources of sediment are considered to be relatively insignificant and are likely to continue to contribute little to the coastlines on either side of the mouth. The entrance to the Medina Estuary has been dredged on several occasions to maintain a navigable channel for car ferries.	The Shrape breakwater in particular will continue to help prevent sediment encroaching into the Estuary mouth from the east –important in maintaining a navigable and commercial channel to the upper Estuary.	maintenance of a navigable and commercial channel to the upper Estuary. Rising sea levels and increasing storminess may affect the behaviour and interactions of the Estuary system at the mouth and will impact upon the intertidal habitats of the central Estuary.
IW59 ***Name:* EAST COWES OUTER HARBOUR** **From: Floating Bridge, East Cowes** **To: Shrape Breakwater**	**No Active Intervention**	*Short description of predicted defence failure*	This 917km frontage forms the eastern mouth of the Medina Estuary and is similar in character to the western mouth (see unit IW58 Cowes Parade & Harbour). For most of the frontage a variety of vertical walls rise from the silt of the river bed. Low-lying coastal land on both sides of the Medina Estuary is heavily developed. The southern limit of this frontage is the key transport link of the Floating Bridge (or Chain Ferry) vehicle and passenger river crossing. Moving northwards from the Floating Bridge a series of concrete and masonry seawalls and steel sheet piles protect properties and businesses along the waterfront. Unmaintained, the sections of seawall will generally fail in 15-25 years, and the steel sheet piling in 26-60 years. At the northern end of this unit East Cowes promenade is a brickwork wall with concrete buttresses and encasement, with short concrete groynes at intervals along the frontage. It is expected to fail in 10-15 years. The promenade	Remaining sections of seawall will fail early in this epoch, with the exception of the sections of steel sheet piles fronting the commercial site on Castle Street which may remain for approximately 25-30 and 30-70 years.	No defences along the majority of the frontage. Any remaining remnant structures will be outflanked and regularly inundated.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			behind provides road and footpath access to the coast. The East Cowes (Shrape) Breakwater consists of a concrete wall with concrete braces on the southern side, expected to fail in 15-25 years.		
		Description of cliff erosion/ reactivation	This urban area is at risk principally from coastal flooding. With no further intervention or maintenance the defence structures in the north and south of the frontage will breach at the end of epoch 1. Erosion at 0.12m/yr may result in scattered patches of recent erosion by the end of the epoch (up to 0.6m in total by year 20). There is flood risk to a large number of properties in the town centre and along seafront roads. Overtopping and tidal flooding already occurs (for example at the Car Ferry terminal frontage). The wave climate at the mouth of the Medina is relatively moderate due to the shelter of Shrape breakwater, however, there is likely to be an increase in the frequency of flooding.	Defences in the centre of the unit will deteriorate and fail progressively. Exposure of the shoreline will increase following failure of the Shrape breakwater. An increase in the frequency of flooding is likely as a result of sea level rise and increasing adverse weather conditions. The flood risk area covers the town centre, Albany Road Castle Street, Ferry Road, York Avenue, Dover Road and Well Road and Clarence Road. Erosion will continue at approx. 0.15m/yr where defences have failed, with a total of approx. 5m retreat possible during this epoch (6m in total since year 1). Shoreline change will be controlled by remaining hard defence points along the centre of the frontage.	Rising sea levels will significantly increase flood risk, with flooding of East Cowes and Cowes town centres on most tides. Erosion will continue at approx. 0.18m/yr then 0.19m/yr, with a further approx. 9m of shoreline retreat possible during this epoch (or 15m in total since year 1). However, the most significant risk to the frontage will be extensive tidal flooding.
		Description of beach evolution	This frontage comprises the eastern mouth of the Medina Estuary. For much of the frontage vertical walls rise from the silt of the river bed. Westwards directed, but very weak, littoral drift occurs from a drift divergence at Old Castle Point towards the Shrape breakwater. The Shrape Breakwater prevents sediment input into Cowes Harbour and into this frontage; however, falling beach levels and lack of significant accretion against the breakwater indicate low drift rates. Cowes Harbour entrance therefore represents a drift convergence boundary, although the very small quantities of sediment moved by littoral transport towards the Medina entrance, together	Failure of the Shrape Breakwater will release quantities of stored sediment into the harbour mouth and entrance channel, and could divert or weaken the tidal regime across a wider entrance to the estuary. Sediment levels along this frontage are expected to remain negligible, with limited sediment input from patchy erosion following defence failure.	Continued erosion will supply very limited quantities of sediment to the shoreline, however sediment levels along this frontage are expected to remain negligible, with fine sediments removed by the tidal flows of the Medina Estuary.

