Beachy Head to Selsey Bill Shoreline Management Plan

Appendix C: Baseline Process Understanding

Contents

Contents by Policy Unit

Note the geographic breakdown of the appraisals presented in this Appendix is not necessarily the same as the final Policy Units (PU). Here the breakdown has been based upon coastal process and morphological changes along the shoreline. For ease of reference, the following table identifies the page number on which appraisals relevant to each PU start.

C.1 Assessment of Shoreline Dynamics

C.1.1 INTRODUCTION

This Appendix should be viewed as supplementary to information held within Futurecoast (2002) and more specifically the Shoreline Behaviour Statements for the following areas:

- Selsey Bill to Brighton Marina
- Brighton Marina to Beachy Head

It 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 must be read in conjunction with one another to provide a full understanding of dynamics and behaviour across different spatial and temporal scales.

C.1.2 SMP OVERVIEW

The coastline between Selsey Bill and Beachy Head has been shaped by post glacial sea level rise, when the entire English Channel and Dover Straits were inundated around 8000 years ago. Breaching of the low-lying land that once split this water body from the North Sea, initiated a strong eastward transport of sediment into the eastern channel. During the early stages of this period, the onshore migration of this sediment led to major episodes of sediment accumulation resulting in the formation of shingle barriers. A shingle barrier now extends the length of the coastline, from Selsey Bill to Brighton Marina, and, in the majority of places, is a relict feature.

The shoreline between Selsey Bill and Beachy Head is characterised by a shallow embayment held at either end by two headlands: (i) Selsey Bill, a ‘soft’ (and potentially highly mobile) protrusion from the natural coastal alignment, held seaward by the offshore control exerted by the Mixon Rocks; and (ii) Beachy Head, a moderately resistant Chalk headland. Both headlands are erosional features, but provide a degree of shelter to adjacent shorelines from predominant waves. Brighton Marina is constructed on Black Rocks, a natural headland, which marks a change in shoreline geomorphology and behaviour, from barrier transgression along the West Sussex coastal plain to cliff erosion to the east. Between the headlands, the backshore is characterised by:

- gently sloping hinterland in the west
- steeply rising ground and cliffs in the east

There are a number of tidal inlets situated along the coast, including Pagham Harbour and the mouths of the rivers Arun, Adur, Ouse and Cuckmere. The nearshore and offshore zones are characterised by a thin layer of relict gravel deposits that form nearshore banks at some locations, with some sandwaves that occur offshore between Worthing and Beachy Head.

The coastline between Selsey Bill and Beachy Head is considered to be a relatively closed system. There are few new sources or stores of material and there is generally a scarcity of naturally derived sediment (Futurecoast, 2002). The key sources to this frontage include: (i) the episodic onshore transport of sand and shingle left stranded on the seabed by continuing post-glacial sea level rise, forming submerged deposits that periodically feed the shoreline in the vicinity of Selsey Bill. This process continues episodically to the present day; (ii) sand found at the shoreline that has originated from the seabed and coastal erosion; (ii) erosion of the backshore and erosion and sub-aerial weathering of the cliffs; and (iv) rivers, which generally have relatively small discharges and do not contribute greatly to the sediment budget (Futurecoast, 2002). A generally limited supply of sediment to the frontage results in only sparse sediment coverage of the shore platforms in the east.

There is a sediment drift divide at Selsey Bill, with material from offshore being transported westwards towards the Isle of Wight and eastwards towards Pagham Harbour. A localised drift reversal and/or wave refraction across the ebb tidal delta shingle banks may account for the development of a spit at the northern side of Pagham Harbour (Futurecoast, 2002). Between Selsey Bill and Beachy Head the south-westerly dominant wave direction drives longshore drift in an easterly direction. The actual transfer of sediment along this stretch of coastline is considerably less than the natural potential, due to the relative scarcity of fresh sediment input (as well as present management intervention) (Posford Haskoning, 2003). There is potential for this sediment and other locally eroded material to be transported around Beachy Head and to the east, however, due to the lack sediment supply, there is no actual transport.

Trapping of littoral drift and the prevention of shingle rollback due to the presence of coastal defences has resulted in the general denudation of sediment to downdrift frontages, causing and exacerbating the process of foreshore narrowing and steepening, which is a prevalent feature of beaches throughout the frontage. As a consequence, the upper shore has become exposed to increased wave attack. Now, the inlets and rivers mouths of the Pagham Harbour and the Rivers Arun, Adur and Ouse and Cuckmere Haven are all trained and produce, or reinforce partial barriers to longshore drift. Additionally, during periods of high river flows, the estuary and river mouths have the potential for forcing the off-shore transport of sand and shingle, reducing the volume of material that would otherwise be supplied to downdrift sections of coastline.

Continued cliff recession between Brighton Marina and Beachy Head has resulted in the formation of hard rock platforms, which are themselves subject to platform lowering. A veneer of sand and shingle exists at the base of the cliffs, supplied by the delivery of material from updrift, offshore, or where present, directly from the cliffs behind. The rate of recession has been slowed by the construction and maintenance of coastal defences, which means that much of the coast is not commensurate with the shoreline energy conditions. This has implications for future shoreline management.

C.1.3 LARGE SCALE: SELSEY BILL TO BRIGHTON MARINA (INCLUSIVE)

Interactions:

Despite the tendency for Selsey Bill to erode, it still acts as a control on the development of the shoreline to the east and west. To the east, a shallow embayment has formed between Selsey Bill and Brighton (Futurecoast, 2002). To the west of Selsey, Medmerry shingle barrier extends from Selsey towards West Wittering. Behind that and to the north of Selsey is the Manhood Peninsular, an area of very low lying land (around the 5m contour). The Selsey Bill headland is held in its seaward location by the Mixon Reef. A series of submerged shingle deposits, known as the Inner Owers and Kirk Arrow Spit also exist around Selsey Bill. It has been suggested that they may play a part in controlling the coastline on the east face of Selsey Bill and provide an episodic onshore supply of material to the coastline at Selsey.

Sea bed sediments are composed largely of fine sands and exposed bedrock, with only limited amounts of coarse material offshore in water depths greater than 8m. These sediments tend to become finer in a shoreward and eastward direction (Halcrow, 2003). The size of shingle is similar throughout the frontage, with some cross-shore and alongshore variation. More coarse material is found towards the back of the beach, or, if present, on the beach ridge. Finer shingle is found at the seaward edge of the upper beach, towards the boundary with the underlying sand (Halcrow, 2003).

The coast is predominantly exposed to south, south-westerly wind and waves and is susceptible to storms, which are the primary mechanisms for sediment transport along this coastline. There are localised variations in the prevailing conditions that occur due to sheltering and shoreline orientation, which give rise to local alterations in the sediment transport direction. Halcrow (2003) suggest that the coastal frontage between Shoreham Harbour and Brighton Marina is thought to be entirely self-contained in terms of shingle movements, whereby shingle is mobile within the limits of the system, once it has bypassed Shoreham harbour-mouth. There are thought to be few new sources of sediment, hence there is a scarcity of naturally derived material (Futurecoast, 2002) and only a minimal sediment supply from the west to the Selsey Bill to Brighton Marina frontage. It is unlikely that there is any significant contemporary exchange of coarse sediments between the beach and offshore areas (Halcrow, 2003), although there is some evidence to suggest that there is potential for a small amount of onshore shingle transport via creep and kelp-rafted shingle, from the offshore seabed and along the length of the coastline between Selsey Bill and Brighton Marina (Gifford, 1997).

Key sediment inputs are from

- submerged shingle deposits, such as the Inner Owers, that exist around Selsey Bill, which periodically feed the shoreline in the vicinity of Selsey Bill (Futurecoast, 2002);
- episodic supply of shingle deposits from offshore of Selsey Bill;
- potential onshore transport of sand-sized material (Halcrow, 2003).

Fluvial sediments are supplied to the system, although Rendell Geotechnics (1996) suggest that these are negligible.

Selsey Bill acts as a drift divide, with material being transported to the east and west of the headland. Material is transported from Selsey Bill in a north-westerly direction towards East Wittering, occurs due to a drift reversal brought about by the deflection of incoming wave and tidal streams around the eastern peninsula of the Isle of Wight and to the west of Selsey Bill. Waves and tides that are not deflected to the west will either head directly towards the southern tip of the peninsula of Selsey Bill, or will be deflected around it to the east.

From here, sediment transport takes place from west to east in response to the predominant wind and wave direction from the south and south-west. Tidal currents play little part in sediment transport along this coastline, except at estuary mouths (SCOPAC, 2003). Transport rates are spatially variable and reflect the barriers to movement and the effectiveness of bypassing mechanisms, sediment availability and the energy of the transportation process (SCOPAC, 2003). Local variations also occur along the length of the coastline due to sheltering and changes in shoreline orientation (Futurecoast, 2002) and nearshore bed topography. In general, the rate of transport decreases from the west to east as the shoreline becomes more aligned with the dominant wave direction (SCOPAC, 2003; Halcrow, 2003). Any material that makes it past Brighton Marina could potentially pass around Beachy Head to the east (Futurecoast, 2002).

Net drift along the upper beach between Selsey Bill and Beachy Head is predominantly shingle. Modelling of beach profiles by HR Wallingford (2002) showed the net drift at Pagham to vary between 20,000-40,000m^3/year, decreasing in an easterly direction towards the training walls at the entrance to the River Arun. Halcrow (2003) also suggests that there is potential for sand sized material to be moved in suspension around various structures along this section of shoreline. Cross-shore structures, such as groynes and outfalls, significantly influence the passage of coarse sediments along the frontage, which in turn dictates the drift rates experienced between the River Adur and Brighton Marina (Halcrow, 2003). The Shoreham breakwaters interrupt the longshore drift of shingle from west to east (Halcrow, 2003; Scott Wilson, 1999a). It is suggested that Brighton Marina also acts as a barrier to longshore transport of shingle (Halcrow, 2003) although there is some bypass of sands and finer grained sediments (Futurecoast, 2002).

Significant volumes of material can be lost from the beaches during storms, as waves are reflected by seawalls resulting in scour and material being drawn down off the beach. This material is then released to the littoral zone where significant longshore transport of shingle takes place Halcrow, 2003). Where no seawalls are present or the waves do not reach them, higher storm waves push shingle onto the upper beach to form a berm (Halcrow, 2003).

2-D depth-averaged current and sediment modelling carried out for the Brighton Marina to River Adur Strategy Plan (Halcrow, 2003) shows that during storms there are pockets of re-circulation eddies, along the Shoreham to Brighton frontage, with material being transported to the west and offshore. Some material is also moved onshore, creating a balance of transport. This is seen to take place at the mouth of the River Adur, around Hove and at the western end of Brighton Marina.

There are no significant sediment outputs from the beach system and, in response to a progressive denudation of sediment from updrift areas in a downdrift direction, beach recycling is carried out at several locations including Church Norton Spit, Elmer, Climping, Lancing and Brighton.

Shoreline Movement:

The present day shoreline was formed by the onshore migration of a shingle barrier over the low-gradient coastal plain in response to post-glacial sea level rise. Some shingle remained on the coastal plain and now forms submerged deposits that periodically provide a limited supply of sediment to the shoreline. The growth of spits across the mouths of the River Arun and Adur due to eastward longshore transport resulted in the deflection of the rivers to the east. The shoreline is eroding as evidenced by the loss of villages between Selsey and Lancing to the sea in the past (Futurecoast, 2002). Within the last few years, one of the banks around Selsey Bill has become attached to the Selsey shoreline, representing a pulse of sediment to the beach (Futurecoast, 2002).

The natural behaviour of this coastline is largely influenced and constrained by past management practices and the presence of coastal defences. Growth of the spits at Pagham Harbour may have been accelerated by land reclamation, reducing the hydraulic flushing power and tidal prism of the estuary, which will in turn have enabled material drifting from west to east to accumulate (Futurecoast, 2002). Groynes, constructed throughout the frontage from Selsey Bill to Brighton Marina, and the offshore breakwaters at Elmer, retain shingle that is carried eastwards along the foreshore by littoral drift. The implementation of these management practices along virtually the entire frontage has led to a progressive starvation of sediment from downdrift frontages, causing narrowing and steepening of the foreshore and exposing the upper shore and its defences to increased wave attack.

At some locations along the frontage, beach volumes have increased. Beach volumes to the west of Shoreham Harbour have shown a significant increase since 1991 and Halcrow (2003) report that there is a historic trend of accretion at Kemp Town.

This accretion can be accounted for by a number of reasons, and it is understood that this accretion is not sufficient to reduce the overall net erosion that is taking place locally downdrift or along the large scale coastline. Halcrow (2003) suggest that the local increase in beach volume is linked to the build up of sediment the breakwaters, training walls and the construction of rock groynes, which act to trap material in their lee and not to the input of any new sediment into the system. Beach replenishment and recycling practices have been used to reduce the rate at which this shoreline change is taking place. It is possible that the sediment accretion occurring at Kemp Town is a result of sediment trapping by the natural headland at Black Rocks.

C.1.3.1 LOCAL SCALE: Selsey Bill (Selsey to Pagham Harbour)

Interactions:

The clay headland of Selsey Bill shelters the coastline to the immediate east from the predominant south-westerly storms, although overtopping by storm waves occurs at some locations. Kirk Arrow Spit and Mixon Reef are key nearshore geomorphological features which lie approximately 2-3km offshore of Selsey Bill and help to hold the clay headland of Selsey Bill in its present position. Further inshore are a number of nearshore shoals, collectively known as the Inner Owers. Selsey Bill is subject to erosion (English Nature, 2003) and relies heavily upon Kirk Arrow Spit, Mixon Reef and the Inner to provide protection from direct wave attack by dissipating wave energy before it reaches the shoreline. Strong ebb tidal currents around the Bill also help to reduce wave attack from any direction east of due south.

The fronting shingle beaches help to dissipate any wave energy that does reach the shoreline.

In their review, SCOPAC (2003) list the key sediment inputs to this coastline as:

<u>Inputs to Selsey Bill:</u>

- Onshore shingle feed from Kirk Arrow Spit
- Onshore feed from The Streets and Malt Owers Reefs (a mobile shingle bank, located some 300-500m offshore and which is exposed at low water)

Inputs to Selsey Bill East Beach and Pagham Harbour:

- Erosion of Selsey Bill headland
- Beach renourishment and recycling between Selsey Bill and Pagham Harbour
- Onshore feed from the Inner Owers
- Onshore transport of weed and kelp rafted shingle

The episodic growth, breakdown and onshore movement of Kirk Arrow Spit, provides a supply of material to this coastline. Gravels and shingle are fed ashore from the Kirk Arrow Spit in pulses, at approximately 20-30 year intervals. The last period of onshore movement of gravels and shingle occurred between 1998 and 1999 (English Nature, 2003). The gravel added is preferentially drifting northward, thus explaining the marked difference in beach width to the north and south of the feature (Malcolm Bray, by correspondence).

A clockwise moving eddy between The Streets Reef and Kirk Arrow spit is set up during the ebb tidal flow (east to west) (Wallace, 1990a), which also encourages the onshore transport of material. There is also some potential for onshore-offshore sediment exchange between the East Selsey shoreline, including the western spit at the entrance to Pagham Harbour, and the Inner Owers (Futurecoast, 2002).

Wave energy is the primary mechanism for longshore drift and Selsey Bill acts as a drift divide. Material that is fed from offshore can be transported to both the east and west of the headland. Transportation of material from Selsey Bill in a north-westerly direction towards East Wittering occurs due to a drift reversal brought about by the deflection of incoming waves and tidal streams around the eastern peninsula of the Isle of Wight and to the west of Selsey Bill. Waves and tidal streams that are not deflected to the west will either head directly towards the southern peninsula of Selsey Bill or will be deflected around it to east. Material that is transported by longshore drift from Selsey Bill and the Inner Owers, moves along the shoreline to the Pagham Tidal inlet, but can intercepted by strong currents generated by the tidal exchange occurring within harbour channel (English Nature, 2003). Any material released from the headland joins the local longshore transport system.

Tidal currents adjacent to the west/south-west facing coastline flow predominantly eastwards/south-eastwards, as indicated by both float tracking and the morphology of patchily distributed sand waves on the seabed (HR Wallingford, 1995, 1997, 2000). This tidal stream moves towards the banks and reefs south of the Bill, where it is confined, and movement is determined by their alignment. During the peak ebb flow, movement is north/north-eastwards. The Selsey peninsula protrudes into this tidal stream, which creates an anticlockwise circulating gyre, (or “back eddy”) to the north-east. The residual current speed of the tidal stream ranges between 0.3 to 0.4m/s at the peak of the flood stage. A smaller, clockwise moving eddy between The Streets reef and Kirk Arrow spit is set up when the ebb tidal flow is east to west (Wallace, 1990a). This causes a local net drift reversal and the formation of a net drift convergence zone at the entrance to Pagham Harbour, (Scott Wilson, 1999a; HR Wallingford, 2002; and English Nature, 2003).

Shoreline Movement:

SCOPAC (2003) estimated the long term average rate of retreat either side of Selsey Bill to be in the region of 350-400m since the 1800's. Estimates of historical beach erosion around Selsey Bill vary, ranging from approximately 1m/year (Futurecoast, 2002) and 2-3m/year (Wallace, 1990a).

Seawall and embankments have fixed the landward limits of the beaches east of Selsey Bill, at East Beach. This is since resulted in a long term trend of profile steepening and a reduction in foreshore width of over 650m in the last 125 years.

Predictions of Shoreline Evolution:

In the next 100 years the rate at which Selsey Bill retreats will be influenced by the continued presence of Mixon Reef, sea level rise and sediment supply. Over time, the Mixon Reef will exert less protective influence on Selsey Bill as sea levels rise and create deeper waters and continued erosion of Selsey Bill effectively increases the distance of the reef from the shoreline. Futurecoast (2002) estimated that the shoreline along the eastern flank of Selsey Bill would retreat by up to 200m or more over the next 100 years if there were no defences. This prediction is similar to the findings of Wallace (1990a), who based his result on a historical erosion rate of 2-3m/year prior to the construction of defences. For the future we must assume that the rapid supply of material from Kirk Arrow Spit, typical of the past 50-100 years will continue. At some point however, it is likely that the nearshore gravel stores that sustain this onshore feed will become exhausted.

Narrowing and rollback of the shingle barrier is predicted to continue, increasing the risk and frequency of breaching. Permanent breaches could occur where barriers roll back over low-lying soft compressible and erodeable deposits (Futurecoast, 2002), however, the low topography and discontinuous gravel deposits that that form the coastline mean that little sediment would be released in this event. Breaching of the Medmerry Shingle Barrier, in Bracklesham Bay, could result in large scale flooding of the Manhood Peninsula and, ultimately, the opening of a new channel as it cuts through to Pagham Harbour and the formation of Selsey Bill as an island. Selsey would, however, continue to act as a control to the coastline in the east.

C.1.3.2 LOCAL SCALE: Pagham Harbour

Interactions:

Pagham Harbour is regarded as an ebb-dominant tidal inlet. English Nature (2003) refers to Pagham Harbour as a coastal plain type estuary, with a tidal prism of 5,300,000m^3. Extensive double spits mark the harbour entrance, which today are controlled by:

1. the rate of sediment supply from updrift sources or from offshore, and the subsequent re-working of this material;
2. the hydraulic flushing power of the tidal inlet, and;
3. the type and extent of management policy.

Ebb currents are weak around the periphery of the inlet and wave-driven transport dominates. Migration of swash bars takes place under wave action, resulting in the onshore transport of sediment, which tend to end up at Pagham Beach, north-east of the harbour entrance (English Nature, 2003).

Both wave and tidal energy are accountable for longshore transport along the spits at Pagham Harbour. Wave-driven sediment transport is net easterly, however, the interactions between wave activity and the ebb-tidal delta at Pagham have resulted in the formation of a local drift reversal, or in this case, net drift convergence zone to the east of the entrance to Pagham Harbour (Scott Wilson, 1999a; HR Wallingford, 2002; and English Nature, 2003). This local anomaly is responsible for the south-westerly transport of material along the northern spit (the net westwards transport of material immediately east of Pagham Harbour is in the region of 5,000m^3/year); but to the east the net easterly trend of sediment transport resumes and material is transported from Pagham towards Aldwick.