Location	Scenario		Predicted change for: Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
			with the Shrape breakwater, makes this little more than a notional feature. There will be no direct sediment input into this frontage until defences start to fail later in the epoch, and defences generally rise from the silt of the river bed with no fronting beach sediments.		
	With present management	*Short description of predicted defence failure*	The present concrete and masonry seawalls and steel sheet piles could be maintained at their current standards of effectiveness.	Concrete and masonry seawalls and steel sheet piles will be maintained and replaced at their current standards.	Concrete and masonry seawalls and steel sheet piles will be maintained and replaced at their current standards.
		Description of cliff erosion/ reactivation	Maintaining the existing sea walls without improving the current standard of protection will prevent shoreline change due to erosion but will not reduce the current and future levels of flood risk. Tidal inundation already encroaches into the developed area. The flood risk zone will expand in future epochs and the area will be at high flood risk. Maintaining the Shrape breakwater will prevent wave overtopping of these walls.	Maintaining the existing sea walls without improving the current standard of protection will prevent shoreline change due to erosion but will not reduce the high flood risk. Overtopping and tidal flooding of the town centre and seafront roads will become increasingly frequent, with large numbers of residential commercial and industrial properties affected. Maintaining the shoreline in its current position will help to preserve the harbour entrance channel and retain the commercial operation of the estuary and the important cross-Solent ferry links.	Rising sea levels will result in extensive tidal flooding overtopping the defence structures and inundating the low-lying centre of the town. Increasing numbers of residential commercial and industrial properties will be affected. The seawalls will continue to prevent erosion from changing the shoreline position, but the frequency of flooding could trigger the abandonment of areas. Maintaining the shoreline in its current position will help to preserve the harbour entrance channel and retain the commercial operation of the estuary, although the cross-Solent ferry links are located in the flood risk zones.
		Description of beach evolution	No significant change in the shoreline is anticipated if present management practices continue. Continuing the use of vertical walls in this location is acceptable because of the low energy wave climate.	No significant change in the shoreline is anticipated if present management practices continue. There would be no sediment inputs into the frontage from local erosion or significant inputs from adjacent units.	No significant change in the shoreline is anticipated if present management practices continue. There would be no sediment inputs into the frontage from local erosion or significant inputs from adjacent units.
IW1 **Name: East Cowes**	**No Active Intervention**	*Short description of predicted defence*	This 890m frontage marks the northern edge of the town of East Cowes, with an esplanade road and scattered properties protected by an aging seawall which is expected to fail in 15-25 years.	Remaining sections of the seawall and Shrape Breakwater will fail at the start of this epoch, leaving the frontage undefended.	No defences.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
Esplanade **From: Shrape Breakwater** **To: Old Castle Point**		*failure*	Short concrete groynes fronting the seawall will fail in 10-15 years. This unit is heavily affected by the presence of the Shrape Breakwater, approx. 325m in length and attached to the land at the western boundary of this frontage, extending seawards to the north-west to shelter the harbour and channel at the mouth of the Medina Estuary. This has a residual life of 15-25 years.		
		Description of cliff erosion/ reactivation	This frontage is characterised in the east by an Esplanade road backed by grassy public open space with scattered buildings (adjoining the main town of East Cowes), moving into thickly wooded coastal slopes in the west, also fronted by Esplanade road sea wall. No Active Intervention along this frontage will allow the defences to fall into disrepair and eventually fail. The slope would remain stable in the short term but there is potential for erosion and slope reactivation in the longer term, especially when Shrape Breakwater fails. The western 200m of this unit is relatively stable, and will erode at approx. 0.26m/yr after the seawall and sheltering influence of the Shrape Breakwater is removed in year 15, resulting in approx. 1m of erosion by year 20. The eastern 600m is at risk from reactivation of the steep slopes behind. Erosion of the ground forming the toe weighting to the adjacent coastal slope could reactivate failure planes within the coastal slope. Once the defences have failed in year 15 erosion at approx. 0.26m/yr will commence, and is soon likely to trigger a slope failure and retreat of approx. 65m. The Esplanade and seafront properties in the east of the frontage are at risk from tidal flooding, and overtopping of the defences already occurs.	The western 200m will continue to erode at approx. 0.26m/yr (8m retreat in this epoch, or 9m in total from year 1). This section may be affected by land slippage resulting from adjacent ground movement in the eastern section of the unit. The eastern section will continue to erode at approx. 0.26m/yr (8m retreat in this epoch, in addition to the 1m erosion and 65m reactivation at the end of epoch 1, resulting in approx. 34m retreat by year 50. Without the Shrape Breakwater and beach depletion, the coastal slip may extend westwards into the Cowes development.	The western 200m will continue to erode at approx. 0.31m/yr then 0.34m/yr (16m retreat in this epoch, or 25m in total from year 1). The eastern section will continue to erode at 0.31m/yr and 0.34m/yr (16m retreat in this epoch), resulting in up to 90m of coastal retreat over 100 years.

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	Years 20-50 (to approx. 2055)	Years 50-100 (to approx. 2105)
		Description of beach evolution	Currently accreting, a narrow shingle/coarse clastic beach fringes the cliff foot and defence structures, widening westwards and terminating at the Shrape Breakwater, with weak net westerly littoral drift. Shingle foreshore levels increase in a south-westerly direction, with a narrow muddy intertidal foreshore. Old Castle Point, at the western limit of this unit, functions as a drift divide and the unit effectively functions as a closed embayment. Littoral drift divergence means around Old Castle Point means the area is especially sensitive to variations in the local sediment supply and susceptible to sediment starvation. Accretion against the eastern side of Shrape Breakwater since its construction in 1936/37 (and similar smaller structures) indicates a long-term trend for net westward littoral drift along this East Cowes Esplanade frontage (in contrast with the general trend in surrounding units). The Strategic Monitoring Programme shows this beach has been stable from 2004-09, with some slight accretion in the centre of the unit. Erosion in this unit could be reduced if beach accretion continues and limits the extent of slope failure, but beach levels are likely to drop following failure of the Shrape Breakwater.	Erosion will start to supply significant sediment to the local beaches in slope reactivation occurs. Loss of the Shrape Breakwater at the end of the previous epoch is likely to result in loss of sediment to the west, which may impede navigation in Cowes Harbour (dependent on the impact of the loss of the sheltering breakwater on the process interactions at the estuary mouth).	Sediments will be yielded from the reactivated and eroding cliffs, but will be removed from the beach by littoral drift to the west.
	With present management	*Short description of predicted defence failure*	The seawall, concrete groynes and Shrape Breakwater will be maintained at their current standard without improvement.	The maintained seawall, groynes and breakwater will continue to prevent erosion.	The maintained seawall, groynes and breakwater will continue to prevent erosion.
		Description of cliff erosion/ reactivation	Maintenance of the defences will prevent coastal erosion and slope reactivation, but tidal flooding of the esplanade and adjacent properties during extreme water level events will still occur if the seawall is maintained at its current standard. Outflanking of the seawall from the east by 2m will occur as erosion increases in the breaches in	Seawall maintenance will reduce the likelihood of slope reactivation, although increasingly frequent overtopping will occur and may have a destabilising influence. Tidal flooding of the Esplanade will continue in the west of the frontage. Outflanking of the seawall from the east by a	The seawall will be frequently overtopped and several seafront properties inundated by tidal flooding. Outflanking of the seawall from the east by a further approx. 7m will occur (up to 43m in total, including slope failure).