Material that is transported by longshore drift from Selsey Bill along the shoreline to the Pagham Harbour can be intercepted by strong currents generated by the tidal exchange with the harbour (English Nature, 2003). Material that bypasses the mouth of Pagham Harbour, however, supplies the downdrift frontages to the east with a source of material. Net drift along the upper beach is predominantly shingle. Modelling of beach profiles by HR Wallingford (2002) showed net drift at Pagham to vary between 20-40,000m^3/year.

Pagham Harbour and spit act as a sediment sink. Coarse material, including gravels and sands that are flushed from the harbour are deposited at the harbour entrance, which can then be trapped within the tidal delta. Fine sediments are transported in suspension and into the harbour where they may be deposited to form mudflats and saltmarsh (English Nature, 2003). It has been suggested that storm incursion of sediment into Pagham Harbour may be an important mechanism of outer estuary infilling (English Nature, 2003).

Shoreline Movement:

Prior to the 1670s, the southern spit at Pagham grew north eastwards as material was first transported onshore and then redistributed in a north-easterly direction by longshore transport. By 1672, the southern spit was nearly 1km long and the northern spit was nearly 700m long. Over the next 200 years, the southern spit extended another 1km, diverting the entrance to Pagham Harbour to the north-east, which resulted in the exposure of the low clay cliffs towards Pagham Church and their subsequent erosion (Futurecoast, 2002). The entrance was later sealed to prevent further migration and erosion, to leave Pagham Lagoon. Land reclamation in Pagham Harbour during the late 1800's reduced the tidal prism and is thought to have resulted in a reduction of the ebb-tidal delta and the more rapid response of the inlet in order to maintain equilibrium than would otherwise have happened in the absence of land reclamation (English Nature, 2003). It has been suggested that a group of shingle nearshore shoals, collectively known as the Owers, could be the remnants of the Pagham Harbour ebb-tidal delta prior to its reclamation (Futurecoast, 2002). Later, in 1910, a storm breach flooded the land leading to the reintroduction of tidal waters to the harbour to reform Pagham Harbour.

Historically, the spits at the entrance to Pagham Harbour have shown great instability, with phases of extension and breaching and the channel mouth has switched positions, from north to south. Two storm breaches in 1955, resulted in the landward movement of the central section of the harbour to leave a wider harbour entrance as sediment spread out. The harbour mouth has been stabilised by the new cut, training works (early 1960s) and coastal defence activities.

Within the sheltered conditions of the harbour, the inner harbour bed, mudflat and saltmarsh have been accreting in the long-term at a rate of 4-8mm per annum (English Nature, 2003). However, this does not agree with a 28% loss of habitat between 1971 and 2001, as stated in the Solent CHaMP (English Nature, 2003).

Predictions of Shoreline Evolution:

HR Wallingford (2002) predicted that in a no-defences scenario there could be up to 150m of erosion over the next 100 years. Futurecoast (2002) predicted that erosion would be slightly less, with 50-100m of erosion and the extension of the southern spit fed by material released following the erosion of Selsey Bill. The harbour mouth would be deflected eastwards and the northern spit would decrease in length. Sea level rise could cause rollback of the spits with an increased risk of inundation of the backshore tidal flats and marshes. As part of the process analysis completed for the SMP, an estimate of 115m of erosion at Pagham has been calculated using historical trends and projecting them forward to account for sea level rise (refer to No Active Intervention Baseline Scenario in this Appendix). English Nature (2003) have added to this suggesting that the low lying and reclaimed land around Medmerry could be subsequently be flooded from Pagham to form a new tidal channel and Selsey Bill would form an island. Mudflats and saltmarsh would form at the head of the tidal channels.

C.1.3.3 LOCAL SCALE: Pagham Harbour to Middleton-on-Sea

Interactions:

Wave energy is the primary mechanism for longshore drift between Pagham Harbour and Middleton-on-Sea. Net sediment transport is easterly, with the exception of local drift reversal to the east of Pagham. Here, the ebb tidal delta and wide, accreting foreshore sets up complex wave refraction and provides protection against the dominant south-westerly waves (Jolliffe, 1978; Barcock and Collins, 1991; Gifford Associated Consultants, 1997; Posford Duvivier, 2001a; and SCOPAC, 2003). Sediment is generally supplied to this coastline via longshore drift, where:

- approximately 20,000-40,000m^3/year of material is supplied from the west/south-west (HR Wallingford, 2002).
- Pagham shingle banks supply Pagham West with approximately 20,000-40,000m^3/year (HR Wallingford, 2002).
- 5,000m^3/year is supplied westwards to Pagham Harbour (SCOPAC, 2003).

SCPOAC (2003) suggest three other inputs to this section of coast (although the significance of the volumes transported to the overall sedimentary regime is questionable):

- Wave powered onshore-shingle creep
- Kelp-rafted shingle transport
- Kelp-rafting initiated in water depths of 20-40m

The frontage between Pagham and Middleton-on-Sea is an important shingle source for downdrift beaches and is also used as a sediment source for recycling and beach renourishment. Rates of sediment transport are spatially variable along this coastline, varying at each location due to the type of coastal defence, sediment availability and the energy of transportation processes (SCOPAC, 2003). The rates of transport provided below indicate the variability along this coastline:

- Approximately 20,000-40,000m3/year (SCOPAC, 2003; HR Wallingford, 2002) of sediment estimated potential drift is transported from Pagham towards Aldwick. The rate of longshore transport from Pagham decreases towards Aldwick, as the groynes at Aldwick allow only intermittent transport (SCOPAC, 2003).
- From Aldwick, the rate of sediment transport increases to 47,000m3/year, along the main Bognor frontage (Gifford Associated Consultants, 1997), before decreasing once again to

10,000m3/year past Bognor Regis, which may relate to the effect of defences at these locations.

- At Felpham, there is approximately 50,000-60,000m3/year of sediment transport (SCOPAC, 2003), but only 15,000m3/year at Hannah's Groyne (Middleton) and 4,000m3/year to the east of Middleton.

Shoreline Movement:

Analysis of Ordnance Survey Maps, 1875 to 1979, reveals a long-term history of coastline retreat, narrowing of the intertidal zone and foreshore steepening (SCOPAC, 2003). Rates of retreat have been estimated to vary in the region of 0-4m/year (Mouchel, 1995; Gifford Associated Consultants, 1997). The recent accretionary trend of 0.5-1m/year in Aldwick Bay would be accounted for by the local drift reversal.

Predictions of Shoreline Evolution:

If accretion at a rate of 0.5-1m/year at Aldwick continues, by 2105, there could be as much as 50-100m of accretion. Elsewhere, if the defences were not maintained, the natural response of the shingle barrier would be to continue to roll back across the gently rising backshore slope, with as much as 50-100m of erosion (Futurecoast, 2002). As the shoreline erodes, beach-sized sediments presently stored within backshore raised beaches would start to be re-worked, providing sediment input to the foreshore stock and subsequently being transported downdrift (eastwards). There would also be a significant increase in wave overtopping.

C.1.3.4 LOCAL SCALE: Elmer

Interactions:

Wave energy is the primary mechanism for longshore drift at Elmer. Net sediment transport is easterly. There is no local sourcing of material so, under natural conditions, the coastline is dependent upon the supply of updrift sediment to maintain the beaches. The offshore breakwaters at Elmer and terminal groyne at Poole Place can trap a large amount of this material and the transport of sand is largely constrained across the frontage. Littoral drift reduces from 4,000m^3/year east of Middleton-on-Sea to 3,000m^3/year at Elmer (HR Wallingford, 2002).

Shoreline Movement:

The trend of shoreline behaviour at Elmer Breakwater is erosion, however, the construction of offshore breakwaters has led to accretion and the development of tombolos in their lee. Beach levels at Elmer have also been raised with the addition of 20,000m^3 of marine aggregate in 1989 and 200,000m^3 in 1993 (HR Wallingford, 2002; SCOPAC, 2003).

Predictions of Shoreline Evolution:

The breakwaters at Elmer are holding the present position of the beach and backshore in a seaward position; therefore further evolution will depend upon the future management of these defences. Futurecoast (2002) made predictions for the future evolution of this coastline for an "unconstrained scenario" for a 100-year time period. Futurecoast concluded that the natural response of the shingle barrier would be to continue to roll back across the hinterland, with between 50-100m of erosion. As the barrier rolls back, there would initially be rapid steepening of the sand and shingle foreshore, followed by erosion of the backshore. Beach-sized sediments presently stored within the hinterland would start to be re-worked, providing sediment input to the foreshore stock, and subsequently be transported downdrift (eastwards).

C.1.3.5 LOCAL SCALE: Poole Place to River Arun (Inclusive)

Interactions:

Wave energy is predominantly from the south-west and is the primary mechanism for longshore transport along this stretch of coastline, hence net sediment transport is easterly. Sediment transport into this frontage from updrift is limited by the presence of the offshore breakwaters at Elmer and the terminal groyne at Poole Place. It is therefore unlikely that material supplied by the erosion of Selsey Bill and the adjacent coastline would reach the Poole Place to River Arun frontage, since the groynes and offshore breakwaters at Elmer would trap it. Other management practices, such as training wall construction carried out to reposition the mouth of the River Arun, artificially intercept the eastward drifting sediments, reducing the amount of sediment arriving at downdrift sections of coast, such as Rustington.

Storms are responsible for severe cutback and overtopping to the immediate east of the terminal groyne at Poole Place, thus supplying the fronting beaches with sediment. SCPOAC (2003) suggest several additional sediment inputs to this section of coast (although the significance of the volumes transported by creep and kelp rafting, to the overall sedimentary regime is questionable):

- Shingle movement in the offshore area of this region ranges from 30-60,000m3/year, some of which is fed onshore to the beaches between Elmer and the River Arun (HR Wallingford, 2002).
- Fine grained, suspended material from the River Arun (no more than 4,000m3/year)
- Wave powered onshore-shingle creep
- Kelp-rafted shingle transport
- Kelp-rafting initiated in water depths of 20-40m

Easterly longshore transport of sand and shingle either side of Littlehampton Harbour is estimated to be 65,000m^3/year (13,000m^3/year of which is shingle) (HR Wallingford, 1987a and b). Later calculations by Gifford Associated Consultants (1997) estimated proposed this figure to be in the region of 60,000m^3/year and Scott Wilson (2000a, b and c) derived a figure of 50,000 m^3/year. The presence of training walls and the harbour breakwater at Littlehampton has resulted in the trapping of material and the progressive accretion of the beach and since the early 1970's and growth and regeneration of the dunes at Climping (SCOPAC, 2003). HR Wallingford (2002) however, has also found that some areas of dune are eroding and that the River Arun itself supplies little sediment to the frontage. 50-70% (10-35,000m^3/year) of this material is recycled from the Littlehampton terminal groyne to the frontage west of Climping, as far as Poole Place terminal groyne (HR Wallingford, 2002). To maintain the shoreline in its current position would require continuation of the present programme of recycling of 30,000 m^3 of material annually.

The hydraulic barrier effect caused by the River Arun and the annual recycling of a portion of the accumulating shingle westwards both significantly modify rates of sediment transport (Futurecoast, 2002).

The discharge and tidal exchange at the mouth of the River Arun has a very small impact on the local hydraulic and suspended sediment transport pathways across the river mouth (HR Wallingford, 2002) and Environment Assessment Services (1997) reported of significant sand transport across Littlehampton Bar, offshore of the river mouth. It is thought, however, that strong tidal flushing in the river mouth and the presence of the training walls form a barrier to bedload movement of shingle (SCOPAC, 2003). Scott Wilson Kirkpatrick (2000a, b and c) found that a proportion (possibly as much as 50,000m^3/year) of the sand and fine gravel that is transported along the Climping frontage is transported around the western training wall, thus bypassing Littlehampton Harbour.

Shoreline Movement:

This coastline has a long-term historic trend of erosion with retreat of the low water line, beach loss and foreshore steepening. Since the late 1960s, however, the trend has been one of overall equilibrium or accretion. This is largely due to the obstruction to longshore transport by the Littlehampton Harbour Western training wall and a continued "hold the line policy" achieved through recycling of shingle (SCOPAC, 2003). At Climping, this has resulted in mean high water advance. Land reclamation in the past has also resulted in mean high water advance, by reducing the hydraulic flushing power and tidal prism at the mouth of the River Arun, thus providing calmer conditions for sediment accretion.

Predictions of Shoreline Evolution:

Futurecoast (2002) made predictions for the future evolution of this coastline, both with and in the absence of management practices, over the next 100 years. The shingle barrier would continue to roll back and transgress on-land, with 50m-100m of landward retreat. Episodic breaching of the barrier could lead to flooding of the low-lying hinterland. With foreshore rollback, beach-sized sediments presently stored within backshore raised beaches would start to be re-worked, providing sediment input to the foreshore stock and subsequently being transported downdrift (eastwards).

C.1.3.6 LOCAL SCALE: Littlehampton to East Worthing

Interactions:

Wave energy is primary mechanism for longshore drift between Littlehampton and East Worthing. Net sediment transport is easterly. Sediment is generally supplied to this coastline via longshore drift. Sediment supply from the River Arun is low and a large volume of sediment that could be supplied to this shoreline from updrift sources in the west is intercepted by the Littlehampton Harbour training walls. East of Littlehampton Harbour longshore transport increases along the frontage. Taking into account the effect of the groynes on temporary storage, longshore transport along Littlehampton East Beach (Rustington) and has been estimated to be in the region of 37,500m^3/year (Gifford Associated Consultants, 1997). This rate varies along the frontage towards Worthing, peaking at 70,000m^3/year along the East Preston to Ferring Rife frontage, and reducing to 40,000 m^3/year at Worthing (Scott Wilson Kirkpatrick, 2000a, b and c). This variation is likely to be explained by the presence of defences between these locations and their possible interruption to longshore drift.

Erosion of material stored along the foreshore of this frontage can potentially feed downdrift locations although, as discussed, rates of longshore drift decreases towards Worthing. SCPOAC (2003) suggest three other inputs to this section of coast (although the significance of the volumes transported to the overall sedimentary regime is questionable):

- Wave powered onshore-shingle creep
- Kelp-rafted shingle transport
- Kelp-rafting initiated in water depths of 20-40m

There are a number of areas below predicted high water levels that would flood in the event of a breach of the existing defences. Other areas would be protected from breaching due to higher land levels, but are subject to coastal erosion (Scott Wilson, 2000b). The highest rates of accretion take place along those sectors of coastline whose orientation is closer to the predominant direction of wave approach (SCOPAC, 2003).

Shoreline Movement:

Where sections of coastline are held in a fixed position by seawalls, such as Rustington, there has been no net lateral movement, accretion or foreshore movement. At the western end of Littlehampton, the low water line has been dynamically stable.

Elsewhere, the coastline has been eroding, with a long-term trend of low water line retreat and beach steepening. At the eastern end of this frontage, the low water line has retreated at a rate of 1.5-2.0m/year, resulting in further beach steepening, which continues today.

Predictions of Shoreline Evolution:

As part of the Futurecoast Study (Futurecoast, 2002) predictions were made for the future evolution of this coastline in the absence of management practices over the next 100 years. Retreat of 50-100m was estimated by Futurecoast (2002), which is supported by the findings of Scott Wilson (2000a) who estimated around 20m of erosion by 2025, and therefore around 40-50m by 2105. With foreshore rollback, beach-sized sediments presently stored within backshore raised beaches would start to be re-worked, providing sediment input to the foreshore stock and subsequently being transported downdrift (eastwards). Episodic breaching of the barrier could lead to flooding of the low-lying hinterland.

Where the barrier fronts the alluvial course of Ferring Rife, potential would exist for the creation of a new tidal inlet, although an entrance would probably not be kept open permanently due to the very limited potential for tidal exchange within the constrained stream channel. The most likely scenario is one of episodic breaching and re-sealing (Futurecoast, 2002).

C.1.3.7 LOCAL SCALE: Lancing to Shoreham Harbour

Interactions:

The coastline between Lancing and Shoreham Harbour is characterised by a multi-ridge shingle storm ridge and gentle gradient sandy foreshore. Wave energy is the key driver to coastal processes along this coast. Local waves are the primary mechanism for the net easterly longshore transport of sand, however, it is solely storm waves that have the energy to transport shingle along the coast. Despite limited availability, sand transport takes place under normal conditions (Halcrow, 2003). Van Wellen *et al.* (2000) suggest a mean annual drift rate of about 15,000m^3/year, which compares to a rate of 14,539m^3/year derived from analysis of beach profiles and volume change using aerial photographs from 1975 to 1984 (SCOPAC, 2002); and to longshore modelling results (Halcrow, 2003), which indicate that the supply of material into this frontage is approximately 16,000m^3/year. SCOPAC (2003) carried out a detailed review of the sediment budget along this length of coastline. The study found that, in addition to a general supply of material via longshore drift, gravel, sand and shingle is also supplied to the coastline via:

- onshore wave-transport, including wave powered onshore shingle creep from offshore
- periodic rubble tipping east of Shoreham Harbour entrance
- kelp-rafting initiated in water depths of 20-40m (although the significance of the volumes transported to the overall sedimentary regime is questionable).
- beach replenishment at Shoreham

The volumes of sediment supplied via these sources are minimal and of insufficient quantity to sustain the beach in their own right. Hence, the shingle beach should be considered relict (Halcrow, 2003).

Management practices, carried out updrift and around the mouth of the River Adur and Shoreham Harbour, act to alter the natural volume of sediment input to this frontage. Breakwater construction at the mouth of the River Adur intercepts the eastward drifting sediments and cross-shore structures, such as groynes, significantly influence the passage of coarse sediments along the frontage. This has resulted in beach accretion to the west of Shoreham Harbour. The regular bypassing of sediment excess from the west side of Shoreham Harbour entrance to the east side is carried out to compensate for the interruption of longshore drift by the harbour breakwaters. This practice, in turn, dictates the drift rates experienced between the River Adur and Portslade (Halcrow, 2003).

With the exception of some transfer of sand-sized material across the mouth of the River Adur, in both directions and under the action of waves (Halcrow, 2003), shingle bypassing of the River Adur is the principal contemporary feed of sediment into the frontage east of Shoreham Harbour entrance. 5-10,000m/$yeat^3$ of mechanical shingle bypassing across the mouth of the Adur has taken place since 1992 to compensate for the interruption in littoral drift due to the breakwaters (Halcrow, 2003).

Shoreline Movement:

The shingle spit that forms Shoreham West Beach (Lancing to Shoreham Harbour) has a complex history of movement. Prior to the construction of breakwaters at Shoreham Harbour entrance, the spit was subject to natural and artificial breaching, and extension eastwards (SCOPAC, 2003). Since then, the construction of the breakwaters and implementation of management practices have been responsible for shaping the shoreline. The use of heavy groyne management at Worthing has also resulted in the progressive loss of shingle volumes and both beach narrowing and steepening between South Lancing and Shoreham Beach.

Just to the east of Shoreham Beach, however, obstruction of longshore transport by groynes and the Shoreham Harbour breakwaters has resulted in beach accretion and advance of the mean high water line. Beach volumes at Shoreham have been increasing on average at a rate of 19,000m^3/year.

Predictions of Shoreline Evolution:

Futurecoast (2002) has made predictions for the future evolution of this coastline in the absence of management practices, over the next 100 years. The natural response of the shingle barrier would be to continue to roll back across the gently rising backshore slope. As the shingle ridge rolls back over the hinterland behind and the backshore becomes exposed to marine erosion, beach-sized sediments presently stored within backshore raised beaches would start to be re-worked. This would provide sediment input to the foreshore stock and subsequently being transported downdrift (eastwards).

C.1.3.8 LOCAL SCALE: Portslade-by-Sea to Brighton Marina (Inclusive)

Interactions:

The principal driving force along this coast is the predominant south-westerly waves, which induce a net easterly transport of sediment and it is solely storm waves that have the energy to transport shingle along the coast. Despite limited availability, sand transport takes place under normal conditions (Halcrow, 2003). The volumes arriving at Portslade-by-Sea are dependent on whether material can bypass the mouth of the Rivers Arun and Adur and their respective training walls and breakwaters. There is no natural transfer of shingle past the mouth of the River Adur (Halcrow, 2003). Instead, bypassing (artificial feed of sediment) of the river mouth of the River Adur has been undertaken (5-10,000m^3 since 1992) to compensate for the interruption in littoral drift due to the breakwaters (Halcrow, 2003). There is, however, thought to be some transfer of sand-sized material across the mouth of the River Adur in both directions and under the action of waves (Halcrow, 2003). From there, a net drift of approximately 50,000m^3/year is transported between Portslade and Hove (Halcrow, 2003).

SCOPAC (2003) carried out a detailed review of the sediment budget along this length of coastline. The study found that, in addition to a general supply of material via longshore drift, gravel, sand and shingle is also supplied to the coastline via:

- onshore wave-transport, including wave powered onshore-shingle creep from offshore

- kelp-rafting initiated in water depths of 20-40m (although the significance of the volumes transported to the overall sedimentary regime is questionable).
- periodic rubble tipping east of Shoreham Harbour entrance
- fluvial inputs from the River Adur

Of this sediment supply, some material is stored within the foreshore and within Kemp Town beach, near Brighton. Material stored within the foreshore can potentially move to feed downdrift locations as far east as Brighton Marina and, if it can bypass Brighton Marina, further downdrift also (Futurecoast, 2002). Gravels and sands are lost from the system via downdrift littoral transport, onshore-offshore transport and dredging (SCOPAC, 2003). Brighton Marina is constructed on Black Rocks, a natural headland, which to some extent interrupts the eastward drift of sediment, resulting in an accumulation of shingle to the west of the marina. The shingle ridge at Southwick beach, at the western edge of this frontage is narrow and long, whilst the beach to the west of Brighton Marina at Kemp Town is significantly wider (Halcrow, 2003).

Some bypassing of Brighton Marina takes place and evidence suggests that Brighton Marina occupies a site of natural discontinuity in longshore transport, and does not therefore play a significant role in preventing the amount of the sediment transport along this coastline (SCOPAC, 2003), but instead only reducing it (Halcrow, 2003). Sand and finer sediments (silts and clays) move within a zone that is wider than the seaward projection of the marina breakwaters and are therefore less affected than coarse, gravel-sized sediment (SCOPAC, 2003).

Cross-shore structures, such as groynes and outfalls, also significantly influence the passage of coarse sediments along the frontage, which in turn dictates the drift rates experienced between the Portslade-by-Sea and Brighton Marina (Halcrow, 2003).

Shoreline Movement:

Over the past century, the foreshore has experienced erosion and steepening (Futurecoast, 2002). Historic Mean Low Water retreat of around 0-1.5m/year has occurred between Portslade-on-Sea and West Hove, and up to 1.25m/year of Mean Low Water retreat has taken place at West Hove (although the shoreline has been fixed by seawalls since the mid 1850's) (SCOPAC, 2003). The recent trend of net accretion between Portslade-on-Sea and West Hove is due principally to shingle bypassing at Shoreham Harbour entrance (SCOPAC, 2003). The low water mark around Brighton Marina has been historically retreating at a rate of 0.5m to 1.8m/year.

Predictions of Shoreline Evolution:

Between 50-100m of erosion could take place by the year 2105 (Futurecoast, 2002). Halcrow (2003) has predicted that over the next 50-years under a scenario of no defences, the shoreline between the River Adur and Brighton Marina would re-align itself to the prevalent wave direction. The shingle ridge would rollback and the backshore would be subject to reworking. The potential drift rate would increase with accretion of material at Kemp Town beach to the west of Brighton Marina. There is potential for flooding of the low lying hinterland and the possibility of closure of the River Adur outlet.

C.1.4 LARGE SCALE: BRIGHTON MARINA TO BEACHY HEAD

Interactions:

The natural headland at Beachy Head acts to control the shoreline to the west. The coastline between Brighton Marina and Beachy Head is mainly cliffed, with exception of some areas where there are tidal inlets, such as Newhaven and Cuckmere Haven, or where there is a difference in backshore geology, such as at Birling Gap. Relict gravels cover the offshore zone and nearshore banks and rock reefs/shore platforms exist at various locations along this section of coastline.

The predominant wind and wave direction is from the south and south-west, along the entire frontage from Brighton Marina to Beachy Head, and there is a net easterly drift of sediment over the nearshore and offshore zone. The supply of fresh sediment into and along this frontage is limited, which is largely due to the degree of management intervention along the updrift sections of coastline, for example sediment retaining structures such as groynes between Hove and Brighton. This means that the actual sediment transport is considerably less than the natural potential. Brighton Marina occupies a site of natural discontinuity in longshore transport (SCOPAC, 2003), but is however thought to permanently obstruct the alongshore movement of shingle material (Futurecoast, 2002). The breakwaters are not of sufficient length to extend fully across the littoral zone (Halcrow, 2003), and therefore permit the bypass of sand and finer sediments (silts and clays) to the adjacent coastline. As a result, shingle material has tended to accrete on Kemp Town beach (Halcrow, 2003). Material that is transported easterly from Brighton Marina by longshore transport, becomes trapped within the mouth of the Rivers Ouse and Cuckmere, detracting from the local sediment budget. Beachy Head acts as a natural fixed barrier to sediment transport out of subcell 4d.

Supply from fluvial/estuarine discharge from the Cuckmere Estuary does not contribute greatly to the sediment budget and material that is released tends to accumulate within the nearshore at the mouth of the tidal inlet. The rivers Cuckmere and Ouse are also thought to exert insignificant hydraulic influence on the coastline. There is thought to be some onshore transport of shingle via shingle creep and kelp-rafted shingle import, however, this is believed to be very small (Gifford, 1997; Futurecoast, 2002) relative to the overall sediment budget.

Shoreline Movement:

Sea cliff recession has taken place along this coastline, with the resulting formation of shore platforms. As local headlands have emerged within the receding cliff line, the shingle barrier beach has become compartmentalised between them (Futurecoast, 2002). Interruption to the natural path of longshore transport due to the construction of coastal defences and marine structures has reduced sediment supply, and has resulted in the narrowing and steepening of the shingle barrier (Futurecoast, 2002). Cliff erosion takes place via marine erosion at the cliff toe, but also by sub-aerial weathering of the cliff top, which results in cliff failure. This material subsequently accumulates at the base of the cliff, from where it is eroded and transported eastwards. Erosion of the cliffs via sub-aerial erosion will be exacerbated as increased rainfall, resulting from climate change, penetrates the cliffs and increases the risk of joint failure and cliff slumping.

Land reclamation within the Rivers Ouse and Cuckmere has reduced their hydraulic flushing power and tidal prisms, enabling material drifting from the west to accumulate progressively across the mouths (Futurecoast, 2002). The mouths of the Rivers Ouse and Cuckmere have also experienced an eastwards deflection due to the development and growth of shingle spits, although these are now trained and producing partial barriers to longshore drift (Futurecoast, 2002). Consequently, sediment has become trapped and resulted in localised beach accretion.

C.1.4.1 LOCAL SCALE: Brighton Marina to Harbour Heights

Interactions:

The natural headland. Black Rocks, on which Brighton Marina has been constructed, interrupts the eastward drift of shingle-sized sediment. Evidence suggests that Black Rocks is a site of natural discontinuity in longshore transport, and does not therefore play a significant role in preventing the amount of the sediment transport along this coastline (SCOPAC, 2003), but instead only reducing it (Halcrow, 2003). Some sand and finer sediments are able to bypass Brighton Marina. Brighton Marina is subject to maintenance dredging and the spoil is dumped south east of the breakwater structures (Halcrow, 2003). This results in the accumulation of sand and shingle to the west the marina, with little bypass to the coastline east of the marina. The coastline to the east of Brighton Marina is consequently starved of sediment supply from the west.

The predominant wind and wave direction along this coastline is from the south, south-west. Wave energy is the primary mechanism for longshore drift, but drift reversals occur during south-easterly storms (Posford Duvivier, 2001a). It has been suggested that there is potential for some supply of sand to this coastline via off to onshore wave-driven transport (SCOPAC, 2003). The presence of management practices along the majority of this coastline limits the amount of longshore transport that takes place, starving the downdrift frontages of sediment. The supply of sediment to the east and downdrift is partly controlled by groynes designed to retain beaches at Ovingdean. It is assumed that 2,200m^3/year of beach material (shingle flints) is supplied to the frontage between Brighton Marina and Saltdean. Other inputs have been artificially placed, including beach recharge material at Rottingdean and Saltdean (Posford Duvivier, 2001a).

This coastline of cliffs and shore platforms, cut into chalk, is marked by sections of defended and undefended cliffs. Where defended, the cliff is protected from erosion at the base by a seawall. Elsewhere, the cliff is either protected by a wave-cut platform, or is subject to undercutting at its base by wave erosion, close to the high water mark. Undercutting leads to conditions of instability, loosening of the rock along joints and bedding planes and promoting chalk falls (Futurecoast, 2002). The platforms are also subject to biological and sub-aerial activity. Where undefended, the cliffs between Brighton Marina and Harbour Heights are prone to failure, producing an accumulation of debris at the cliff toe that can then be quickly removed by wave action. This re-exposes the cliff toe and fronting shore platform to undercutting, recession and lowering. Rates of platform lowering vary from 1 to 4mm/year along the coastline (SCOPAC, 2003). The supply of contemporary sediment input to this frontage is minimal. Cliff falls provide the main source of material to this coastline. A typical cliff failure (usually small scale topples, involving the detachment of wedge-shaped units) will provide 0.5m^3 of material at a frequency of 8-10 years (SCOPAC, 2003).

The existing shore platforms and sand and shingle beaches are generally not substantial enough to provide adequate energy dissipation and the small amount of beach material retained is exacerbating abrasion problems on the shore platform. There are, however, two exceptions, where relatively healthy beaches are maintained. The first is Rottingdean, where the orientation of the cliff line, the effect of timber and rock groynes and beach recharge act to protect the coastline and, as a result, the beach has displayed higher foreshore levels; and the second is at Saltdean where the construction of rock groynes and beach recharge have resulted in higher foreshore levels (Posford Duvivier, 2001a).

Shoreline Movement:

The frontage between Brighton Marina and Peacehaven has been subject to a long-term history of platform lowering and sea cliff erosion. The backshore and shoreline position has since been fixed by seawall, but beach steepening between Brighton Marina and Saltdean is taking place with net profile retreat of 0 to 2m/year. Beach steepening between Telscombe and Peacehaven has historically been taking place with net profile retreat of around 0.6 to

1.4m/year. The coastline between Saltdean and Telscombe is an eroding coast, with a historic rate of cliff-top retreat of around 0.4m/year. These rates are averages and it should be noted that cliff erosion can also take place episodically, with between 5-10m of erosion in one event. Newhaven Harbour breakwater acts to trap alongshore sediment, which has resulted in the beach accretion to the west.

Predictions of Shoreline Evolution:

Futurecoast (2002) has made predictions of the potential evolution for the coastline between Brighton Marina and Harbour Heights over the next 100 years. Platform lowering will continue, despite a potential increase in sediment supply from increased erosion to the east. The rate of sea cliff recession will continue but at a rate dictated by sea level rise, cliff retreat by sub-aerial weathering processes and platform lowering. The rate at which this could take place is relatively high, with potential for at least 40m of change to take place over the next 100 years. This prediction is considerably less than that suggested by Mouchel (2002), which states that there would be around 20-60m of erosion at various locations along this frontage by 2105. Any material released as a result of cliff failure would be removed from the toe of the cliffs to add to the volume of material being transported east by longshore drift.

C.1.4.2 LOCAL SCALE: Harbour Heights to Seaford

Interactions:

The coastline consists of near vertical cliffs and, between Newhaven and Seaford, a shingle beach overlying a wave cut platform (Scott Wilson, 1999b). The platform is subject to erosion by wave and tidal abrasion, biological and sub aerial activity and, as a result, the cliff face is locally undercut at the base. Elsewhere, a history of land slippage at Castle Hill and a trend of shingle accretion against the western breakwater at Newhaven tends to protect the cliff base from wave attack. Annual recycling of 120,000m^3 takes place from the beach at Newhaven to the frontage at Seaford.

Wave energy is the primary mechanism for longshore drift. Drift is variable in both direction and rate, but net sediment transport is easterly (Scott Wilson, 1999b). There is generally only a minimal supply of contemporary sediment input to the frontage from updrift sources and the sediment yield from the Ouse is small. Following beach recharge at Seaford in 1987, it is thought that the wider beach, which dissipates more energy than the pre-recharged beach, encourages some onshore transport of sand and shingle (Scott Wilson, 1999b). SCOPAC (2003) also suggest that sands and gravels are supplied to Seaford Bay via wave-driven onshore-offshore transport.

The Newhaven breakwater protects the coastline to the east from dominant south-westerly storms, such that short sections downdrift of the breakwater are dominated by southeasterlies. Local drift reversals are brought about by the interaction of the Newhaven breakwater and south-easterly storms, resulting in the accumulation of material in small pockets to the east of Newhaven Breakwater. The trapping effect of the Newhaven Breakwater limits if not stops the drift of sediment eastwards to the mouth of the River Ouse (Scott Wilson, 1999b), such that the Ouse is a potential sediment sink which slows the rate of drift that would take place from the west of Newhaven Harbour to the east. Beyond the sheltering effect of the breakwater, the predominant eastwards drift continues. This results in a drift divergence zone around Tide Mills and eastwards (Futurecoast, 2002).

Shoreline Movement:

There has been a long-term history of sea cliff recession at Newhaven. At Peacehaven and Harbour Heights, there has been no net lateral movement, but instead beach steepening with net profile retreat of around 1m/year, which has been taking place in the past and continues today. This increases to around 1.0-1.4 m/year at Newhaven Harbour.

Throughout recent history the shingle ridges between Newhaven and Seaford, which formed the main sea defences for the low-lying hinterland, have been subject to breaching in severe storms. Despite a history of long-term erosion, the presence of Newhaven Harbour Breakwater has interrupted longshore transport and trapped material, such that the shoreline to the west of Newhaven Harbour has shown a recent trend of accretion. Beach levels are volatile, and can vary by up to 3m after one severe storm (Scott Wilson, 1999b).

The mouth of the River Ouse has been subject to fluctuations in position, entering the sea further to the east in the past. At this time, the shingle spit was 200m seaward of its present position and the river flowed behind it. Progressive blocking of the mouth led to the construction of the 150m long groyne and Newhaven Breakwater. Over the past 100 years, the coastline to the east of Newhaven has been losing sediment and the foreshore has experienced steepening as the low water line has transgressed landward (Futurecoast, 2002).

Predictions of Shoreline Evolution:

Futurecoast (2002) made predictions for the future evolution of this coastline, in the absence of management practices, over the next 100 years. Cliff recession will continue, but at a rate dictated by the rate of platform lowering. There will be the continuation of chalk falls throughout much of the frontage, with some landsliding evident towards Newhaven, providing the coastal system with limited supply of shingle. Assuming the absence of the Newhaven breakwater, the longshore drift would lead to a major change in landform, with the tendency for the mouth of the River Ouse to eventually become blocked by reformation, development and long-term progressive elongation of a spit from Castle Hill towards Tide Mills.

C.1.4.3 LOCAL SCALE: Seaford Head

Interactions:

The wave-cut platforms at Seaford Head are subject to erosion by wave abrasion, biological and sub aerial activity. As a result, the cliff face is subject to some local undercutting at the base, which leads to the overall erosion of the cliff line. The material released via erosion of the shoreline provides a supply of sediment into the longshore transport system.

Wave energy is the primary mechanism for longshore drift and net sediment transport is easterly. There is, however, only a minimal supply of contemporary sediment to the frontage from updrift sources. This is insufficient sediment to protect the wave-cut platforms, making the feature vulnerable to continued lowering, which in turn controls the rate of sea cliff recession. Erosion of the platforms releases flints to the littoral system, where they can be retained along the foreshore and transported downdrift to the entrance at Cuckmere Haven.

Shoreline Movement:

The shoreline has shown a long-term history of erosion and beach steepening. Cliff top erosion is taking place at a rate of approximately 0.3m/year. At some locations there has been no net lateral movement and at others steepening has been taking place but with net profile retreat of 0 to 0.5m/year and flattening.

Predictions of Shoreline Evolution:

Cliff recession would continue, but at a rate dictated by the rate of platform lowering. Futurecoast (2002) predicts this change to be relatively moderate with around 10-50m of erosion, which agrees with the findings of Scott Wilson (1999b) of around 30m. Some of the Chalk rubble released from cliff falls would contribute to the shingle beach deposits, which would be broken down by marine erosion over the next 100 years before being transported alongshore to the east.

C.1.4.4 LOCAL SCALE: Cuckmere Haven

Interactions:

Cuckmere Haven represents a rare depositional zone along a frontage that is generally eroding (Futurecoast, 2002). The coastline forms a natural embayment which traps material. Accretion of material is enhanced by the presence of coastal defence structures, such as groynes, management intervention practices and the construction of a river training wall. Although river sediment yields are small, the river mouth acts as a sediment sink. Material supplied via fluvial discharge is deposited at the river mouth as a small delta, from where material can become stored within the shingle barrier or ebb tidal delta. SCOPAC (2003) has, however, suggested that there is a potential for sediment bypassing of the River Cuckmere.

Wave energy is the primary mechanism for longshore drift. Net sediment transport is easterly. Material is supplied to the frontage from updrift erosion of shore platforms and sea cliffs along Seaford Head. SCOPAC (2003) also suggests that material is supplied to (and lost from) the frontage via onshore wave driven transport. The tidal delta provides a means by which sediment can bypass this frontage and be transported via longshore drift to the shoreline to the east. There is also a tendency for shingle transport to take place in the opposite direction towards Cuckmere Haven in the east, although these volumes are very small.

Shoreline Movement:

Prior to management intervention in the 1800's the shoreline showed a long-term trend of accretion or stability, before switching to one of instability as the shingle spit extended eastwards and underwent successive breaching to give new mouth alignments. The shingle spit has since been cut through and trained at the river mouth. The shoreline is experiencing a recent erosional trend, retreating at a rate of 1.0 to 1.5m/year.

Predictions of Shoreline Evolution:

Futurecoast (2002) predicted that, over the next 100 years, in an unconstrained scenario, i.e. in the absence of training walls, the mouth of the River Cuckmere would become progressively blocked by material presently stored updrift, followed by the onshore movement of material currently stored in the ebb-tidal delta. It has been estimated by Futurecoast that around 50-100m of shoreline erosion could take place within the next 100 years. Present day shoreline movement varies from beach profile steepening with no net lateral movement to steepening with net profile retreat.

C.1.4.5 LOCAL SCALE: Cuckmere Haven to Birling Gap

Interactions:

At Birling Gap, the coastline is comprised of Chalk cliffs intersected by a dry hanging valley of glacial material, which at its lowest is 12m high. The shore platforms are subject to erosion by wave abrasion, biological and sub aerial activity. As a result, the cliff face is locally undercut at the base.

Wave energy is the primary mechanism for longshore drift and material that is transported via this mechanism is done so in an easterly direction. Material released by sea cliff recession contributes to the local shingle beach deposits at the base of the cliff, although much of the debris is removed from the foreshore by marine processes. Only a relatively sparse amount of material is left to cover the shore platforms, making the features vulnerable to continued lowering, which in turn controls the rate of cliff recession. Continued erosion of dry valley deposits and weathered chalk at Birling Gap provides a local supply of sediment.

Contemporary sediment input to this frontage is low and tends to come from sea cliff recession at both this location and updrift. Sands and gravels are also supplied to (but also lost from) the frontage via onshore wave driven transport (SCOPAC, 2003).