Location	Scenario		Predicted change for:		
			Years 0-20 (to approx. 2025)	**Years 20-50 (to approx. 2055)**	**Years 50-100 (to approx. 2105)**
			the failed seawall in the adjacent unit to the east, plus a potential 30m reactivation in the adjacent unit will further offset the coast line.	further approx. 4m will occur (up to 36m in total, including slope failure).	
		Description of beach evolution	Foreshore narrowing will occur in front of the seawalls. Sediment supply is limited by the nearby littoral drift divide at Old Castle Point and there will be no direct sediment input from this frontage.	Beach levels will generally fall and expose the seawall to wave attack, but sediment will accumulate in the western corner of the unit, trapped by the Shrape Breakwater.	Foreshore narrowing is likely to continue due to limited sediment supply.

Appendix C: South East Strategic Regional Coastal Monitoring Programme

The Southeast Strategic Regional Coastal Monitoring Programme provides a consistent regional approach to coastal process monitoring, providing information of the development of strategic shoreline management plans, coastal defence strategies and operational management of coastal protection and flood defence.

The programme came into being on 1 August 2002 and has been operating ever since. The programme is managed on behalf of the Coastal Groups and is funded by DEFRA, in partnership with the maritime Local Authorities and the Environment Agency.

Data are collected via a series of contracts and also by in-house Local Authority teams. All data collected by the programme are made freely available, via the Channel Coastal Observatory website – www.channelcoast.org. A specialist team has been established at the Channel Coastal Observatory to manage the programme and develop the data analysis, storage and dissemination procedures.

The first beach surveys took place during the winter of 2002. This provides a relatively short time base over which beach changes have been monitored. Detailed interpretation and decision-making is not advisable on the basis of these short-term changes, since the changes may not be representative of longer-term trends. Comment is limited, therefore, to only those sites which show obvious short-term problems, or where long-term data are deemed to be of sufficient quality. As the Programme progresses, more detailed and meaningful reporting will be possible.

Further details are available in the Southeast Strategic Regional Coastal Monitoring Programme Isle of Wight Annual Reports (Channel Coastal Observatory, 2013).

Appendix D: Channel Coast Observatory, Storm Report for Sandown Bay, Winter 2013-2014

The following text and images are an extract of the following report:

Review of south coast beach response to wave conditions in the winter of 2013-14, Southeast Regional Coastal Monitoring Programme, SR01, April 2014 (Channel Coast Observatory).

Important note: The following storm report for Sandown Bay on the south-east coast of the Isle of Wight is located outside the area of the West Wight Coastal Flood and Erosion Risk Management Strategy. However, it contains useful and recent information on storm events and is therefore included as an Appendix.

Storm report for Sandown Bay, Isle of Wight

Wave conditions are measured with a buoy moored about 1.2 km off Sandown, in about 10 m CD water depth. The buoy has been in place for 10 years.

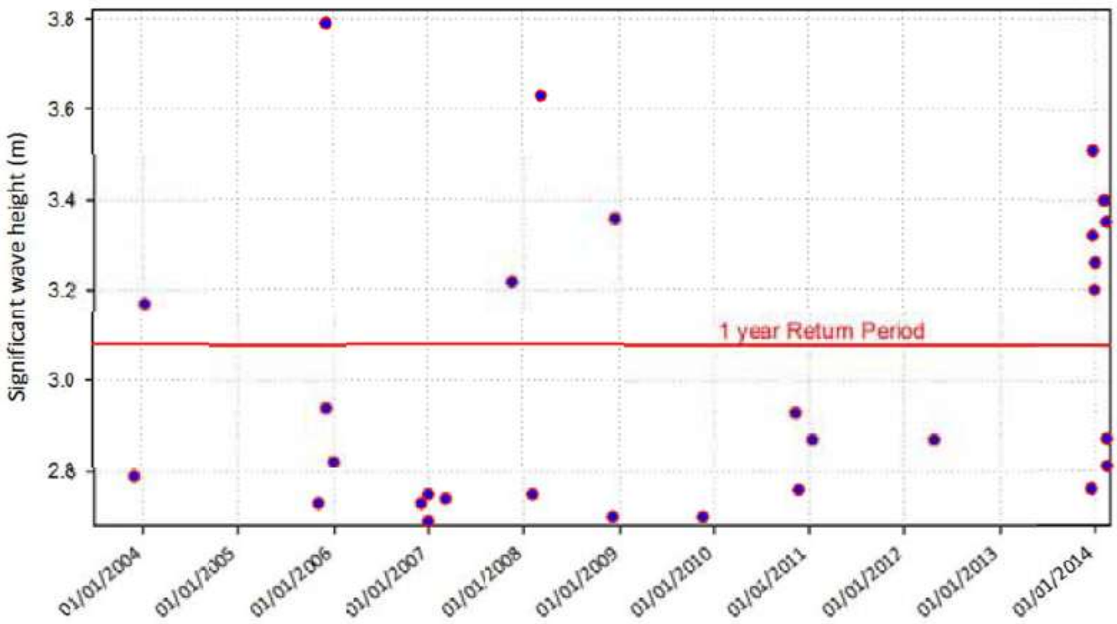
Datawell Directional Waverider buoy in Sandown Bay. Photo courtesy of Fugro EMU Limited

Location of Sandown Bay Directional Waverider buoy (Google mapping)

In an average year, there are usually 3 or 4 storms which have some impact on the beach; these are indicated in the graph below. The red line shows the wave height which a storm is likely to reach once a year, in an average year *i.e.* the 1 year Return Period.

Since 2003, 11 individual storms have exceeded the 1 year Return Period. 6 of those storms (55 %) occurred between October 2013 and February 2014.

Since 2003, 11 individual storms have exceeded the 1 year Return Period. 6 of those storms (55 %) occurred between October 2013 and February 2014.



Storm calendar for Sandown Bay. Each dot on the graph represents the highest significant wave height (Hs) of the individual storm

The individual storms since 2003 are ranked in Table 1, together with the Return Period (this season's storms are shaded pink). The Return Period statistics were last calculated for the period 2003 to 2012.

Highest storms at Sandown Bay		
Date	Wave height (metres)	Return Period
02/12/2005	3.79	Greater than 1 in 10 years
10/03/2008	3.63	> 1 in 5 years
24/12/2013	3.51	> 1 in 3 years
05/02/2014	3.40	> 1 in 3 years
13/12/2008	3.36	> 1 in 2 years
12/02/2014	3.35	> 1 in 2 years
23/12/2013	3.32	> 1 in 2 years
01/01/2014	3.26	> 1 in 1 year
18/11/2007	3.22	> 1 in 1 year
30/12/2013	3.20	> 1 in 1 year
08/01/2004	3.17	> 1 in 1 year

Storms exceeding 1 year Return Period at Sandown Bay since deployment in 2003. Those occurring during the storm season October 2013 to February 2014 are shaded pink

Appendix B
Existing and Predicted Water Levels

B.1 Extreme water levels

Extreme water level data was provided by the Environment Agency "Coastal Flood Boundary Conditions for the Mainland UK Coasts and Islands" 2011 project, for five locations along the frontage: Freshwater Bay, Yarmouth, Totland, Gurnard and Cowes (Table B-1) – the base year of the data is 2008.

Table B-1: Predicted extreme water levels (mOD) along the study frontage (base year 2008).

Location	Return Period (years)										
	1	2	5	10	20	50	75	100	200	500	1000
Freshwater Bay	1.43	1.51	1.60	1.68	1.74	1.83	1.88	1.88	1.94	2.02	2.07
Totland	1.63	1.71	1.80	1.88	1.95	2.03	2.07	2.09	2.15	2.23	2.28
Yarmouth	1.79	1.87	1.97	2.04	2.11	2.20	2.23	2.25	2.31	2.40	2.45
Gurnard	2.31	2.39	2.49	2.56	2.63	2.72	2.75	2.78	2.84	2.93	2.99
Cowes	2.41	2.49	2.59	2.66	2.73	2.82	2.85	2.88	2.95	3.04	3.10

B.2 Climate change

B.2.1 Current guidance

In September 2011 the Environment Agency issued climate change advice for FCERM (Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities) (Environment Agency 2011b). This guidance replaced the previous advice and includes updated sea level rise allowances and is based on the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report 'UKCP09'.

The range of predictions are presented as central estimates of change for each emissions scenario with upper and lower confidence bounds. UKCP09 relative sea level rise projections are available for three emissions scenarios and are presented as 'change factors' which can be extracted for specific locations around the UK; these are provided as change values relative to 1990 and for any year up to 2100. Environment Agency (2011b) guidance states that beyond this time period values should be extrapolated.

A range of scenarios are provided in the Environment Agency, 2011 guidance, including low and high emissions scenarios demonstrating the range of future uncertainty. Based on the latest guidance the upper confidence bound (95th percentile) medium emissions scenario has been adopted as the 'change factor in the Strategy'.

B.2.2 Changes to relative mean sea level due to climate change

The projected increases in relative mean sea level for the Environment Agency 2011 guidance change factor (UKCP 09 medium 95%tile, excluding the surge component) for all the locations for four periods in time over the Strategy appraisal period are shown in Table B-2 and sea level rise at Freshwater Bay is displayed graphically in Figure B-1.