Shoreline Movement:

The coastline between Cliff End (immediately east of Cuckmere Haven) and Birling Gap has shown a historic trend of long-term sea cliff recession and platform lowering. The shore platform is subject to lowering caused by a combination of freeze-thaw cycles, boring molluscs, hydraulic pressure and marine erosion. At Birling Gap, the rate of erosion is higher than adjacent cliffs and has created an embayment with a shingle beach on a wave cut platform. Mean Low Water has been retreating historically at a rate of 1.0 to 1.5m/year, with cliff top erosion between Cliff End and Birling Gap taking place at a rate of 0.3 to 0.5m/year; and platform erosion is taking place at a rate of 0.15m/year. Halcrow (2002) suggested that this figure is even higher as cliff recession in the order of 1m/year has been taking place since 1874. Present day shoreline movement varies from beach profile steepening with no net lateral movement to steepening with net profile retreat.

Predictions of Shoreline Evolution:

Futurecoast (2002) has predicted that in an “unconstrained scenario” there would be continued cliff recession, which would ultimately be controlled by the rate of platform lowering. By 2105, the wave-cut platform would have eroded by 15-20m and the cliffs by 30-100m, or 70-80m at Birling Gap.

C.1.4.6 LOCAL SCALE: Beachy Head

Interactions:

Beachy Head protects the coastline to the east from the incident south-westerly waves. To the west, however, predominant waves approaching the headland erode the shore platform and sea cliffs, which provides a modest contemporary input of sediment to the longshore transport system (Futurecoast, 2002). Landsliding of the south-west facing cliffs also provides a potential supply of sediment to the frontage. Wave energy is the primary mechanism for longshore transport and net sediment transport is easterly. Halcrow (2000a) estimated that there is a potential supply of 540,000m^3/year from the cliffs around Beachy Head, with a maximum volume of material suitable for beach building of around 5,400m^3/year, based on

1% flint content of the potential supply volume. There is potential for material to be transported around Beachy Head and to the east, however, due to the lack of sediment supply, there is no actual transport.

Any material that is transported to the east is of the coarse fraction, whilst fine clay material that is released tends to be transported offshore in suspension (Futurecoast, 2002). Numerical modelling by Halcrow (2000a) identified the potential for offshore movement of sand-sized particle, which are moved by currents in the subtidal zone. Halcrow (2000a) states that tidal currents around the headland are strong enough to transport larger sediments such as shingle towards Eastbourne. An estimated gross volume of 16,000m^3/year and net volume of 6,000m^3/year of material is transported via this pathway.

Shoreline Movement:

The coastline shows a history of long-term retreat and a recent eroding trend, with modest rates of platform lowering and sea cliff recession along the south-west facing cliffs (Futurecoast, 2002). Mean Low Water historic retreat rate around Beachy Head is 1.0 to 1.5m/year and the platforms are seen to be eroding at a rate of 0.15m/year.

Predictions of Shoreline Evolution:

Cliff recession would continue on the south-west facing flank, with preferential erosion along zones of weakness and landsliding on the south-east facing flank. Material released to the toe of the cliff would be temporarily trapped on the shore platform before being released to be transported by alongshore transport. Futurecoast (2002) estimates that the cliffs will erode at a moderate rate, with 10-50m of erosion in the next 100 years.

C.2 Summary Sediment Budget

C.2.1 INTRODUCTION

This summary provides an overview of the sediment budget for the coastline from Selsey Bill to Beachy Head. It is intended that the summary discusses only the inputs, stores, areas of accretion, losses and littoral drift rates for the purpose of policy appraisal at SMP level. As such, the summary is based on the findings of the SCOPAC Sediment Transport Study (SCOPAC, 2003) and provides a review of the general sediment budget and some qualified information.

The sediment budget analysis has been performed for four distinct lengths of coastline:

- **Selsey Bill to Pagham**: a complex environment with differences in wave climate, local tidal currents, presence of offshore and nearshore bars, shoals and reefs; all resulting in several distinct littoral sub-systems.
- **Pagham to Shoreham-by-Sea**: a drift-aligned coastline, interrupted by the mouths of the rivers Arun and Adur. Longshore drift is the dominant means of sediment supply and distribution along the beaches. The shoreline is heavily defended with coastal structures, which has tended to result in areas of intermittent beach accretion and erosion.
- **Shoreham Harbour to Brighton Marina**: a shoreline characterised by a shingle beach, backed by hard linear defences, such as seawalls. The shoreline is heavily defended with coastal structures, which has tended to result in areas of intermittent beach accretion and erosion. Longshore drift is the dominant means of sediment supply and distribution along the beaches, although rates are slightly less than those between Pagham and Shoreham-by-Sea, due to a difference in the orientation of the shoreline.
- **Brighton Marina to Beachy Head**: a shoreline characterised by cliffs and fronting shingle beach, interrupted by the mouths of the rivers Ouse and Cuckmere. To the west, the shoreline is defended with coastal structures and, to the east, the cliffs are largely undefended. Some sediment is supplied to the beaches as a result of cliff erosion, otherwise there is little new sediment delivered to the beaches.

C.2.2 SELSEY BILL TO PAGHAM

C.2.2.1 Overview of Sediment Regime

Sediment is supplied to coastline between Selsey Bill and Pagham, via a number of sources: (i) longshore transport of material, and (ii) wave driven nearshore and offshore zone transport.

Shingle is transported from the drift divide at Sesley, in an easterly direction, towards East Beach and Church Norton, before accumulating along the southern spit of Pagham Harbour.

The material transported from the drift divide at Selsey Bill to the southern spit is supplemented by material supplied from wave driven nearshore and offshore zone transport at East Beach. The amount of longshore sediment transport that takes place between Selsey Bill and Pagham Harbour is very much determined by the defences along this coastline, for example, the trapping of sediment by groynes. The following text provides a quantitative summary of the sediment transport regime between Selsey Bill and Pagham. There are five main sources of sediment between Selsey Bill and Pagham. Some of the sediment is stored within the local beaches and elsewhere and some of which is lost from the system.

(a) Inputs

- An average of 5,000-6,000m3/year of shingle is supplied transported in pulses via the onshore wave transport of material from the Mixon Reefs and Kirk Arrow Spit (Lewis and Duvier, 1977; HR Wallingford, 1995; 1997).
- 1,000m3/year is transported onshore to the Streets and Malt Owers Reefs.
- Shingle is transported from the drift divide at Selsey Bill, eastwards via longshore transport. Based on figures from 1909-1962, Lewis and Duvivier (1977) estimated a yield of 7,500m3/year from Selsey Bill.
- On average 3,000-5,000m3/year of shingle is transported from the Inner Owers onto the beaches at East Beach in pulses (HR Wallingford, 1995, 1997).

(b) Stores

- Kirk Arrow Spit has a volume of 20-40,000m3.
- 65,000m3 of material is stored within the beaches at Selsey Bill (Hillfield Road, specifically).
- 50-55,000m3 is permanently stored on the beach at East Beach (Lewis and Duvivier, 1977).
- An average of 41,677m3/year of material has accreted to the south of Pagham Harbour, based on a total of 5 million m3 accretion since 1866.
- 5.5 million m3 is stored within Pagham Tidal Delta (Barcock and Collins, 1991).

(c) Outputs/Losses

- Offshore losses occur from the beaches at Selsey Bill. Annual losses from the upper beach equate to approximately 1,000m3/year (based on 1973-1992 ABMS data).

- Offshore losses also occur as fines, not retained on beach, leaving behind a medium to medium-coarse sized sand.
- There is a net seaward discharge from Pagham Harbour of 16,000m3/year. (+18,000m3/year landwards movement on the flood tide and -34,000m3/year removal of seawards). Gifford Associated Consultants (1997) also estimated outputs from Pagham Harbour to be in the region of 40,000m3/year.

C.2.2.2 Transport Pathways

(a) Longshore Transport

- At Selsey Bill, the potential drift rate of 13,700m3 is reduced to 5,500m3 when adjusted for assumed groyne efficiency (Posford Duvivier, 2001b).
- Approximately 15,000-25,000m3 (Posford Duvivier, 2001b) of longshore drift takes place, although this depends on groyne performance.
- Between East Beach and Pagham Harbour entrance, the prevailing drift is estimated to be between 24,000m3 and 42,000m3 (Barcock and Collins, 1991). HR Wallingford (1995) calculated drift along Church Norton Spit to be 32,000m3, with less than 17,000m3 of that being for transport of shingle along the upper beach alone. This was later estimated by Posford Duvivier (2001b) to also be in the region of 32,000 m3, which includes inputs from Selsey, Kirk Arrow Spit and the Inner Owers.
- 60,000-75,000m3 of material is potentially available at the entrance to the Pagham Harbour via longshore transport from the south-west and north-east. A portion of this is stored within the spits, while 24,000-40,000m3 is available to bypass the entrance channel (Gifford Associated Consultants, 1997).
- There is a local littoral drift divide at Pagham, with approximately 5,000m3 of shingle being transported to the south, along the northern spit.

(b) Beach Management

It should be noted that these measured and estimated sediment transport rates will reflect past management activities, such as beach renourishment and beach recycling. Recycling along the beach at Church Norton and the southern spit is averaged to have been in the region of 15,000m^3/year since the early 1990s (SCOPAC, 2003).

C.2.3 PAGHAM TO SHOREHAM HARBOUR

C.2.3.1 Overview of Sediment Regime

The shoreline between Pagham and the entrance to Shoreham Harbour is fed largely with the supply of material from updrift. A long feeder zone occurs in an easterly direction from Pagham in the west, to the entrance to Shoreham Harbour. This is evident by the presence of Shoreham Spit, the former eastwards deflection of the mouth of the River Arun and the trapping of sediment on the west side of the groynes along this frontage (Robinson and Williams, 1993).

There are two major interruptions to the "free-flow" of sediment between these locations, including Littlehampton Harbour (the River Arun) and Shoreham Harbour (the River Adur). Pagham Harbour is also considered to limit the amount of sediment bypass, although it by no means forms a permanent barrier to longshore transport. In addition to this, coastal structures, such as groynes (timber and rock) and offshore breakwaters at Elmer, act to suppress the natural feed of material. Beach sediment recycling and renourishment are also common methods of beach management practiced along this length of coastline.

In the past, coastal management schemes have impacted on the sediment budget. These include (HR Wallingford, 2003b):

- A number of minor (<6,000m3) recharge schemes along the shore since 1979.
- More substantial works at Elmer in 1989 (about 20,000 m3) and in 1993 (200,000 m3).
- Bypassing of material across the River Arun, where it is removed from Shoreham Beach, on the updrift side of the breakwater, transported by road and deposited largely on Southwick beach (Halcrow, 2000b).
- Substantial recycling from Climping back to Poole Place groyne (following the Elmer breakwater construction).

The following sections provide a quantitative summary of the sediment transport regime between Pagham and Shoreham-by-Sea (Southwick).

(a) Inputs

- It is estimated that the beaches between Pagham and Aldwick are fed with material coming in from the nearshore banks and across from the harbour itself, an influx that tends to be due to the episodic migration of nearshore banks. Using numerical modelling, HR Wallingford (2003b), calculated these inputs to be in the region of 20,000-40,000m3/year.
- From Aldwick to Shoreham, there are no significant natural sources of sand or gravel to the shoreline (HR Wallingford, 2003a) and instead, the main input of sediment is that supplied from updrift. Using estimations of longshore drift for the Pagham to Poole Place frontage, HR Wallingford (2003) calculated the potential sediment inputs for defined sections of frontage. These are shown in Table 1.
- Continued shoreline erosion downdrift provides a supply of material to the beaches to the east of Pagham, such that each section of coastline is continually fed with material from updrift; the rates are discussed in Transport Pathways section below.

- 1600 m3/year of material is potentially lost from the beaches at Bognor and 2000m3/year is potentially from the beaches at Middleton-on-Sea (HR Wallingford, 2002).

Table 1: Sediment Inputs via longshore drift sections of coastal frontage, Pagham Harbour to Poole Place (terminal groyne), as predicted by shoreline modelling. Source: (HR Wallingford, 2003b)

Location (length of coastline)	**Volume (m^3)/ year**
Dark Lane, Aldwick to Aldingbourne Rife	7,000 Increasing to 27,000, when natural bypassing of Pagham Harbour entrance is at its highest.
Aldingbourne Rife to westernmost offshore breakwater at Elmer	11,000 net input of shingle to this frontage (assumes that there is no shingle transport past the River Arun training wall) and excludes effects of renourishment.
Elmer breakwaters to Poole Place	3,000-23,000 net input of shingle to this frontage (assumes that there is no shingle transport past the River Arun training wall) and excludes effects of renourishment.

- 200,000m3 of mixed sand and shingle was used to replenish Elmer beach in 1993.
- Between 1994-1996, 5,300m3/year accumulated to immediate west of the Elmer breakwaters (King et al., 2000), but a loss of 14,250m3/year occurred to the east of the breakwaters.
- Between 1994 and 1996, losses from the frontage east of the breakwaters reached an average of 7,125m3/year, however, this increased to 90,000m3 between 1993 and 1997, equivalent to approximately 22,500m3 of loss/year.
- Potential inputs from the River Arun are estimated to be 17,000 tonnes/year suspended load (approximately 9,100m3/year, based on a unconsolidated, wet density of 1,900kg/m3 (Allaby and Allaby, 1996)), however, the actual delivery is reduced by flood barriers, flow diversions at times of high discharge in lower flood plains. Actual quantities are more in the region of 11,000-12,000 tonnes/year (approximately 5,800-6,400m3/year, based on an unconsolidated, wet density of 1900kg/m3 (Rendel Geotechnics and University of Portsmouth, 1996).

- Potential inputs from the River Adur are in the region of 20-26,000 tonnes/year (approximately 10,700-13,900m3/year, based on a unconsolidated, wet density of 1900kg/m3 (Allaby and Allaby, 1996)), but as with the River Arun, the actual quantities are less, and more in the region of 2,600 tonnes/year (approximately 1,400m3/year) (Rendel Geotechnics and University of Portsmouth, 1996).
- No significant input of coarse sediment is provided by the rivers or from offshore, such as kelp-rafting/wave powered onshore creep, although there is a potential feed of 48,000-72,000m3/year if mobilised shingle exists on the seabed (Crickmore et al, 1997).

(b) Stores (volumes)

- Pagham Beach, east of Pagham Harbour entrance has a volume of 2-3 million m3 (Wallace, 1990b).
- The beach at Climping is a store of medium and coarse gravel. Since the 1970's, dune growth and regeneration behind the beach has taken place, indicating the retention of sand and some coarser material. The dunes are an open, active accretionary system, stabilised with vegetation planting.
- Beach accretion is also taking place at Worthing (Worthing Borough Council, 1987), which is largely due to trapping of longsghore drift material by groynes. Annual accretion of 7,000m3, between 1974-1985 was recorded by Binnie and Partners (1987) and 9,000m3 (1973-1998) by (Scott Wilson Kirkpatrick, 2000b and c). These beaches are, however, subject to winter erosion.
- Central-east Worthing beach has a volume of 2.5million m3 (Scott Wilson Kirkpatrick, 2000b and c).
- Shoreham Beach (west of Shoreham Harbour entrance) has historically been accreting at a rate of 19,000m^3/year, or 470,000m^3 since 1974 (Scott Wilson Kirkpatrick, 2000a and c). This is a result of beach material being retained adjacent to the breakwater. Between 1993 and 2000, 98,000m3 of material accumulated on this beach, which is equivalent to 14,000m3/year (Scott Wilson Kirkpatrick, 2000a and c). This is, in turn, is roughly equal to the amount of longshore drift arriving at this location; hence the beach could be considered stable/net accreting. The beach to the west of Shoreham harbour entrance has a volume of 2.5million m3.

(c) Losses

- East of Pagham Harbour, 5,000m3/year is transported westwards towards the harbour entrance. This is brought about by complex local wave refraction around the ebb tidal delta and wide, accreting foreshore.
- Using sediment transport models, HR Wallingford (2002), found offshore losses of shingle from Middleton-on-Sea to be in the region of 0-5,000 m3 per year.

- 24,000m3 of material is recycled annually from the beach between Climping and the River Arun to the beaches between Poole Place and Atherington.
- Between 1992 and 2000, 8-20,000m3/year has been removed from 100m length of coastline, adjacent to the Shoreham Harbour west breakwater (owned by Shoreham Port Authority) to replenish a 3km length of coastline downdrift of the harbour entrance 1992 (Halcrow, 2000b). This management is the responsibility of Shoreham Port Authority. It has been confirmed (Halcrow, 2000b) that this quantity of bypassing is sufficient to maintain the down-drift beaches. Beach monitoring, carried out between 1993 and 2000, has demonstrated that there has not been a loss in beach volume at Shoreham Beach (i.e. west of Shoreham Harbour entrance) and this is therefore regarded as a viable source of future recycling (Vaughan, 2001).

C.2.3.2 Sediment Transport – Littoral Drift

As discussed previously, 5,000m3/year is transported westwards, from the drift divide at Pagham Harbour, towards the harbour entrance. To the east of this local drift reversal there is a persistent zone of erosion, otherwise referred to as a drift divide (Wallace, 1990b; Posford Duvivier, 2001b). 90,000m^3 of sand and shingle was eroded from Pagham East between 1972 and 1992 (HR Wallingford, 1995), which is equal to an average erosion rate of 4,500m^3/year.

As material is fed onshore, some sand and shingle becomes temporarily stored on the tidal delta, before bypassing the drift divide and supplying the beaches at Aldwick. Updrift of Aldwick, the volume of material supplied to the beaches via longshore feed is greater than the onshore supply of shingle (Wallace, 1990b), hence this becomes the predominant source of material to the beaches east of Aldwick.

East of Poole Place groyne, there is a small amount of shingle that is transported seaward of the offshore breakwaters (some 800m offshore) and around Poole Place groyne. This material then moves onshore, contributing to a zone of accretion at Climping, to the west of the Littlehampton harbour breakwaters. This adds to the volume of shingle that is transported eastwards by longshore drift. HR Wallingford (2003a) estimate that there is potential for between 0-20,000m3/year of shingle to bypass Littlehampton Harbour.

Hydraulics Research (1987a and b) and the Environment Assessment Services Ltd (1997) report significant sand transport via Littlehampton Bar which is located offshore of the river mouth. Hydraulics Research (1987), who found that there is total of 65,000m^3/year of littoral drift along this frontage, 13,000m^3 of which is shingle. This leaves 52,000m^3 of sand to be transported along shore per year. Table 2 provides a list of longshore transport rates from Aldwick to Shoreham Harbour entrance.