Table B-2: Relative sea level rise changes from 2015 (in metres), UKCP09 medium emission scenario

Location	2015	2025	2055	2115
Freshwater Bay	0	0.056	0.249	0.752
Totland	0	0.056	0.249	0.752
Yarmouth	0	0.056	0.249	0.751
Gurnard	0	0.056	0.248	0.750
Cowes	0	0.056	0.248	0.750

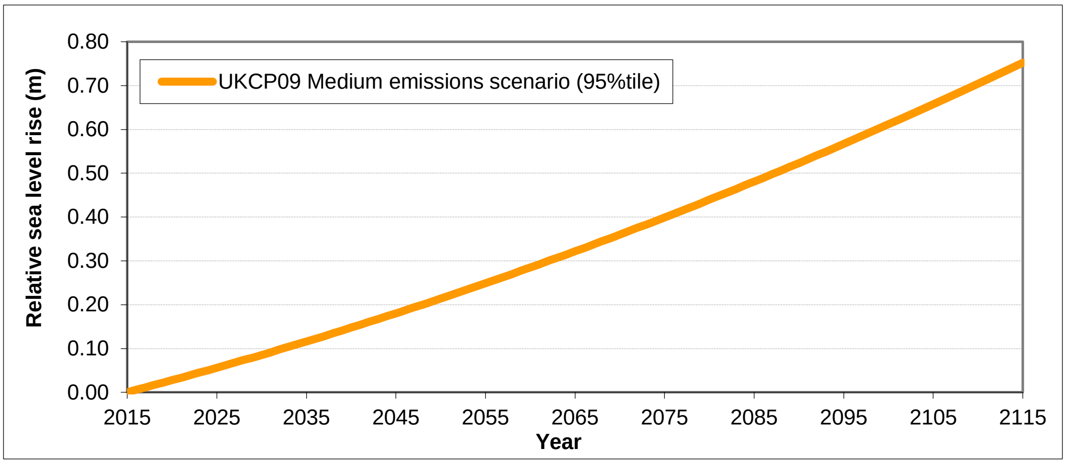


Figure B-1: Relative sea level rise at Freshwater Bay (base year 2015)

B.2.3 Changes to storm surges due to climate change

Extreme water levels occur as a resultant combination of mean sea level, astronomical tide levels and the non-tidal components (such as storm surge). The Environment Agency recommends applying storm surge change factors to account for potential increased storminess and changes in storm tracks over the UK in the future.

Following this advice the long term trends in storm surge (defined as skew surge in UKCP09) for the five locations on the frontage were downloaded from the UKCP09 User Interface website. Note that some locations are within the same data selection cell so have the same storm surge change value.

The downloaded data points were plotted using a logarithmic scale on the x-axis (shown for Freshwater Bay in Figure B-2) to identify the trend in order to establish the change factor for the full range of return period events (Table B-3).

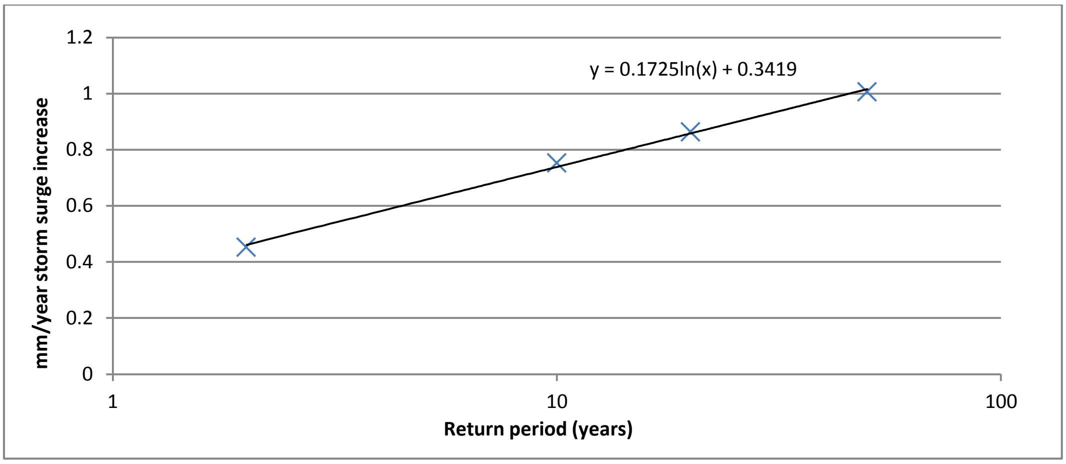


Figure B-2: Annual storm surge increase based on the recommended Environment Agency medium emissions scenario estimate (Freshwater Bay)

Table B-3: Extrapolated surge increase for a range of return period events (95th percentile medium emissions scenario)

Return Period	mm/yr				
	Freshwater Bay	Totland	Yarmouth	Gurnard	Cowes
1	0.34	0.34	0.34	0.36	0.34
2	0.46	0.46	0.46	0.48	0.45
5	0.62	0.62	0.62	0.63	0.60
10	0.74	0.74	0.74	0.75	0.72
20	0.86	0.86	0.86	0.87	0.83
50	1.02	1.02	1.02	1.03	0.98
75	1.09	1.09	1.09	1.10	1.05
100	1.14	1.14	1.14	1.15	1.10
200	1.26	1.26	1.26	1.27	1.21
500	1.41	1.41	1.41	1.42	1.36
1000	1.53	1.53	1.53	1.54	1.48

B.2.4 Future extreme water levels

Future extreme still water levels were calculated by adding the mean sea level changes and surge increases to the current extreme water levels (shown in Figure B-3 for the 1:200 event at Freshwater Bay). The 2015 extreme water levels were estimated by adjusting the 2008 water levels (Table B-1) for sea level rise and are displayed in Table B-4.