Table 2: Rates of longshore drift (Pagham Harbour East to Shoreham Harbour entrance)

Frontage	Amount of longshore drift (m^3/year)			Source
	Sediment Type			
	Sand and shingle	Sand	Shingle	
Pagham to Aldwick			40,000	HR Wallingford (2003a)
Aldwick			20,000	HR Wallingford (2003a)
Pagham Beach to Bognor	60,000			Gifford Associated Consultants (1997)
Bognor			10,000	HR Wallingford (2003a)
Bognor main frontage to Felpham	47,000			Gifford Associated Consultants (1997)
Felpham	60,000			Mouchel (1997a, b and c)
	50,000			Gifford Associated Consultants (1997)
Middleton-on-Sea (west)			15,000	HR Wallingford (2003a)
Middleton-on-Sea (east)			4,000	HR Wallingford (2003a)
Elmer			3,000	HR Wallingford (2003a)
Climping			20-50,000	HR Wallingford (2003a)
Recycled: Climping to Poole Place, Atherington			-10-35,000	HR Wallingford (2003a)
Littlehampton, west beach	65,000		13,000	Hydraulic Research (1987)
	60,000			Gifford Associated Consultants (1997)
	50,000			Scott Wilson Kirkpatrick (2000a, b a and c)
Littlehampton, east beach	37,500, accounting for groynes on temporary storage			Gifford Associated Consultants (1997)
East Preston, Ferring Rife	70,000			Gifford Associated Consultants (1997)
Worthing			16,000 (actual net shingle transport) 120,000 potential net shingle transport	Scott Wilson (2000d)

Frontage	Amount of longshore drift (m^3/year)			Source
	Sediment Type			
			(assuming no groynes)	
	38, 500 based on observed and estimated in inter-groyne compartments.			Gifford Associated Consultants (1997)
Lancing	35,000			Gifford Associated Consultants (1997)
Shoreham, west beach	14, 539			Chadwick (1988c and d; 1989b and 1990).
	15-20,000			Coates et al. (1999)
	10-15,000			Halcrow (1990)
	16,000			Scott Wilson Kirkpatrick (2000a and c)
	Westwards drift (reverse due to south-easterly waves of 1,700)			Scott Wilson Kirkpatrick (2000a and c)

C.2.4 SHOREHAM HARBOUR TO BRIGHTON MARINA

C.2.4.1 Overview of Sediment Regime

(a) Inputs

Prior to the construction of the harbour breakwaters at Shoreham, sediment would have naturally bypassed the entrance to the River Adur, thus supplying the beaches downdrift at Southwick and Portslade-by-Sea with a source of beach building material. Following the construction of the breakwaters, the volume of sediment that is able to bypass the entrance to the River Adur has been drastically reduced. Throughout the mid and late 1900s, the only sources of sediment tended to be supplied via one-off events such as dumping of dredged spoil.

It was not until 1990, when a Beach Management Plan for this shoreline was developed (Halcrow, 1990). In the Plan, it was suggested that the biannual transfer of beach material from the beaches updrift at Shoreham Beach, should take place. Halcrow (1990), suggested that the amount recycled from Shoreham Beach should equal that of the material lost from the beaches at Southwick/Portslade-by-Sea (which, as stated below, is in the region of 15,000m^3/year). Such recycling and beach recharge has resulted in the stabilisation of beaches up to 3km down drift of Shoreham Harbour breakwaters.

In practice, the actual amount of sediment recycling has varied, with an average annual transfer of 8,500m^3 between 1993 and 2000 (Vaughan, 2001); and within that there have also been variations, for example no recycling took place during 1996, although over 16,500m^3 was transferred in 2000.

Between 1988 and 1992, the beaches at Southwick/Portslade-by-Sea were replenished and the groyne bays infilled, using spoil from reclamations for harbour development.

(b) Stores

The major store of sediment along this frontage is Kemp Town beach, East Brighton. The volume of the beach at this location is 1,822,000 m^3 of shingle has accumulated at this location and continues to do so. A proportion of the sediment stored within the beaches at Kemp Town, Brighton (and also Aldrington/West Hove) is relict, in that its source no longer exists. As suggested by SCOPAC (2003), this material has been inherited from:

- Littoral input supplied from updrift prior to the construction of Shoreham Harbour Breakwaters, which also previously fed eastwards spit migration.
- Onshore barrier migration.

(c) Losses

Since the construction of Shoreham Harbour breakwaters in the late 1880s, the beaches down drift at Southwick and Portslade-on-Sea have experienced sediment starvation, as there is now no natural transfer of shingle across the mouth of Shoreham Harbour (Halcrow, 2000b). Despite attempts by Shoreham Port Authority at shingle bypassing, there has been a net reduction of beach volume of almost 150,000m^3 between 1962 and 1988 (Halcrow, 1988; 1990), which was estimated to be approximately 25% of the equilibrium capacity of the beach.

Some of the material available along this frontage is also transported from the coastal system and up-channel of the River Adur, or stored within the inner and outer bars, located around the mouth of the River Adur. The exact quantities lost from the system via these pathways are uncertain, but have been estimated to be in the region of 30,000-100,000m^3/year (SCOPAC, 2003). It is thought that this is a gross estimate and further investigation of this would be necessary to provide a more accurate estimate.

C.2.4.2 Sediment Transport – Littoral Drift

The construction of Shoreham Harbour breakwaters significantly reduced the amount of material that could bypass the mouth of the River Adur, although, some sand is still transported across the harbour entrance via wave transport, and some coarse bedload (mainly gravel) material is transported across the harbour mouth within the offshore zone, via short-term storage within inner and outer bars. A net volume of approximately 14,000-20,000m^3/year gravel is transported across the mouth of the River Adur via this pathway (Hydraulics Research, 1984; Halcrow, 1990), although it is dispersed along the beach shortly afterwards.

Approximately 15,000m3/year of material is transported alongshore from the east of Shoreham Harbour entrance to Portslade-on-Sea (Halcrow, 2000b). East of Portslade, littoral drift from west to east has been estimated to range from 14,200m^3/year, accounting for groyne storage (Halcrow, 1988) to 15,000m^3/year (Scott Wilson Kirkpatrick, 1994; Halcrow, 2000b), to 17,400m^3/year (Gifford Associated Consultants, 1997). It is agreed that net transport rates are higher in winter than in summer.

Between central Hove and Kemp Town beach, Brighton, the drift rate has been estimated as 50,000m^3/year (Halcrow, 2001b), which reduces to 18,000m^3/year when the effect of groynes is accounted for. Halcrow (2001b) has suggested that the rate of net longshore transport is lowest for the sector along central Brighton beach, due to the fact that it has a better developed swash orientation than adjacent beach lengths.

Immediately updrift of Brighton Marina the rate of longshore transport decreases to 4,000m^3/year (Scott Wilson Kirkpatrick, 1994).

SCOPAC (2003) presents a concise summary of the sediment budget for the coastline between Shoreham Harbour entrance and Brighton Marina, which is presented in Table 3.

Table 3: Summary sediment budget (Source: SCOPAC, 2003). All figures are given in m^3/year.

Gravel					
Inputs		**Stores**		**Outputs (Permanent Losses)**	
14,000	Updrift littoral transport bypassing Shoreham Harbour breakwater	1,822,000	Kemp Town Beach	4,500 – 8,000	On-offshore loss
8,500	Renourishment of the beach to the east of Shoreham			****	Dredging, Shoreham Harbour approach and

Gravel					
Inputs		**Stores**		**Outputs (Permanent Losses)**	
	Harbour entrance.				entrance channels.
2,500	Shingle Creep and Kelp Rafting (although not certain)			****	Abrasion
****	Periodic rubble tipping, east of Shoreham Harbour entrance.				
Sand					
Inputs		**Stores**		**Outputs (Permanent Losses)**	
****	Offshore to onshore wave-driven transport	****	Foreshore	****	Foreshore to nearshore, and offshore transfer
****	Updrift littoral transport	2,000 – 8,000	Shoreham Harbour and approach/entrance channels	****	Downdrift littoral transport
2,800	Fluvial discharge			32,000	Dredging at Shoreham Harbour approach and entrance channels

C.2.5 BRIGHTON MARINA (ROEDEAN) TO NEWHAVEN; AND TIDE MILLS TO BEACHY HEAD

Between 1992 and 1996, a total of 200,000m^3/year of gravel was used to mitigate against depletion of the flint gravel beaches at Ovingdean and Rottingdean to Saltdean. This renourishment material was sourced from the Owers Bank, located approximately 12miles offshore of Littlehampton, and may be a source that can be exploited again in the future, should a similar method of beach management be recommended for this coastline.

SCOPAC (2003) found there that there is no available quantified data for the coastline between Tidemills and Beachy Head.

C.2.6 SUMMARY

C.2.6.1 Areas of Sediment Storage

There are a number of individual lengths of coastline where significant accumulation of sediment has taken place in the past, and has not since been eroded. This material has subsequently been stored within the beaches and foreshore. Areas of significant sediment storage are listed in Table 4.

Table 4: Areas of significant sediment storage

Location	**Volume stored**
Kirk Arrow Spit	20,000-40,000 m^3
Selsey Bill beaches	65,000 m^3
Selsey, East Beach	42,000-50,000 m^3
Pagham Harbour Tidal delta	5.5 million m^3
Pagham Beach	2-3 million m^3
Elmer (updrift of groynes)	Approximately 5,300 m^3
Climping	Unquantifiied
Worthing, east and central beach	2.5million m^3
Shoreham Beach	2.5 million m^3
Kemp Town, Brighton	1.8 million m^3

C.2.6.2 Areas of Sediment Accretion

The coastline between Selsey Bill and Beachy Head shows an overall general trend of erosion, however, there are several areas where there is a trend of net accretion. The reasons for the erosion vary, but tend to be related to the construction of breakwaters and coastal defences. The reasons for the accretion, and rates of accretion (where known), are listed below:

- Pagham Beach (due to local net drift reversal)
- Bognor Regis (due to groynes)
- Elmer (updrift of rock reefs) approximately 5,300 m^3/year
- Climping (updrift of Littlehampton Harbour Breakwater)
- Worthing, east and central beach (due to groynes) 7,000-9,000 m^3/year

- Shoreham Beach (updrift of Shoreham Harbour Breakwater) 14,000-19,000 m^3/year
- Kemp Town, Brighton (updrift of Brighton Marina breakwaters)

C.2.6.3 Areas of Beach and Shoreline Erosion

As mentioned above, the shoreline between Sesley Bill and Beachy Head is generally an eroding one. Areas where erosion is most prominent are:

- Selsey Bill
- West Bognor
- Downdrift of the Elmer breakwaters and between Poole Place and Atherington
- Littlehampton (east of the harbour entrance)
- East Preston to West Worthing
- Southwick and Portslade-by-Sea
- Hove
- Brighton

C.2.7 DISCUSSION OF FINDINGS

It is evident from this assessment that the coastline between Selsey Bill and Brighton Marina, is both eroding and accreting at intermittent intervals along its length. This is not only due to local forcing conditions such as waves and local drift reversals, but also the construction of coastal defences. As a general rule, where a coastline is accreting, due to presence of defences, the adjacent coastline is eroding. In locations such Climping, coastal managers have utilised this pattern, by removing sediment from the adjacent accreting area and recycling it back to the original location of erosion. There is no reason that this cannot be carried out elsewhere along this length of shoreline, although the amount of material recycled should not exceed that which has arrived at the location of accretion. Furthermore, in order to maintain an equilibrium sediment budget as far as possible, the amount of material recycled should be relatively equal to the rate of longshore drift between the eroding and accreting coastlines.

Based on these findings, a number of sites have been recommended where this method of beach management could be applied:

- West Bognor: sediment recycling from east to west Bognor
- Worthing: sediment recycling from Worthing to the east

- Shoreham-by-Sea: recycling from Shoreham Beach to areas to the west that are devoid of sediment input, e.g. Sompting, West Worthing
- Kemp Town: recycling from Kemp Town to Brighton and Hove

C.3 Defence Assessment

The table on the following pages provides a summary of the existing defences along the SMP frontage together with an assessment of residual life. An assessment of residual life under a 'no active intervention' policy was undertaken using the condition data together with NADNAC condition deterioration curves (CDC), using the table below (from the 2004 Procedural Guidance, Volume 3) as a guide.

Defence Description	**Estimate of residual life (years) under NAI policy**				
	Existing Defence Condition Grade:				
	Grade 1	**Grade 2**	**Grade 3**	**Grade 4**	**Grade 5**
Seawall (concrete/ masonry)	25 to 35	15 to 25	10 to 15	5 to 7	0
Revetment (concrete/ rock)	25 to 35	15 to 25	10 to 15	5 to 7	0
Timber groynes and other timber structures (e.g. breastwork/ revetments)	15 to 25	10 to 20	8 to 12	2 to 7	0
Gabion	10 to 25	6 to 10	4 to 7	1 to 3	0
Note: Grade 5 is not used in the CPSE, but is included here as a measure of failure.					

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	Any past changes to defences that might be relevant, e.g. time of first intervention, time of previous defences on currently undefended coasts, information on other coastal structures.	*Divided by elements (e.g. seawall/ groynes), where necessary.* *Estimate of residual life provided for each element, where relevant.*	*Based on Future coast*
1. Selsey Bill Chainage: -900m to 3750 National Grid: (484450E, 093000N) to (487370E, 094590N) Defence Length Codes: (CPSE: 3414-3402)	Groynes (pre-1876) were constructed as mitigation of historic erosion and beach steepening. *1960*: small section of concrete wall/apron in west of unit constructed. *1960-1970*: First timber groynes placed in front of Selsey. *1970s/1980 –early 1990s*: Concrete sections extended over much of unit. A few gaps still remain. *1940-early 1990s*: Hard revetment constructed along much of unit (covers peninsular and central regions). Revetment is mostly concrete. *1980-1986*: Much of rest of unit timber groyned. *1986*: Recharge performed from IRB station to East Beach along with construction of groynes in the area.	Existing coastal defences around Selsey Bill to Selsey West Beach include sea walls (with sheet piled toes) and groynes. At Selsey West beach there is a rock scour apron at the toe. The foreshore is generally low and narrow and some of the groynes have deteriorated to a condition where they are ineffective. Sections of the seawall are subject to direct wave attack leading to erosion and the risk of undermining. Overtopping by storm waves currently occurs at Selsey Bill and East Beach. <u>Residual Life</u> Timber Groynes (Selsey and East Beach) <5-10yrs Timber Groynes (Selsey Bill) <15 yrs Concrete Seawalls and apron <5-10yrs, <15yrs Average Residual life in Do Nothing Case and Standards against Overtopping (SaO), (Pagham-East Head CDS 2001): Selsey Bill & Selsey West Beach, RL 10 yrs, SaO 1:200 Selsey East Beach, RL 20 yrs, SaO 1:50	Defence works have reduced historically high rates of HW and LW realignment. Supply of sediment from Selsey “Cliffs” has now been halted by construction of seawalls. Kirk Arrow Spit is a mobile shingle bank which periodically migrates onshore.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	1993: Replacement of some timber groynes at tip of Peninsular. *1996*: Proposal for replacement of groynes at East Beach. Other coastal structures include Lifeboat station.		
2. Church Norton to Pagham Chainage: 3750 to 7100 National Grid: (487370E, 094590N) to (489150E, 097150N) Defence Length Codes: (CPSE: 3401, 3537) (SDS: 2101-2102, 2120D)	Since 1963 the Pagahma harbour entrance channel has been stabilised in its current location. There are remains of a concrete training wall, including the remnant of an old harbour entrance to the south at Church Norton. Other redundant training walls scattered around from previous channel positions. Today, there is one active sheet-piled training wall in Pagham Harbour entrance, which holds the mouth in its present position (the SW side is free to move). Timber groynes were constructed at both west and east ends (1960-1963). *1986:* Timber groynes at Church Norton, and supplemented with steel sheet piling (circa 1950s).	Limited defences in this region and shingle beaches and banks are the main defences, along with timber and rock groynes and man-made defences associated with Pagham Harbour. At Church Norton the shingle ridge is wide with long timber groynes in fair condition. Moving northwards towards Pagham Harbour there are a series of shorter timber groynes prior to the steel sheet piled training wall that fixes the north spit (or east of Pagham side) of the harbour entrance. North of the harbour entrance, the four timber groynes have been encased in and extended using rock. Possibly some increase in erosion rate at east end of beach as a result. <u>Residual Life</u> Timber groynes <5-10 yrs, <15yrs Rock groynes c20yrs, <35-40yrs. Average Residual life in Do Nothing Case, (Pagham-East Head	Defences & Pagham Harbour development have influenced historic rates of erosion. Over the past 250 years there has been a net accretion at Pagham Beach rather than historical erosion prior to works. Much of the land towards the River Arun is divided into a series of headlands and bays. The headland locators are believed to be the result of early defence works (may also be geological factors).

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	1993/4: The seaward end of 4 no. timber groynes at Pagham were encased in rock and extended. Tidal flows at Pagham Harbour entrance cause a partial interruption to longshore transport, which results in the deposition of material at the harbour entrance. In the past annual recycling of shingle was carried out to clear harbour mouth and maintain the shingle revetment.	CDS 2001): Church Norton, RL 30 yrs, SaO 1:100 Pagham Harbour Shingle Spits, RL 20 yrs, SaO 1:200 Pagham Harbour, Exposed Shoreline, RL 15 yrs, SaO 1:20 Pagham Harbour, Sheltered Shoreline, RL 5 yrs, SaO > 1:20 Pagham Beach, RL 15 yrs, SaO Minimum 1:100	Pagham Harbour and Spit acts as a cyclic sediment sink, periodically releasing material onto Pagham Beach. The Inner Owers is a mobile shingle bank, which predominantly migrates onshore.
3. Pagham East to Aldwick Chainage: 7100 to 9400 National Grid: (489150E, 097150N) to (491250E, 098200N) Defence Length Codes: (CPSE: 3536) (SDS: 2120D)	Historic defence – groynes (pre-1909). 1980s: Construction of wall and groynes at east end of unit (Aldwick). Other coastal structures include drainage outfalls (likely to become buried if accretion continues unmanaged).	In the west of this section, there are almost no artificial defences and the accreting shingle beach provides the primary defence. Some timber groynes and concrete seawall at east end of unit (Aldwick). <u>Residual Life</u> Shingle ridge <35-40yrs Timber groynes <5-10 yrs, <15yrs Seawall c20yrs	Currently accreting.
4. Bognor Regis, Felpham, Middleton-on-	Historic groynes (pre-1909 & pre-1876) constructed as mitigation of historic LWL	Existing defences consist mostly of concrete seawalls, with some hard revetment. The shingle embankment is predominantly	Net sediment transport is easterly.

<table>
<tr><th>Location</th><th>Defence History (optional)</th><th>Present Defences & Residual Life</th><th>Natural Features</th></tr>
<tr><td>Sea, Elmer

Chainage: 9400m to 16700m

National Grid:

(491250E, 098200N) to (498010E, 099950N)

Defence Length Codes:

(CPSE: 3536-3523, 3522-3515)

(SDS: 2301, 2310D- large part of this area not covered in database)</td><td>retreat and beach steepening. Accretion now trend.

1910/1920&1950s: Small section of concrete/masonry seawall constructed in west of unit (Bognor Regis).

1960s: Timber groynes and sections of concrete seawall/apron extended in west of unit (Bognor Regis) and large sections constructed in front of Felpham. Hard (concrete) revetment constructed in front of West Felpham.

1972-77: Groyne-field extended in front of Bognor Regis, Felpham and Middleton-on-Sea, now covering most of unit.

1970-1980s: Concrete wall completed over unit length – various structures some with splash walls/aprons.

1970s: Timber breastwork constructed in front of Middleton-on-Sea.

1980s: Timber groynes placed in front of Middleton-on-Sea and east Bognor Regis.

1989: Renourishment of Bognor Regis frontage to east of pier.</td><td>groyned.

Along much of the Aldwick frontage the beach is volatile and the concrete seawall exposed to the risk of undermining. The situation improves towards west Bognor and along the Esplanade where recent groyne repairs and recharge activities at Bognor Regis have taken place. The recent upgrade of defences includes the groyne scheme and shingle beach nourishment at Felpham, which appears to be performing well.

At Middleton-on-Sea there are a number of small timber groynes with low level backshore protection in the forms of breastwork with signs of erosion. Further along at Old Point the beach in front of the seawall is depleted (despite the presence of a number of old timber groynes), with the wall foundations exposed to wave action, providing a low standard of defence. At Southdean the concrete seawall and timber groyne field west of the Elmer breakwater are fronted by low beach levels due to the accretion of material within the lee of the Elmer breakwaters. As a result wave action on the wall is frequent.

<u>Residual Life</u>

Timber groynes (Bognor Esplanade): <15yrs, c20yrs

Rock Groynes (Bognor Esplanade/Felpham): <50yrs

Timber groynes (remainder): <5-10yrs, <15yrs</td><td></td></tr>
</table>

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	1990s: Small sections of seawall in front of Middleton-on-Sea refurbished. *1995:* Small rock revetment placed in front of seawall at Middelton-on-Sea due to failing wall. Terminal rock groyne constructed in front of Felpham and central timber groynes re-profiled. *1998:* Existing groynes at Bognor Regis replaced with rock/timber and beaches renourished with shingle. *1999:* Concrete seawall re-facing, rock toe and groyne refurbishment scheme, with shingle beach nourishment between Outram Road and Limmer Lane. Other coastal structures include Bognor Outfall, Bognor Pier and Aldingbourne Rife Outfall.	Seawall (Middleton-on-Sea) <5-10yrs, <15yrs Seawall (remainder) c20yrs, <35-40yrs	
5. Elmer Breakwater Chainage: 16700m to 18200m National Grid: (498010E, 099950N) to	Groynes (pre-1876) mitigate LWL retreat and beach steepening. *1930:* Concrete wall built along frontage. *1963:* Timber groynes built. *1989:* Works to the clay bank at Alleyne	Protection is afforded in part by the old walls in addition to the nourished beach. The old concrete seawall fronted by a beach and timber groynes has largely been superseded by the 8 no. rock armour offshore breakwaters and beach recharge behind them, extending eastwards to the Poole Place terminal rock groyne. Beach nourishment material placed creating wide backshore, but	

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
(499500E, 099950N) Defence Length Codes: (CPSE: 3515) (SDS: 23020D, 2305)	Way. *1990:* Emergency works, consisting of a) new rock revetment required when flood embankment opposite Alleyne Way on EA frontage came close to failure through piping and overtopping; and b) two rock breakwaters on Arun DC frontage. *1991:* Poole Place terminal groyne reconstructed (rock throughout). *1992:* 8 rock detached breakwaters constructed (6 new and 2 existing enlarged) *1993:* Shingle renourishment. *1990:* Rock armour revetment between breakwaters 5-6.	pinch points between breakwaters 3-4 & 5-6 has resulted in placing of rock revetment between breakwaters 5-6 (although some evidence of subsequent erosion at toe). Old backshore defences are piecemeal, consisting of stretches of concrete walls, timber breastwork and rock armour revetment. Residual Life Timber groynes & Seawall N/A Rock breakwater <50 yrs Rock revetment between breakwaters 5-6 <5-10yrs, <15yrs	
6. Poole Place to Littlehampton Harbour Entrance Chainage: 18200m to 22000m National Grid: (499500E, 099950N) to	Historical Groynes (pre-1876) and timber Breakwaters at harbour entrance (1930). *1930:* Timber breastwork pier (estimated date of construction) & timber breastwork harbour arm. *1950:* Steel sheet piled training wall & groyne (Dicker Works). The timber groynes range in age from 1971	East of the Poole Place terminal groyne the land is fronted by a shingle ridge and wide sandy foreshore. The shingle beach is groyned immediately east of the terminal groyne and again over a wide frontage centred on Atherington. There are discontinuous lengths of old masonry or concrete walls and lines of large concrete blocks demarking the backshore. The shingle beach width is highly variable and cuts back significantly near The Mill where sand dunes replace the wall as the backshore defence.	Littoral drift is easterly. River Arun is potential sediment sink, slowing the rate of littoral drift. As a result, there is a tendency for bars to form across the estuary mouth.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
(502850E, 101230N) Defence length codes: (CPSE: 3512-3514) (SDS: 2401- 2403, 2410D)	to 1987. *1977, 1992, 1994 &1995:* Rock placed in front of gap in old military defence WWII wall (referred to as a seawall) at end of Climping Street with surplus rock from Elmer scheme c1995. River training walls constructed to stabilise the river mouth – cause accretion to the west. Annual Recycling from the west of the harbour entrance to Poole Place. Other coastal structures include Littlehampton Harbour West Pier.	Annual recycling from west of the Littlehampton Harbour entrance to Poole Place/Atherington. The gap in the seawall at Climping is frequently overwashed. Timber breastwork in front of the gap has been extensively repaired a number of times. <u>Residual Life</u> Timber groynes <5-10yrs, <15yrs Seawall (Climping) <5-10yrs Seawall (elsewhere) <15yrs, c20yrs Harbour training wall <15yrs, c20yrs (CDSS'02) For Defence Length SDS-2403: Backshore: shingle backed by dunes, RL: 50 yrs.	The stabilisation of the mouth by training works has promoted the accumulation of sediment on the west (updrift) side of the mouth and a deficit immediately downdrift to the east. A dune ridge exists to the west of Littlehampton Harbour, at Climping. The sand dunes are fronted by the shingle bank/beach, which acts to intercept sand feed to the dunes. As a result there is no new sand supply to the dunes and they are now eroding (as evident by blowouts). The sand dunes are included in the West Beach Local Nature Reserve (LNR),

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
			which itself forms part of the Climping Beach Site of Special Scientific Interest (SSSI).
7. Littlehampton Chainage: 22000m to 24500m National Grid: (502850E, 101230N) to (505320E, 101400N) Defence Length Codes: (CPSE: 3512-3508) (SDS: none exist)	Historic defences in form of groynes (*pre-1867*) mitigating retreat and beach steepening at east end. *1910*: Seawall constructed along western section of unit. *1930:* Seawall constructed along eastern section of unit. *Late 1940s*: Stone block wall with concrete capping constructed - east wall extension. *1960:* Construction of groynes – east end of unit. *1971:* Centre of unit groyned, including a new concrete seawall. *1986-1987*: Most of 1960 groynes replaced. *1994:* Rock revetment built and rock groyne built (replacing timber groyne). Dredged shingle from harbour has been placed at the east of unit. Other structures include the Littlehampton	Timber groyne field in fair/good condition, with shingle beach. Beach levels close to top of seawall (at rear of beach) and promenade level except for east end of unit (Angermering), where no or intermittent seawall is present. No groynes at Littlehampton pitch and putt course (middle of unit), where beach is naturally stable. Dredged shingle from harbour has been placed at the east of unit. Residual Life Timber groynes <5-10yrs Seawall <15yrs, c20yrs	

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	Harbour East Pier and Littlehampton Outfall.		
8A. Littlehampton to Goring-By-Sea Chainage: 24500m to 31600m National Grid: (505320E, 101400N) to (512360E, 101900N) Defence Length Codes: (CPSE: 3508-3501, 3607, 3610-3612) (SDS: 2501, 2510D)	Mitigation of erosion and beach steepening using groynes (pre 1876). *1950s*: Construction of timber groynes along unit and timber breastwork constructed in centre of unit. *1980-1987*: Many 1950s timber groynes replaced. *1984*: Timber breastwork constructed at Kinsgton Gorse in conjunction with groyne reconstruction. *1987-88*: New timber and rock groynes built at eastern end of unit. *1994:* West end of unit feature two rock groynes built to replace 5 old timber groynes. *1995*: Replacement of 4 timber groynes with new timber groynes in centre of unit. Grout injected curtain at east end of unit. Recycling & recharge. Other coastal structures included an outfall at East Worthing, with an end that is a long way from the beach.	Some seawall, groynes (mixture of rock and timber) and shingle embankment. At Rustington, between Sea Lane and South Walk the defence consists of a wide grassed area with timber and rock groynes (in good condition). There are no current signs of distress to the grassed area. At East Preston and Kingston there are timber groynes fronting the grassed areas/gardens. There is also a low bank approximately 1m high at South Walk (East Preston), which cannot be considered a reliable defence. The timber groynes are effective at holding the beach and some have been raised to widen the crest. The groynes are in good condition and an isolated sequence that were in need of replacement at Kingston have been recently addressed. The majority of the length has a wide crest, and it would therefore be some time before the defences would be expected to fail. At Ferring the defence consists of timber breastwork and groynes plus a short length of rock revetment. At Ferring Rife the defence is vulnerable to breach. <ins>Residual Life</ins> Rock Groynes <35-40yrs Timber groynes (1980s) <15yrs	Historical trend of LWL retreat and beach steepening (mitigated by groynes). Recent average trend for net accretion within the unit. Net sediment transport is easterly.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	2003: New timber groynes and shingle recharge at Ferring.	Timber groynes (old) <5-10yrs Timber breastwork (Ferring Rife) <5-10yrs Timber groynes (Ferring Rife) <25 years	
8B. Worthing Chainage: 31600m to 37000m National Grid: (512360E, 101900N) to (517500E, 103300N) Defence Length Codes: (CPSE: 3601-3606) (SDS: 2520D, 2601)	Mitigation of erosion and beach steepening using groynes (pre 1876) *1920s*: Section of concrete wall built at west end of unit. *1950-1960s*: Middle-west of unit groyned (timber) *Late 1980s/early 1990s*: Rest of Unit groyned (timber) *Early 1990s*: small section of rock revetment constructed, along with sections of concrete wall and recharge. Some rock armour and gabions placed at very eastern end of unit. *1998*: Short section of rock revetment at Ham Rd, East Worthing Annual shingle recharge Other coastal structures include East Worthing Outfall, Pier and The Lido.	Along most of this frontage there is a splashwall, with some seawall in places. Along its length there are groynes and shingle embankment. Grout injected curtain at west end of unit. At East Ferring the beach defence is maintained by timber and rock groynes, which are in poor condition and are programmed for repair/replacement within the next 5 years. A rock groyne holds the present beach alignment. At Worthing the defence varies along the frontage. Along most of the frontage there is a shingle/earth bank with a beach in front (crest 20 and 25m), timber groynes (good condition) and 7 rock groynes. One rock groyne at the extreme western end appears to be visibly working, whilst the other 6 have been completely buried with accreted shingle and have subsequently achieved their maximum potential. Further east between West Parade and Splash Point there is an intermittent wall at the seaward end of the promenade, again with timber groynes with some rock heads, but many are in a poor	Historical trend of LWL retreat and beach steepening (mitigated by groynes). Recent average trend for net accretion within the unit. Net sediment transport is easterly.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
		condition, particularly near the Pier. The crest width of the beach varies from 5 to 20m. Between Splash Point and Ham Road the promenade and road is protected at each end with a rock revetment and a seawall of varying height. Timber groynes are in good condition, but there is little beach (0-15m). Finally, at Brougham Road, there are again no defences other than timber groynes which are in poor condition and retaining little shingle. Beach width is approx. 10m. <u>Residual Life</u> Rock Revetment (Ham Rd) <35-40yrs Timber groynes <5-10yrs, <15yrs Seawall (recent) c20yrs Seawall (old) <5-10yrs Shingle recharge 5-10 years	
9A. Lancing to Shoreham Harbour Mouth Chainage: 37000m to 43300m National Grid: (517500E, 103300N) to	Historic defences: seawall (1775) and pre-1876 groynes constructed to mitigate general historic trend of erosion and beach steepening. *1950's-1990:* Construction and upgrades of west breakwater at Harbour mouth. *1995:* 3 rock groynes constructed at west end of unit (Western Road, Lancing-Brooklands).	Timber groynes front the entire unit. However, there are no groynes at Shoreham West Beach, which is naturally stable. A concrete seawall exists along most of frontage. Rock groynes at east and western end of unit. At Brooklands Park the crest of the shingle beach has been artificially reprofiled to provide protection. The timber groynes are in fair condition, but buried at the heads. To the east there are some stretches of timber breastwork close to the 3 new rock groynes. The timber groynes in this area are in good condition. At	River Adur is potential sediment sink, which slows the rate of sediment drift. The sediment yield of the Adur is small. At western end of unit long-term historic trend of LWL retreat and

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
(523500E, 104550N) Defence Length Codes: (CPSE: 3705) (SDS: 2602-2606)	*1996-1999:* 11 rock groynes and shingle recharge constructed to replace timber groynes at eastern end of unit (Kings Walk, Shoreham). Other structures include West Breakwater. *2002-2003:* 9 rock groynes and shingle recharge constructed at Widewater.	the sailing club and caravan park (Widewater) breastwork continues and some reprofiling of the beach has also been undertaken; the timber groynes are in fair condition, but buried at the heads. At Widewater there is a concrete wall with steps protecting the beach huts. The timber groynes are in fair condition, but the shingle beach is narrow at the crest. At the far eastern end of the unit there are large rock groynes as well as the timber groynes, which are largely redundant. New rock groynes and recharge have not been implemented. Beach crest widths are wide. Recharge, Recycling, Bypassing and Dredging. In 2000, over 16,500m3 of shingle was excavated annually from the beach adjacent to the west breakwater and transported by road to the beaches, east of the harbour entrance. <u>Residual Life</u> Timber groynes <5-10yrs, <15yrs Timber breastwork (Mermaid Café, Sailing Club, Caravan Park) <5-10yrs, <15yrs (depending on existing shingle width) Rock groynes >50yrs Assume older timber groynes & sea defences have 5-10 or >5 West Breakwater >50 yrs	beach steepening, however, recent average trend has been new accretion within the unit.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
9B. Shoreham Harbour Mouth to Aldrington (W Hove) Chainage: 43300m to 46600m National Grid: (523500E, 104550N) to (526780E, 104500N) Defence Length Codes: (CPSE: 3705-3701, 3817-3812) (SDS: none)	Seawall (1775) and pre-1876 groynes constructed to mitigate general historic trend of erosion and beach steepening. *1950:* Seawall sections constructed towards eastern end of unit. Inner harbour arm and east breakwater at Shoreham Harbour constructed. *1950-1960's:* Timber groynes and breastwork constructed in centre of unit. Steel sheet piled wall at Basin Road. *1990s:* Rock groynes built at eastern end and in the centre of unit. *1990:* Stabit armoured block breakwater built off Harbour east breakwater. *1991:* Block revetment with rock toe armour placed adjacent to east breakwater. Rock groyne field constructed near Harbour wall with rock headland at eastern end. *1992 onwards:* recharge in area of 1991 rock groyne field. Other structures include storm water overflow, Shoreham Power Station outfall, Southern Water treatment plant outfall,	West of Shoreham Harbour entrance the beach is accreting and there are no hard defences. Some bypassing has been undertaken to compensate for the interruption to the littoral sediment transport caused by the estuary mouth and associated breakwaters. Shoreham Port Authority suggests this was in the region of 8-22,000m^3 between 1992 and 2000. There are timber groynes along the majority of the frontage, together with eight rock groynes. The east side of the harbour entrance consists of a sheet piled inner harbour arm with spending beach between the breakwater and pier. East of the entrance there is a concrete seebee revetment with concrete splash wall and armour toe protection with rock headland at the eastern end. At Basin Road there is a section of steel sheet piled wall to the rear of the shingle and timber groynes, with gabions to the car park before the frontage reverts to a shingle beach, which is backed by rubble and concrete rings. At Portslade by Sea there is a reinforced concrete wall and apron, showing some signs of wear and damage, and a short stretch of timber/concrete construction in poor condition. Beyond the wall the shoreline is a shingle beach with rock groynes and concrete rubble behind the beach crest.	

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	Hanson aggregate plant outfall.	<u>Residual Life</u> East Pier <50yrs Spending Beach c20yrs East Breakwater <35-40yrs, <50yrs Concrete revetment <5-10yrs, <15yrs Timber groynes <5-10yrs Sheet piling/rubble beach (Basin Road) <5-10yrs, <15yrs Concrete wall (Portslade by Sea) <5-10yrs, <15yrs Concrete rubble (Aldrington) <5-10yrs	
10. West Hove to Brighton Marina Chainage: 46600m to 53500m National Grid: (526780E, 104500N) to (533410E, 103250N) Defence Length Codes: (CPSE: 3811-3801, 3920-3912) (SDS: none)	Historical defences include 1885 groynes and seawall (1884, 1925, 1929) *1870-1970*: Seawall (varying material of concrete, masonry) constructed along much of the unit. *1890*: Concrete groynes built at eastern end of unit (poor condition). *Pre-1900's*: Goynes constructed between the west side of Palace Pier and east side of West Pier, at Brighton and towards west end of unit. *1949-1950's*: Concrete groynes (and few timber groynes) constructed west of West	Timber or concrete groynes are present along the majority of this frontage. Concrete wall is present along the rear of much of the unit, which, despite its age is largely in good condition. Shingle widths vary along the length. Accumulation of shingle in the western margin of the marina breakwater. Most works in this area are quite old. Presently, material is recycled from the west side of Shoreham Harbour to the beaches at Southwick, from where it is left to supply the beaches to the east via longshore drift. <u>Residual Life</u>	

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
	Pier. *1960-70's*: In 1968 further timber groynes constructed along frontage. Other structures include West Pier, Palace Pier. Pre-1990's-All other concrete groynes constructed between the piers.	Groynes <5-10yrs Brighton Palace Pier west sheet piling <15yrs Seawall (all locations) c20, <35-40yrs Shingle ridge (Hove Western Esplanade to Kingsway) <5-10yrs. (Brighton Marina to River Adur Strategy Plan April '03)	
11. Brighton Marina Chainage: 53500m to 54600m National Grid: (533410E, 103250N) to (534480E, 103150N) Defence Length Codes: (CPSE: 3908-3911)	Historical defences include1885 groynes (1885, 1887-1907) and seawall (1928-1936). The groynes have since been removed only the seawall remains. *1975:* Marina constructed.	Concrete caisson breakwater with concrete units as toe protection (ongoing problem with scour at toe). Sheet piled wall, flood gates and shingle outer beach within confines of breakwater arms. Residual Life Breakwaters <15yrs, Shingle beach c20yrs, Sheet piled walls c20-25yrs	
12. Brighton Marina to Saltdean Chainage: 54600m to 59050m	Cliff toe erosion protected by groynes since the later 1870s, after which a seawall was built. *1935*: Concrete seawall and groynes constructed through out entire unit.	Foot of cliffs defended along whole frontage by seawall (1930s serves as walkway/promenade) with short rock revetment at the eastern end to prevent outflanking at Saltdean. Seawall was supplemented with a completed field of 98 groynes from Black Rock to Saltdean. No beach recharge was involved at this time. The beaches were later recharged at Rottingdean and Saltdean,	

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
National Grid: (534480E, 103150N) to (538600E, 101700N) Defence Length Codes: (CPSE: 3908-3911, 3906-3901, 4018)	*1980s* – Programme for reconstruction was approved 1989, and involved 3 phases. *Initial Phase:* involved Lewes DC frontage at Saltdean in about 1991. Here, wall encasement and removal of groynes took place. *1995*: Phase 1-Ovingdean to Rottingdean: concrete & 4 rock groynes placed in front of playing field at Rottingdean with shingle recharge, seawall encased and strengthened. All other groynes were removed. *1997*: Phase 2 – Rottingdean to Saltdean: encasement of the existing wall, 4 concrete and 2 rock groynes placed with shingle beach recharge fronting Saltdean Park, all other groynes removed. *2003*: Phase 3 – Marina to Ovingdean Phase 3 – Seawall encased and rock revetment placed at toe of wall, 6 groynes at the west end and 3 at Ovingdean have been reconstructed, all other groynes have been removed. Works due to be completed Summer 2004.	including that amongst the remains of groyne field and a limited, varying amount of retained beach material was also placed between Ovingdean and the Marina. <u>Residual Life</u> Concrete/rock groynes (1990s) <50yrs, >50yrs Seawall (1930s) c20yrs Seawall (1990s) <35-40yrs, <50yrs. Brighton Marina to Ovingdean, most vulnerable section of this unit. If beach and groynes are not maintained, than seawall will breach within 1 year and after that cliffs will erode within 3 yrs. Works due for completion is due to take place in summer 2004. From Ovingdean to Saltdean failure of defences is not expected for at least 25 yrs.	