Table B-4: Current extreme water levels (mOD) along the study frontage (base year 2015)

Location	Return Period (years)										
	1	2	5	10	20	50	75	100	200	500	1000
Freshwater Bay	1.47	1.55	1.64	1.72	1.78	1.87	1.90	1.92	1.98	2.06	2.11
Totland	1.67	1.75	1.84	1.92	1.99	2.07	2.11	2.13	2.19	2.27	2.32
Yarmouth	1.83	1.91	2.01	2.08	2.15	2.24	2.27	2.29	2.35	2.44	2.49
Gurnard	2.35	2.43	2.53	2.60	2.67	2.76	2.79	2.82	2.88	2.97	3.03
Cowes	2.45	2.53	2.63	2.70	2.77	2.86	2.89	2.92	2.99	3.08	3.14

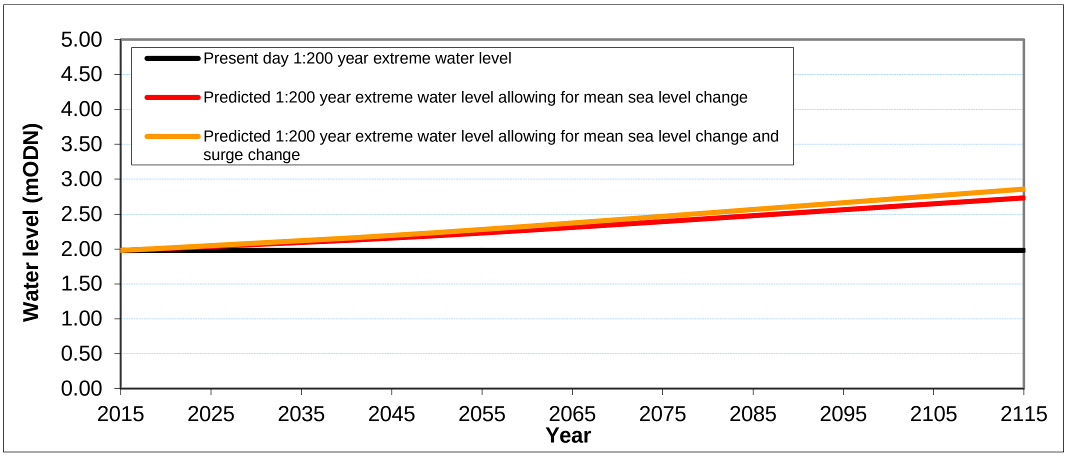


Figure B-3: Graphical representation of prediction of future extreme water levels at Freshwater Bay (1:200)

The future extreme water levels were estimated for the Strategy using Environment Agency 2011 guidance 'change factor'. This includes allowance for changes in relative mean sea level based in the medium emissions scenario 95%tile and also for increases in storm surges.

The existing and predicted future extreme water levels are presented for the five locations below.

Table B-5: Existing and predicted future extreme water levels (mOD) for Freshwater Bay

Freshwater Bay	Medium Emissions Scenario 95% + Storm Surge			
	Extreme Water Level (mOD)			
Return Period (years)	2015	2025	2055	2115
1	1.47	1.53	1.73	2.25
2	1.55	1.61	1.81	2.34
5	1.64	1.70	1.91	2.45
10	1.72	1.78	1.99	2.54
20	1.78	1.84	2.06	2.61
50	1.87	1.93	2.16	2.72
75	1.90	1.96	2.19	2.76
100	1.92	1.98	2.21	2.78
200	1.98	2.04	2.28	2.85
500	2.06	2.13	2.36	2.95
1000	2.11	2.18	2.42	3.01

Table B-6: Existing and predicted future extreme water levels (mOD) for Totland

Totland	Medium Emissions Scenario 95% + Storm Surge			
	Extreme Water Level (mOD)			
Return Period (years)	2015	2025	2055	2115
1	1.67	1.73	1.93	2.45
2	1.75	1.81	2.01	2.54
5	1.84	1.90	2.11	2.65
10	1.92	1.98	2.19	2.74
20	1.99	2.05	2.27	2.82
50	2.07	2.13	2.36	2.92

75	2.11	2.17	2.40	2.97
100	2.13	2.19	2.42	2.99
200	2.19	2.25	2.49	3.06
500	2.27	2.34	2.57	3.16
1000	2.32	2.39	2.63	3.22

Table B-7: Existing and predicted future extreme water levels (mOD) for Yarmouth

Yarmouth	Medium Emissions Scenario 95% + Storm Surge			
	Extreme Water Level (mOD)			
Return Period (years)	2015	2025	2055	2115
1	1.83	1.89	2.09	2.61
2	1.91	1.97	2.17	2.70
5	2.01	2.07	2.28	2.82
10	2.08	2.14	2.35	2.90
20	2.15	2.21	2.43	2.98
50	2.24	2.30	2.53	3.09
75	2.27	2.33	2.56	3.13
100	2.29	2.35	2.58	3.15
200	2.35	2.41	2.65	3.22
500	2.44	2.51	2.74	3.33
1000	2.49	2.56	2.80	3.39

Table B-8: Existing and predicted future extreme water levels (mOD) for Gurnard

Gurnard	Medium Emissions Scenario 95% + Storm Surge			
	Extreme Water Level (mOD)			
Return Period (years)	2015	2025	2055	2115
1	2.35	2.41	2.61	3.13
2	2.43	2.49	2.69	3.22
5	2.53	2.59	2.80	3.34
10	2.60	2.66	2.87	3.42
20	2.67	2.73	2.95	3.50
50	2.76	2.82	3.05	3.61
75	2.79	2.85	3.08	3.65
100	2.82	2.88	3.11	3.68
200	2.88	2.94	3.17	3.75
500	2.97	3.04	3.27	3.86
1000	3.03	3.10	3.34	3.93

Table B-9: Existing and predicted future extreme water levels (mOD) for Cowes

Cowes	Medium Emissions Scenario 95% + Storm Surge			
	Extreme Water Level (mOD)			
Return Period (years)	2015	2025	2055	2115
1	2.45	2.51	2.71	3.23
2	2.53	2.59	2.79	3.32
5	2.63	2.69	2.90	3.44
10	2.70	2.76	2.97	3.52
20	2.77	2.83	3.05	3.60

50	2.86	2.92	3.14	3.70
75	2.89	2.95	3.18	3.74
100	2.92	2.98	3.21	3.78
200	2.99	3.05	3.28	3.86
500	3.08	3.15	3.38	3.96
1000	3.14	3.21	3.44	4.03

Appendix C
Future Erosion Predictions

C.1 Background

The West Wight Strategy requires estimates of future shore recession (erosion). The estimates reported here are based on estimates of historic erosion rate, which must be increased to account for acceleration in sea level rise. The equation of Walkden and Dickson (2008) has been chosen to do this based on, in part, its adoption during the prior Shoreline Management Plan Review (SMP2, 2010).

Owing to the time that has elapsed between the SMP2 and the West Wight Strategy, the SMP2 projections of future shore change have been revisited. This is mainly to account for changes in:

(1) Understanding of historic sea level rise
(2) Projections of future sea level rise, and
(3) Changes in epochs over which erosion is to be projected to reflect the Strategy epochs of 2015-2025, 2025-2055 and 2055-2115.

It is important to note that the coastal erosion predictions presented in this report are only an estimate, based on available historic and current data, and actual erosion in the future may be greater (or less). This is particularly applicable to those areas where reactivation of coastal slopes / pre-existing landslide complexes could result in significantly larger erosion distances than those locations where erosion only occurs as a result of marine forcing i.e. via extreme water levels and/or wave action. Failure of unstable slopes may be triggered by other forcing mechanisms such as rain and high groundwater levels. It is beyond the scope of the Strategy to make a detailed assessment and prediction of reactivation distances from different forcing mechanisms. However, the key coastal landslide risk areas have been identified, and the integral role of the current coastal erosion defences in minimising the risk of coastal landslide reactivation has been highlighted and considered where appropriate. For the purposes of the Strategy, the potential economic impact of reactivation has been considered as part of the option appraisal and economic assessment sensitivity testing to evaluate the benefit of improving the defences – refer to Option Assessment and Economic Appraisal appendix for further details. The predicted rates, therefore, should be treated as an average, and are used as a means to identify relative erosion across the study area and those locations where the most assets are at risk i.e. prioritising the need for intervention.

C.2 The Walkden and Dickson (2008) Equation

The Walkden and Dickson (2008) equation is:

$$\varepsilon_2 = \varepsilon_1 \sqrt{S_2/S_1}$$

Equation 1

Ɛ and S represent equilibrium rates of recession and sea level rise respectively, and the subscripts represent past ($_1$) and future ($_2$) conditions. Equilibrium conditions take a long time to emerge relative to management timeframes (i.e. the duration of the Strategy), so the expression may be adopted to represent shorted timeframes by the inclusion of a response factor (f), as follows:

$$\varepsilon_2 = \varepsilon_1 + f(\varepsilon_1\sqrt{S_2/S_1} - \varepsilon_1)$$

Equation 2

Each term in Equation 2 is dealt with below.

C.3 Historic Recession Rates (ε_1)

Historic erosion rates have been provided by the Council, as shown in Table C-1. The locations for historic erosion rate are identified against the reference numbers used in SMP2 and the SMZs used in the Strategy.

Table C-1: Current/Historic Erosion Rates across the West Wight Study Area

SMP2 Reference No.	SMP2 Unit Name	SMP2 Policy Unit No.	SMZ	Current/Historic Erosion Rate (m/yr)
41	Freshwater Bay	6A.1	3	0.30
42	Tennyson Down & The Needles	6A.2	1	0.25
43	Alum Bay	6A.2	1	0.30
44	Headon Warren	6A.2	1	0.30
45	Totland & Colwell	6B.1	2	0.50
46	Central Colwell Bay	6B.2	2	0.50
47	Fort Albert	6B.3	2	0.50
48	Fort Victoria Country Park	6B.4	2	0.30
49	Fort Victoria & Norton	6B.5	3	0.30
50	Yarmouth Estuary	6C.1-5	3	0.10
51	Yarmouth Town & Bouldnor	6C.6	3	0.30
52	Bouldnor Copse & Hamstead	7.1	4	0.30
53	Newtown Estuary – western spit	7.2	4	0.60
53	Newtown Estuary – eastern spit	7.2	4	0.62
53	Newtown Estuary – inside eastern spit	7.2	4	0.20
54	Thorness Bay	7.3	4	0.40
55	Gurnard Luck	1A.1	5	0.30
56	Gurnard & Cowes Esplanade	1A.2-3	5	0.30
57	Cowes Parade & Harbour	1A.4	6	0.30
58	Medina Estuary	1B.1-5	6	0.10
59	East Cowes Outer Harbour	1A.5	6	0.20
1	East Cowes Esplanade (west)	1A.6	6	0.20
2	East Cowes Esplanade (east)*	1A.6	6	0.25

*Rates of 0.15-0.35 historic coastal change quoted by the NE Coastal Strategy Study 2004.