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
13A. Telscombe Chainage: 59050m to 60750m National Grid: (538600E, 101700N) to (540100E, 101050N) Defence Length Codes: (CPSE: 4018-4015) (SDS: none)	*1970:* concrete seawall and two concrete groynes forming a protected platform for the Telescombe sewerage pumping station. *1993:* Rock armour is being placed in west of unit to protect the defences updrift from being undermined. Other structures include Portobello Outfall.	Undefended chalk cliffs backed by open space and housing except at the Portobello Outfall Works Defences, which consists of a concrete seawall and two concrete groynes forming a protected platform for the Telscombe sewerage pumping station. Rock armour has been placed at the western limit of the unit to prevent the defences in updrift from being undermined. <u>Residual Life</u> Outfall – not CP works Rock Armour c20yrs, <35-40yrs	Near vertical chalk cliffs with wave cut platforms and shingle beach in front. Cliff face is locally undercut at the toe.
13B. Peacehaven Chainage: 60750m to 63300m National Grid: (540100E, 101050N) to (542540E, 100350N)	*1977:* Stage I of Peacehaven Coast Protection Scheme. Construction of section of concrete wall/splash wall-middle and east of unit (Groyne 14 to 19). Areas in front of works groyned (concrete groynes) *1980:* Phase II construction of concrete seawall/splash wall – west end of unit. Areas in front of works groyned (concrete groynes). (Phase 2 and 3 = groyne 1 to 13). *1983:* Phase III construction of concrete	Concrete seawalls at the toe of the cliff helps maintain stability. Concrete groynes are present on the foreshore. There is evidence of undermining of the foundations of the groyne and wave cut platform in front of the seawall. <u>Residual Life</u> Phase I works: Concrete groynes <5-10yrs Concrete seawall c20yrs Phase II & III works: Concrete groynes <15yrs	Near vertical chalk cliffs (regraded to stable angle) with wave cut platforms and shingle beach in front.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
Defence Length Codes: (CPSE: 4014-4009) (SDS: none)	seawall/splash wall-covering gap at west and extension of east wall. Areas in front of works groyned (concrete groynes) *1995-98:* final section of concrete wall/splash wall constructed (groyne 13 to 14). Concrete wall now covers whole of unit. Areas in front of works groyned (concrete groynes)	Concrete seawall <35-40yrs Phase IV works: Concrete Seawall <35-40yrs, <50yrs	
14. Peacehaven Heights to Harbour Heights Chainage: 63300m to 65700m National Grid: (542540E, 100350N) to (544730E, 099950N) Defence Length Codes: None		No hard defences exist. There is a trend of shingle accretion against the western breakwater at Newhaven, which has tended to protect the cliff base.	Near vertical chalk cliffs ungraded and undefended, with wave cut platforms and shingle beach in front. Platforms are subject to erosion by wave action, abrasion, biological and sub-aerial activity. The cliff face is locally undercut at the base.
15A. Newhaven Harbour Chainage: 65700m to	Historic defences in form of seawall (1898, 1881-1882) and breakwater (1887) *1880:* East concrete breakwater constructed.	Concrete/masonry breakwater and pier which acts as protection to the harbour. East pier also prevent shingle losses into the deep water channel of the port. The navigation channel is regularly dredged (annually) and deposited approx 1.5km south of the main	The Ouse is a potential sediment sink, which slows the rate of sediment drift; the

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
66750m National Grid: (544730E, 099950N) to (545800E, 100130N) Defence Length Codes: (CPSE: 4008-4007) (SDS: 3001)	*1930:* West concrete breakwater constructed *1995:* Tetrapod concrete block patterning added to existing east masonry breakwater. Other coastal structures include Newhaven New Outfall.	breakwater. Current maintenance comprises placing additional concrete armour units to the head and west side of the breakwater as necessary and ongoing repairs to the main concrete structure. The western breakwater obstructs the net easterly drift of sediment, and there is a trend of accretion in this area. <u>Residual Life</u> Breakwaters c20yrs	sediment yield of the Ouse is small.
15B. Tide Mills to Seaford Chainage: 66750m to 70500m National Grid: (545800E, 100130N) to (549100E, 098000N) Defence Length Codes: (CPSE: 4006-4005) (SDS: 3001)	Historic defences in form of seawall (1898, 1881-1882) and breakwater (1887) & beach erosion treated via beach recharge *1930s:* Stepped concrete wall and timber groyne constructed. *1970-1980:* Construction of hard revetment (concrete) and steel/concrete groyne. The concrete wall was subsequently reinforced with rock armour and timber breastwork. *1987:* Shingle recharge performed over unit. Other structures include the Water Treatment Works at Newhaven.	The beach is retained by Splash Point groyne (steel sheet piled) close to the eastern end of the unit. The old concrete surrounded outfall (now disused) also acts to hinder longshore movement. There is a length of seawall, which is now protected by a shingle beach nourished as part of the Seaford Beach Scheme. Further east there is a short stretch of old concrete wall, which has been covered by concrete block armouring behind timber breastwork and timber groyne. Cliffs immediately east of terminal groyne, no erosion problems and no defences present. <u>Residual Life</u> Sheet piled groyne: c20yrs, <35-40yrs	Units downdrift do not require beach nourishment.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
		Seawall <5-10yrs, <15yrs Breastwork and armour <5-10yrs, <15yrs Do nothing case, after 4 yrs shingle lost on 400 m of beach. After 15 yrs depleted section of beach increased to 1000 m, overtopping of seawall will occur and later wall will breach. Terminal groyne, RL 40 yrs, however beach loss sooner After 15 yrs, breach probability of seawall 20%, and seawall exposed over 200 m After 40 yrs, loss of terminal groyne, seawall exposed over 2500 m	
16. Seaford Head Chainage: 70500m to 7300m National Grid: (549100E, 098000N) to (551250E, 097430N) Defence Length Codes: (CPSE: 4004) (SDS: none)	*1979:* Gabions constructed to protect beach access at Hope Gap.	Largely undefended other than some stone gabions, which were constructed to protect beach access and not as a defence. Clifftop is undeveloped. <u>Residual Life</u> Gabions <5-10 yrs	Near vertical chalk cliffs ungraded and undefended, with wave cut platforms and shingle beach in front. Platforms are subject to erosion by wave action, abrasion, biological and sub-aerial activity. The cliff face is locally undercut at the base

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
17. Cuckmere Haven Chainage: 73000m to 74250m National Grid: (551250E, 097430N) to (552200E, 097450N) Defence Length Codes: (CPSE: 4003-4001) (SDS: 3101)	Canalised river, 19th Century. *1940:* Small sections of concrete wall and toe piling constructed in centre of unit perhaps to protect Coastguard cottages. *Approx 1960:* Bagwork revetment and toe piling. *1960:* Timber groynes constructed east of section of concrete wall. *1980-1990:* Construction of new concrete wall. *1994:* Maintenance work on the concrete wall. Other structures include the river mouth training works.	Concrete seawall and concrete (bagwork) revetment with steel toe piling provides protection to the Coastguard Cottages. There is a thin shingle beach overlying the chalk bedrock, which provides some protection to the toe piles. Some seawall, some hard revetment, mostly shingle revetment. The mouth and spit are now constrained by training works, groynes and recycling. Residual Life Bagwork revetment <5-10yrs Concrete seawall (and toe piling) <15yrs, c20yrs Timber groynes <5-10yrs 1 km of Canal training works are currently at end of their life.	Cuckmere mouth is a shingle tidal delta over deep alluvial and estuarine sediments. Eastward extension of the shingle spit has undergone successive breaching to give new mouth alignments. Cuckmere mouth is a potential sediment sink; river sediment yields are small and net sediment transportation easterly.
18A. Cuckmere Haven to Birling Gap Chainage: 74250m to 77300m National Grid: (552200E, 097450N) to (554940E, 096300N)	Other structures include a beach access stairway.	No hard defences and undeveloped clifftop	Chalk cliffs with Upper Chalk wave-cut platforms and with intermittent shingle beaches and cliff falls at the base.

Location	Defence History (optional)	Present Defences & Residual Life	Natural Features
Defence Length Codes: None			
18B. Birling Gap Chainage: 77300m TO 78300m National Grid: (554940E, 096300N) to (555700E, 095650N) Defence Length Codes: None	Other structures include a beach access stairway.	The cliff top is 12m high and continued erosion exposes the truncated dry valley deposits and extensively weathered chalk. There are currently no hard defences. There is an existing small development at Birling Gap.	Chalk cliffline is intersected by a hanging dry valley at Birling Gap.
18C. Birling Gap to Beachy Head and Holywell Chainage: 78300m to 84000m National Grid: (555700E, 095650N) to (560210E, 097100N) Defence Length Codes: None		There are no defences to the undeveloped clifftop. At Cow Gap steps have been cut into the chalk and a short section of timber steps lead from this onto the foreshore.	Chalk cliffs with Upper Chalk wave-cut platforms and with intermittent shingle beaches and cliff falls at the base.

C.4 SCENARIO REF: BASELINE CASE 1 – NO ACTIVE INTERVENTION

C.4.1 INTRODUCTION

This report describes the expected shoreline response assuming the scenario of “No Active Intervention”. This scenario has considered that there is no expenditure on maintaining or improving defences and that therefore defences will fail at a time dependent upon their residual life (see Defences Table) and the condition of the beaches. For the frontage between Braklesham Bay and Pagham Harbour, the No Active Intervention scenario has been developed using the findings of a separate report carried out specifically for this frontage. The report, ‘Recommendations for a No Active Intervention Policy at Braklesham Bay and Pagham Harbour’, is located at the end of this appendix.

C.4.2 SUMMARY

The following text provides a summary of the analysis of shoreline response, with details specific to each location and epoch contained within the Scenario Assessment Table. In addition to this, maps illustrating the position of the shoreline under a NAI scenario are located in Annex C1.

C.4.2.1 Epoch 0 - 20 years (to 2025)

The behaviour of the shoreline during this period would initially be governed by the existence of coastal defences and gradually increasing pressure from continued sea level rise, although the rate at which this rise takes place will be minimal during this period and more likely to play a more significant role in shoreline behaviour over the medium term.

Some coastal defences, such as seawalls and rock groynes will largely remain during this period and will hold the shoreline in its present position. Less robust defences, such as timber groynes and timber revetment will fail towards the middle and end of this period. As such defences fail, the sand and shingle beaches will narrow, steepen and begin to retreat landwards as a result of limited sediment input, particularly at the western end of the SMP area. There will also be increased longshore drift, although remaining rock groynes and harbour training walls will remain to trap sediment, resulting in localised beach growth. Where low-lying shorelines are not constrained by hard-line defences, such as seawalls, the shingle beach ridge will roll back, resulting in erosion of the hinterland.

Along the sections of coast where defences remain, there will be discontinuities of alignment where undefended shorelines are situated adjacent to those held by defences. Along the cliffed shorelines, the toe of the cliffs would be protected from erosion by the seawall (where present), but there would still be some erosion of the cliff top through sub-aerial weathering processes. Cliff top erosion is driven by sub-aerial weathering processes, which include:

- Percolation of rainwater through joints in the cliffs. Subsequent freeze thaw within joints, leading to their expansion and failure;

- Wedge failure along joints;
- Corrosion of soft chalk via salt laden sea spray ; and
- Cliff face failure via avalanching (chalk cliff slides).

It is important to note that due to the nature of cliff failures, cliff top retreat can occur episodically, with up to 5-10m of retreat at a time.

The wave-cut platform seaward of any seawalls would be expected to erode at a rate similar to that seen historicaly throughout this period. Overtopping of defences will increase, with the potential for more frequent breaching and flooding events. Where unprotected, the cliffs and wave-cut platform would be expected to retreat at their historical rate, becoming offset from the protected shoreline. Accretionary shorelines, such as Aldwick and Cuckmere are expected to continue accreting throughout this period. Sediment released by cliff erosion and wave-cut platform lowering would be available for local pocket beaches at the toe of the cliffs and for transport eastwards by longshore drift.

The intermittent supply of shingle to the shoreline from offshore areas would be expected to continue in a similar manner to present.

C.4.2.2 Epoch 20-50 years (to 2055)

Accelerated sea level rise and increased rainfall due to climate change will put increased pressure on the coastline throughout this period.

By this end of this period the majority of defences, with the exception to the more robust rock groynes and breakwaters, will have failed. Initially, along the defended sections of coast, promontories will begin to develop, causing the beaches at these locations to steepen and narrow and even be totally lost as they will be exposed to deeper water and greater wave heights. Once defences fail, the shingle beach barrier will roll back and shoreline will begin to move landward, exacerbated by a depleting sediment source and accelerated sea level rise. Along the low-lying stretches of coast, more frequent and severe overtopping and breaching will result in more wide-scale inundation and flooding of the hinterland. There could be breaching and reformation of existing entrances to tidal inlets. Such changes to the harbour entrances could alter the harbour currents and channels, causing erosion in some areas and accretion in others and the landward movement of spits under sea level rise. There is also potential for low-lying areas, such as Ferring Rife, to form new tidal inlets with unstable entrances, which would periodically interrupt longshore transport.

Along previously defended clifflines, the cliffs will become reactivated and initially erode at a much faster rate than the adjacent cliffs because they have historically artificially been held seaward. Even where unprotected, cliffs will erode at their base (due to marine erosion), and along the cliff top, (due to sub-aerial weathering processes), at a greater rate than present due to accelerated sea level rise and increased rainfall. Along most of the frontage, cliff erosion will not provide sufficient sediment to build beaches at the toe of the cliffs.

Areas that accreted during the previous epoch would generally be expected to stabilise or even exhibit erosion, due diminishing sediment supply and sea level rise.

C.4.2.3 Epoch 50-100 years (to 2105)

By the end of this period, the entire length of the shoreline will be undefended under this scenario. There will be shoreline retreat along the full frontage between Selsey Bill and Beachy Head, due to diminishing sediment supply and accelerated sea level rise. There will be greater connectivity along the coastline with redistribution of sediment alongshore from west to east; however, this supply will probably be insufficient to maintain the beaches along the length of this frontage.

Initially, in areas where defences have recently failed, shoreline retreat would be more rapid than in adjacent areas because the shoreline will be several metres seaward of the adjacent coastlines. As a more linear coastline is reached, erosion rates would slow after their initial rapid response to defence failure, but overall rates are expected to be greater than historic rates, due to accelerated sea level rise. There will also be local differences in rates along the length of the cliffed frontage, due to the geology, and small coves are likely to form, which may trap pockets of sediment. The general appearance of the cliffed coastline would be similar to that along the presently undefended sections.

Where shingle beaches front low-lying hinterland, overtopping and breaching of the shingle beach ridges and subsequent inundation of the hinterland is likely to occur more frequently due to accelerated sea level rise. At some locations, more permanent tidal inlets could form, where there is insufficient sediment to seal the breach. These would probably exhibit periodic breach and closure behaviour. At current harbour entrances, as a result of breakwater failure during this period, it is possible that spits will start to form, effectively sealing off these tidal inlets or resulting in a change of location of the tidal inlet.

C.4.3 SCENARIO ASSESSMENT TABLE

Note: Retreat distances given in this document are approximate only. They have been estimated from historical retreat rates with an allowance added in beach areas for the effects of climate change (a constant rate of sea level rise of 6mm/year for the next 100 years has been assumed based on current Defra guidance). The accuracy of these retreat values could be ±50%.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Selsey Bill to Church Norton	**The timber groynes and then the seawall would fail during this period.**	**No defences.**	**No defences.**
	The groynes and seawall would generally retain the shingle beach at its existing width and location until the structures failed. The beach would narrow and steepen as the groynes failed. Once the seawalls failed, the shoreline would retreat landward. The shoreline at Selsey is not expected to retreat significantly during this period, however, the coastline between Selsey East Beach and Church Norton could retreat by as much as 20m by 2025. Failure of defence structures at Selsey Bill would provide a small input of sediment to	Landward movement of the shoreline would be expected to continue due to sea level rise, with a net retreat in shoreline position of approximately 100m by 2055. Breaching of the shingle beach ridge and associated flooding of the hinterland may occur, due to the overall shortage of sediment on the frontage and sea level rise. With time and rising sea levels, the frequency of flooding by overtopping would increase.	Landward movement of the shoreline, driven by sea level rise, would continue. At Selsey Bill, this would probably occur at an increasing rate as the sheltering effects of Mixon Reef reduced due to increased sea levels and decreased relative height to sea surface. This shoreline retreat would continue to supply sediment to the coastal system for transport further eastwards. The shoreline would be expected to retreat some 170m by 2105.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	this frontage via longshore transport. In turn, failure of the defences between Selsey Bill and Church Norton would release beach sediment into the coastal system for transport further eastwards. Material from the hinterland would start to be eroded as the shoreline retreated, providing sediment input to the coastal system. Beach-sized sediments would be moved eastwards by longshore transport or remain temporarily in local beaches. Finer sediments would be transported offshore. Intermittent supply of shingle from offshore areas would be expected to continue in a similar manner to the present.		Flooding from overtopping and breaching would also continue to increase with sea level rise. It is possible, that the coastal barrier to the west of Selsey Bill (at Medmerry in Bracklesham Bay) could breach, potentially transforming Selsey Bill into an island. However, it is thought that any future evolution would also be dependent on the policy decisions of the East Solent Shoreline Management Plan and such a breach would be unlikely to have significant effects on wider shoreline evolution during the next 100 years.
Church Norton to Pagham Harbour	**The timber groynes along the western/southern spit would fail during this period. There is presently one active in training wall in the harbour mouth (the south west side is free to move). It is assumed that this training wall will fail**	**The rock and timber groynes along the eastern/northern spit would fail during this period.**	**No defences.**

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	towards the end of this period.		
	The southern spit would grow eastwards, with growth accelerating from about year 15 as more sediment from the coastline to the west is released into the system due to successive groyne failures. Growth of the southern spit would deflect the harbour entrance north-eastwards, which would result in erosion of the end of eastern/northern spit. The western/southern spit would be likely to narrow once the groynes fail, with the potential for the shoreline to roll back by approximately 10m by 2025. These changes would potentially interrupt longshore transport eastwards.	The harbour entrance would be expected to become more unstable, with growth and probable breaching (during extreme storm events) of the western/southern spit and possible closure of the existing harbour entrance. Such changes to the harbour entrance would alter the harbour currents and channels, causing erosion in some areas and accretion in others. The spits might also begin to move landward under the influence of sea level rise, despite the increased sediment supply from the west. Shoreline retreat of 70-80m could occur by 2055. The changes to the harbour entrance would be expected to interrupt longshore (eastwards) transport of sediment, with sediment being released in pulses.	The situation would generally continue as for the 20-50 year period with harbour entrance instability (periodic breaching, spit regrowth and entrance closure) and possible landward movement of the spits. Shoreline retreat of 120m by 2105 could occur. However, if a coastal breach from Bracklesham Bay connected with Pagham Harbour, this would increase the scale of effects at the entrance and within the harbour.
Pagham to Aldwick	***No defences.***	***No defences.***	***No defences.***

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The historical trend of accretion (beach growth) would be expected to continue in the short term. Between 2005 and 2025 the net shoreline movement would be expected to be up to 1-5m of foreshore accretion at Aldwick Bay Estate. However, changes at Pagham Harbour entrance have the potential to cause erosion and narrowing/steepening of the beach towards the end of this period.	Increasing sea level rise would cause shoreline retreat but this might be offset periodically by beach growth as pulses of sediment are supplied by longshore transport from further west. It is estimated that there will be little net change in shoreline position by 2055. Flooding from overtopping would be likely to occur more frequently at the eastern end due to sea level rise.	The shoreline would continue to erode landward due to sea level rise, with net retreat estimated at around 20m by 2105. This erosion would provide an input of sediment to the coastal system. Sea level rise would continue to increase the frequency of flooding from overtopping.
Aldwick to Middleton-on-Sea	**Renourishment at Felpham would cease. Timber groynes (along the entire frontage) would fail during this period. The concrete seawall (along the entire frontage) and the rock groynes would remain.**	**The concrete seawall (along the entire frontage) would fail from the beginning of this period. The rock groynes (Felpham) would fail towards the end of this period.**	**No defences.**
	Beaches adjacent to the timber groynes would be expected to narrow and steepen as the groynes failed. Beaches immediately west of the rock groynes would grow as the rock	Once the seawall failed, the shoreline would be expected to retreat landward, except the beaches immediately west of the Bognor Esplanade and Felpham rock groynes, which	Shoreline retreat would continue under the influence of sea level rise and the overall shortage of sediment on the frontage. Retreat is estimated at 80m by 2105. Further