For more specific information, please refer to the Isle of Wight Shoreline Management Plan, 2010 (see main report Chapter 4 and Appendix C3).

C.4 Sea Level Rise (S)

Historic Rate (S_1)

The recent authoritative estimate of historic sea level rise for the Isle of Wight area provided by Long et al., 2014, of 0.9 mm/y, has been used for the S_1 parameter. The rate established by Long et al. was based on sea level reconstruction from saltmarsh records over the last 300 years. The Long et al. record is applicable to the timeframes associated with the equilibrium conditions captured by the Walkden and Dickson (2008) equation. The record also picks up the short-term acceleration in the late 20th Century rates as part of a lower longer-term rise.

Future Rate (S_2)
The future rate of sea level rise has been identified by reference to UKCP09 projections for different climate change scenarios. The Environment Agency recommends using the upper limit (95 percentile) of the medium emissions scenario as the most suitable for flood and coastal defence planning. Using this scenario, the average projected sea level rise rates for the study area are as follows, using 2015 as the base year. Note that the average rate of sea level rise is used as part of the Walkden & Dickson (2008) methodology, not the average epoch rates i.e. 2015-2025, 2025-2055 etc.

- 2015-2025: 5.56 mm/yr (over 10 years)
- 2015-2055: 6.21 mm/yr (over 40 years)
- 2015-2115: 7.51 mm/yr (over 100 years)

C.5 Response Factors (f)

Response factors have been estimated by reference to the previous work of Walkden and Dickson (2008), and the response time of the coast as a result of changing sea level rise rates. The response factors were derived by measuring the proportion of change in erosion rate ($\varepsilon_2 - \varepsilon_1$) that has occurred by the end of each epoch as a consequence of the change in sea level rise rate. The start of all the epochs is defined as the year in which the rate of sea level rise begins to change i.e. 2015, 2025, 2055. The resulting response functions are for each epoch are:

- 2015: f = 0
- 2025: f = 0.093
- 2055: f = 0.37
- 2115: f = 0.53

C.6 Future Recession Rate (ε_2) and Erosion Distance

The outcome of applying the parameter values described above to the Walkden and Dickson (2008) equation (No.2) is shown in Table C-2; these are the estimates of future recession distances corresponding to the locations in Table C-1. The historic erosion rate is also provided for reference.

The erosion rates reported in Table C-2 show the estimated future erosion distances that would occur for each unit if no defences were in place. Within these units, there are a variety of defence structures with varying residual lives (see Appendix A for details). Therefore, when these future erosion predictions were mapped, the rates were applied from the point of predicted failure of each defence structure, so that the erosion zones used in the Strategy allow for the current condition of the defences (based on their predicted residual life in the absence of maintenance).

Table C-2: Predicted Future Recession Distances across the West Wight Study Area

SMP2 Ref. No.	SMP2 Unit Name	SMP2 Policy Unit No.	SMZ	Current/Historic Erosion Rate (m/yr)	Future Erosion Distance (m)		
					to 2025	to 2055	to 2115
41	Freshwater Bay	6A.1	3	0.30	3	19	60

42	Tennyson Down & The Needles	6A.2	1	0.25	3	16	50
43	Alum Bay	6A.2	1	0.30	3	19	60
44	Headon Warren	6A.2	1	0.30	3	19	60
45	Totland & Colwell	6B.1	2	0.50	6	32	100
46	Central Colwell Bay	6B.2	2	0.50	6	32	100
47	Fort Albert	6B.3	2	0.50	6	32	100
48	Fort Victoria Country Park	6B.4	2	0.30	3	19	60
49	Fort Victoria & Norton	6B.5	3	0.30	3	19	60
50	Yarmouth Estuary	6C.1-5	3	0.10	1	6	20
51	Yarmouth Town & Bouldnor	6C.6	3	0.30	3	19	60
52	Bouldnor Copse & Hamstead	7.1	4	0.30	3	19	60
53	Newtown Estuary – western spit	7.2	4	0.60	7	38	120
53	Newtown Estuary – eastern spit	7.2	4	0.62	7	40	124
53	Newtown Estuary – inside eastern spit	7.2	4	0.20	2	13	40
54	Thorness Bay	7.3	4	0.40	5	26	80
55	Gurnard Luck	1A.1	5	0.30	3	19	60
56	Gurnard & Cowes Esplanade	1A.2-3	5	0.30	3	19	60*
57	Cowes Parade & Harbour	1A.4	6	0.30	3	19	60
58	Medina Estuary	1B.1-5	6	0.10	1	6	20
59	East Cowes Outer Harbour	1A.5	6	0.20	2	13	40
1	East Cowes Esplanade (west)	1A.6	6	0.20	2	13	40
2	East Cowes Esplanade (east)	1A.6	6	0.25	3	16	50**

*Erosion of the toe of the coastal slopes could lead to potential 2m/yr (average) slope reactivation and retreat (Isle of Wight Council, 2010). The figure stated in the table for 'Gurnard & Cowes Esplanade' excludes reactivation. For the purposes of the Strategy, the potential economic impact of reactivation has been considered as part of the Option Appraisal and Economic Assessment sensitivity testing to evaluate the benefit of improving the defences – refer to Option Assessment and Economic Appraisal appendix for further details.

**Plus potential slope failure of 65m in epoch 2 (ref. North-east Coastal Strategy Study, 2004).

C.7 References

Isle of Wight Council (2010). Isle of Wight Shoreline Management Plan 2. Appendix C: Baseline Process Understanding.

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