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	groynes trapped sediment released by the failure of the timber groynes. The landward limits of the beaches would be fixed by the seawall.	would be left slightly seaward of the remainder of the coastline. When the rock groynes failed, these beaches would be expected to erode rapidly as a linear coastline reformed. There could be retreat of approximately 50m by 2055. As the shoreline retreated landward, the shingle beach ridge would be likely to breach at low-lying Aldingbourne Rife. This might result in the formation of a tidal inlet with an unstable entrance, which would periodically interrupt longshore transport and reduce the supply of sediment to eastern areas. Large scale and permanent flooding of the hinterland would also be expected to occur with the breaching and formation of such an inlet. Material from the hinterland would be eroded as the shoreline retreated, providing sediment input to the coastal system.	breaching of the shingle beach ridges and associated flooding of the hinterland could occur. In addition, flooding from overtopping would be likely to occur more frequently due to sea level rise. The erosion of material associated with shoreline retreat would continue to supply sediment to the coastal system.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Middleton-on-Sea	**The timber groynes and seawall would fail during this period.**	**No defences.**	**No defences.**
	The beach would narrow, steepen and begin to retreat landward as the groynes and seawall failed. Retreat of the shoreline is estimated at 0-20m by 2025 under these events. Material from the hinterland would start to be eroded as the shoreline retreated, providing sediment input to the coastal system. Beach-sized sediments would be moved eastwards by longshore transport or remain temporarily in local beaches. Finer sediments would be transported offshore.	The landward retreat of the shoreline and shingle beach ridge would be expected to continue, with a net retreat in shoreline position of approximately 40m by 2055. The small promontories at Sea Drive and Old Point roads would be eroded as part of this retreat as a more linear coastline developed. The erosion of material associated with shoreline retreat would continue to supply sediment to the coastal system.	The shoreline retreat and release of sediment would continue under the influence of sea level rise and the general shortfall of sediment on the south coast. It is estimated that the shoreline could have moved 60-70m landward by 2105.
Elmer (Breakwaters)	**Beach renourishment/ recycling would cease. The rock armour revetment between breakwaters 5 and 6 would fail by the mid to latter part of this period and the earth embankment behind would become**	**The offshore rock reefs would become damaged and redundant. The terminal groyne would fail at the end of this period.**	**Piecemeal backshore defences including stretches of concrete wall, timber breastwork and groynes, and older secondary rock armour revetment would become exposed and are expected to fail**

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	exposed. The detached rock breakwaters and terminal groyne would remain in position.		**during this period.**
	There would be little change to the present coastline, although there may be some loss of beach at the pinch point between the breakwaters leading to localised flooding. The exception to this would be the coastline between breakwaters 5 and 6. When the revetment failed, increasing wave attack on the earth embankment in this area might give rise to breach of the embankment and limited seafront flooding in an extreme storm event. The breakwaters and terminal groyne would continue, as at present, to interrupt longshore transport, affecting the shoreline further east.	The coastline would be as described for the 0-20 year period but with breach between breakwaters 5-6 becoming more likely and overtopping of the seawall more frequent due to sea level rise. The resultant flooding would also be more widespread. When the breakwaters and terminal groyne fail: • The beach would steepen and narrow but would not retreat landward until the seawall and breastwork failed. • The old seawall, groynes, breastwork, and revetment landward of them would be exposed to direct wave attack and would start to deteriorate. • The risk of breach of the defences and hinterland flooding would increase.	Once the remaining defences failed, the shoreline would begin to retreat and realign with the western and eastern coastlines. There could be retreat of up to 110m by 2105. The eastern section of this frontage is low and would develop into salt marsh.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
		• The frequency of flooding through seawall overtopping would increase. • Beach sediment would be released into the coastal system by beach narrowing and steepening.	
Poole Place to Littlehampton Harbour (River Arun)	**Annual shingle recycling at Climping from the west side of the harbour entrance westwards would cease. The seawalls, the timber groynes (west section of frontage) and the western harbour training wall would fail during this period.**	**No defences.**	**No defences.**
	The beach would be expected to narrow, steepen and move landwards once the timber groynes and seawalls failed. This would be likely to be a piecemeal process, as the structures would fail at different times on different sections of the frontage due to their age and condition. Retreat of 0-10m could occur by 2025. The shingle beach ridge might breach as it	Landward retreat of the shoreline (approximately 20m by 2055) would continue under the influence of sea level rise and the lack of sediment supplied to the frontage from the coastline to the west. There would be a greater probability of breach, overtopping and associated flooding of land behind the beach. The shoreline retreat would continue to supply sediment to the coastal system. It	The rate of landward retreat would be expected to slow and the frequency of breaching to reduce as the pulse of sediment released by the failure of the Elmer breakwaters and terminal groyne reached the frontage. By 2105, the shoreline could be some 30m landward of its current position. Regular flooding of the low-lying hinterland.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	moved landward, particularly at Atherington because of the lack of sediment input caused by the Elmer breakwaters and groyne. Rollback of the dunes west of Littlehampton Harbour entrance would be outpaced by the rate of shoreline retreat, which would accelerate at the end of the period with failure of the harbour training wall. Sediment released by the failure of the groynes, beach narrowing/steepening and landward retreat would be available for transport eastwards by longshore drift. Failure of the western harbour training wall at the end of this period would release a large quantity sediment into coastal system, probably resulting in the growth of a western spit/ bar/delta complex eastwards across the existing harbour entrance. Some sediment would also be transported by longshore drift further eastward past the entrance.	would be expected that much of this sediment would feed the continued growth of spit/bar/delta complex at the Littlehampton Harbour entrance. The spit/bar/delta complex would interrupt longshore transport to the east initially, but would then be expected to establish natural bypassing across the entrance. It would also deflect the harbour entrance to the east. The spit would be prone to breaching, with breakdown of the barrier and redistribution of that material which might result in closure of the existing harbour entrance.	The western spit/bar/delta complex would be expected to continue to grow, undergoing cycles of breaching and changes in entrance location.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Littlehampton to Angmering-on-Sea	**The timber groynes (along the entire frontage) would fail during this period. The sections of seawall would fail towards the end of this period. The rock groynes would remain in place.**	**The rock groynes would fail during this period.**	**No defences.**
	Except for the area immediately west of the Rustington rock groynes, the beaches would be expected to narrow and steepen as the timber groynes failed. Sections of the frontage that are not backed by a seawall would begin to retreat as the timber groynes failed, with the remaining frontage holding its position until the seawalls failed. Retreat of approximately 0-10m would be expected for this frontage by 2025. The Rustington rock groyne area, however, would be expected to retain its present position. Sediment released by the failure of the timber groynes, beach narrowing/steepening and shoreline retreat would be available for	There could be temporary growth of the beach in the Littlehampton area following the failure of the western harbour training wall around year 20. However, overall, the frontage would be expected to be subject to periods of erosion/retreat (corresponding to interruptions to drift at the harbour entrance) and stability (as pulses of sediment are moved across the entrance and eastward along the coast). When the Rustington rock groynes fail, rapid initial retreat of this area would be anticipated as the shoreline realigns. Realignment of the shoreline would be also expected to result in the erosion of the small promontory at the eastern end of the frontage (South Strand,	The shoreline retreat and release of sediment would continue under the influence of sea level rise and the general shortfall of sediment on the south coast. It is estimated that the shoreline could move 30m landward by 2105.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	transport eastwards by longshore drift.	East Preston). Retreat of 20m could occur by 2055. Sediment would continue to be released into the coastal system by shoreline retreat.	
Kingston/ Ferring	**The timber groynes (along the entire frontage) would fail during this period and the timber breastwork at Ferring Rife would fail by the end of this period.**	**No defences.**	**No defences.**
	The beaches would be expected to narrow and steepen as the groynes failed. By 2025, shoreline retreat is estimated to be around 20m. A more linear coastline would be expected to develop (i.e. the shoreline retreat would remove the existing offsets in shoreline position between different sections of beach). Material from the hinterland would start to be eroded as the shoreline retreated, supplying sediment to the coastal system.	The landward retreat of the shoreline would be expected to continue, with a retreat in shoreline position of 90m by 2055. If a tidal inlet formed at Ferring Rife, it would be likely to continue to exist throughout this period with periodic closure and breaching and interruption of longshore transport. Sediment would continue to be released into the coastal system by shoreline retreat.	The shoreline retreat and release of sediment would continue under the influence of sea level rise and the general shortfall of sediment on the south coast. It is estimated that the shoreline could move some 170m landward by 2105. A tidal inlet at Ferring Rife would be expected to form during this period, if it has not already done so.

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	Once the breastwork failed, the shoreline at Ferring Rife would be expected to retreat landwards at a faster rate. As the shoreline retreated landward, the shingle beach ridge would be likely to breach at Ferring Rife. This could result in the formation of a tidal inlet with an "unstable" entrance, prone to cycles of closure and breaching. When open, such an entrance would interrupt longshore transport and reduce the supply of sediment to eastern areas. Flooding of the low-lying hinterland would also be expected to occur with the breaching and formation of such an inlet.		
Goring-by-Sea to Worthing	**The timber groynes (west and east sections of frontage) would fail during this period. The rock groynes (centre of frontage) would remain in position.**	**The rock groynes would fail during this period.**	**No defences.**
	With exception to the area immediately west of the rock groynes, the beaches would be expected to narrow, steepen and retreat as	The frontage would continue to retreat, except in the areas immediately west of the rock groynes. Once the rock groynes failed,	The shoreline retreat and release of sediment would continue under the influence of sea level rise and the general shortfall of sediment

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	the timber groynes failed. Retreat of approximately 10m could be expected by 2025 and there would be flooding of low-lying grassed areas. The rock groyne area, however, would be expected to retain its present position. Sediment released by the failure of the timber groynes to the west would be trapped by the rock groynes, resulting in localised beach growth. Sediment released by the failure of the eastern timber groynes would be available for transport eastwards by longshore drift.	however, rapid initial retreat of this area would be anticipated as the shoreline realigns. Retreat of 70m could occur by 2055. Sediment would continue to be released into the coastal system by shoreline retreat. Failure of the rock groynes would temporarily increase the supply of sediment to the coastal system.	on the south coast. It is estimated that the shoreline could move 110m landward by 2105.
Worthing	**The timber groynes would fail during this period. The seawall sections would fail by the end of this period. The rock revetment (Ham Rd) would remain.**	**The rock revetment would fail during this period.**	**No defences.**
	Beaches would be expected to narrow and steepen as the groynes failed. Once the seawalls failed, the shoreline would be expected to retreat landward, except at Ham Rd and Splash Point, where the rock	The frontage would continue to retreat, except at the Ham Rd revetment. Once the revetment failed, however, rapid initial retreat of this area would be anticipated as the shoreline realigns. Retreat of 25-30m could	The shoreline retreat and release of sediment would continue under the influence of sea level rise and the general shortfall of sediment on the south coast. It is estimated that the

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	revetment would hold the present shoreline position. Retreat of up to 0-20m is expected by 2025. Sediment released by the failure of the timber groynes, beach narrowing/steepening and shoreline retreat would be available for transport eastwards by longshore drift.	occur by 2055. Sediment would continue to be released into the coastal system by shoreline retreat.	shoreline would move 40m landward by 2105.
Brooklands Park to Lancing	**The timber breastwork and groynes would fail during this period. The rock groynes (east of Brooklands Park) would remain in place.**	**The rock groyne would fail towards the end of this period.**	**No defences.**
	The beaches along most of the frontage would narrow and steepen as the timber groynes failed. Once the breastwork failed, these parts of the shoreline would be expected to retreat landward by some 20m by 2025. However, between Western Rd and Elm	The landward retreat of the shoreline would be expected to continue, except in the rock groyne area, with the shoreline retreating approximately 40m by 2055. As the shoreline retreated landward, the beach would be likely to breach at Brooklands Park. This could result in the formation of a	The shoreline retreat and release of sediment would continue under the influence of sea level rise and the general shortfall of sediment on the south coast. The pulse of sediment released by the failure of the rock groynes could temporarily slow retreat to the east of the frontage. It is estimated that the shoreline could move 80m landward by 2105. The Brooklands Park tidal inlet would be expected

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	Grove (east of Brooklands Park), the beaches would be expected to retain their present form and position due to the stabilising effect of the rock groynes. By the end of this period, this section of the frontage could therefore become a promontory, lying seaward of the remainder of the frontage. Sediment released by the failure of the timber groynes, beach narrowing/steepening and shoreline retreat would be available for transport eastwards by longshore drift. The rock groynes would trap sediment released by groyne failure, beach changes and shoreline retreat further west.	temporary tidal inlet with an "unstable" entrance, prone to cycles of closure and breaching. When open, such an entrance would interrupt longshore transport and reduce the supply of sediment to eastern areas. Flooding of the low-lying hinterland would also be expected to occur with the breaching and formation of such an inlet. Once the rock groynes failed, the beach in this area would rapidly narrow, steepen, and begin to retreat, releasing a pulse of sediment into the coastal system.	to continue its periodic breach and closure behaviour.
Lancing to Shoreham Harbour Entrance (River Adur)	**Artificial sediment bypassing across the harbour entrance would cease. The timber breastwork and groynes would fail during this period. The rock groynes (centre of frontage) and the western breakwater at Shoreham Harbour would remain. There**	**The rock groynes would fail towards the end of this period. The western breakwater would remain.**	**The western breakwater would fail during this period.**

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	are no defences at Shoreham Beach.		
	The western section of the frontage (Lancing) and the beach immediately east of the rock groynes (West Shoreham Beach) would narrow, steepen and begin to retreat as the timber groynes and breastwork failed. Shoreline retreat of around 5-10m could occur in these areas by 2025. Breaching and overtopping of the shingle beach ridge at Widewater Lagoon would be likely to accompany this shoreline retreat. Continued overtopping and breaching would result in flooding of the hinterland and a tidal inlet could develop at the lagoon. The rock groynes would generally hold the beaches in the centre of the frontage in their existing position. The beach at eastern end of the frontage, adjacent to the western harbour breakwater, would be likely to grow with the cessation of bypassing.	Shoreline retreat at Lancing and West Shoreham Beach would continue with some 30m of retreat by 2055. The beach at the rock groynes would probably become a promontory and the eastern end of Shoreham Beach would continue to widen. An irregular coastline, quite different from the present linear beach, could develop. There would be a possibility that a new harbour entrance could form in the West Shoreham Beach area if the spit was breached and Shoreham spit could become an island. The probability of this occurring would be expected to increase once the rock groynes failed. Flooding, particularly of adjacent areas of reclaimed land, would be associated with the breach. A new harbour entrance would probably have a rapidly changing bar/delta complex early in	In general terms, the shoreline would continue to retreat along the entire frontage, except at East Shoreham Beach, where the westen harbour breakwater would hold the shoreline. Once the breakwater failed, however, East Shoreham Beach would be expected to erode rapidly and a large amount of sediment would be released into the coastal system. Shoreham spit would narrow and could be washed over by waves in large storms. Towards the end of this period, it might become reconnected to the mainland at its northern side. The shape of the shoreline would depend greatly on whether a tidal inlet at Widewater Lagoon and/or a new harbour entrance formed. In global terms, however, shoreline retreat of up to 40m could occur by 2105.

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	Much of the sediment released from the western section of the frontage by groyne failure and shoreline retreat would be carried eastwards by longshore transport and trapped by the rock groynes. Development of a tidal inlet at Widewater Lagoon would result in interruptions to longshore transport and a reduction in sediment supply to the eastern frontage.	its existence and could divert harbour flows, causing the existing entrance to close. Such changes to the harbour entrance would alter the harbour currents, resulting in erosion in the western harbour and silting-up of the eastern harbour. A new harbour entrance would interrupt longshore transport, slowing or halting the growth of East Shoreham Beach.	
Shoreham Harbour (Southwick) to Aldrington	**Sediment bypassing across the harbour entrance would cease. The concrete seebee revetment and splash wall at the harbour entrance, the steel sheet piled wall at Basin Road, the concrete seawall at Portslade on Sea, the rubble defences at Aldrington and the timber groynes would all fail during this period. The rock groynes (west end of frontage), east pier and eastern breakwater would remain. The lock gates at Shoreham port do not act as a coastal defence.**	**The rock groynes are expected to fail at the beginning of this period. The east pier and breakwater would fail during the second half of this period.**	**No defences.**

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The supply of sediment to this frontage would decrease as bypassing ceased. The spending beach between the eastern pier and breakwater would steepen but its location would remain fixed by the structures around it. The small bay-shaped beaches would be expected to narrow and steepen at their western ends, possibly disappearing completely, until the revetment/ wall structures behind the beach failed. Once the revetment/wall structures failed, the shoreline would start to retreat at the western ends of these beaches. The eastern ends of these beaches would be expected to be held in place by the rock groynes, producing small beaches with a north west – south east orientation.	Sediment supply from further west along the coast would continue to be poor, particularly if a second harbour entrance formed. The western end of the small beaches would erode rapidly at the beginning of this period as the rock groynes failed and the series of small, angled beaches would begin to realign into a linear, continuous beach. The shoreline would retreat by some 25-30m by 2055. There would be a risk of breach and increasing overtopping of the shingle beach ridge through this period, possible breaking into the harbour at Aldrington Basin and the lagoon. Once the eastern pier and breakwater failed, the behaviour of the spit would depend on whether a new harbour entrance has formed, *viz*: • If a new entrance has formed, the existing	The shoreline would be expected to continue to retreat landward, with increased probability of breach and overtopping into the harbour and lagoon due to sea level rise. Retreat of 40m is estimated by 2105. In addition, shortening of the spit would be expected to continue if a new harbour entrance did not develop. When the western harbour breakwater failed, the sediment released would be likely to cause shallowing or closure of the existing harbour entrance. Eventually, most of this sediment would be moved further eastward by longshore transport, temporarily slowing the retreat of the spit.

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		channel would be expected to become shallower and the spending beach would probably remain. • If no new entrance developed, it would be expected that the western end of the spit would begin to retreat eastwards and the spending beach would be eroded (i.e. the spit would shorten). This would widen the entrance of the harbour, exposing the inner harbour to more wave energy and therefore increased inner harbour erosion.	
West Hove to Brighton Marina	**Shingle recharge would cease. The timber groynes and concrete groynes (along the western and central frontage) would fail early in this period. The concrete seawall (along the western and central frontage) would remain.** **At Brighton Marina, the breakwaters, sheet-piled walls, concrete walls and artificial shingle beach would fail towards the end of this period.**	**The seawall (along the western and central frontage) would fail during this period.** **Following, failure of the breakwaters, sheet-piled wall, concrete walls and the artificial shingle beach at Brighton Marina, the original concrete seawall that protects the cliffs behind the marina would fail.**	**No defences.**

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	The beach along the frontage would steepen and narrow along most of its length, with this process accelerating once the groynes failed. The beach would also be expected to start to realign as a continuous, linear beach once the groynes failed. Retreat of 0-20m could occur by 2025. Sediment released by the failure of the groynes and beach narrowing/steepening would be available for transport eastwards by longshore drift. Most of this sediment would be trapped on the beach adjacent to Brighton Marina, which would continue to widen until the end of this period. Although the marina breakwaters would fail before year 20, the marina reclamation would continue to trap sediment and retain this beach. The marina reclamation itself, however, would start to erode once the breakwaters, walls and artificial beach failed. The chalk cliffs behind Brighton Marina would	Until the seawall failed, the beach along the frontage would continue to steepen and narrow. Once the defences surrounding the marina and the original seawall failed, the shoreline would begin to move landward. Generally, this retreat would be significantly slower on the eastern part of the frontage than the western part because of the higher ground in the east. By 2055, the shoreline could have retreated by 25-30m. The western beaches would be likely to be wider and flatter than the eastern beaches located beneath the cliffs, which could narrow to the point where they disappear completely. The beach immediately adjacent to the marina might remain until mid-way through this period, depending on the rate of breakdown of the marina structures. The beach would narrow and possibly disappear once the marina debris no longer provided an effective barrier to longshore transport.	West of the chalk cliffs at Brighton Marina, retreat of the shoreline would continue, driven by sea level rise and the shortage of sediment on the south coast. Retreat of 40m could occur by 2105. At Brighton Marina, a new wave-cut platform would begin to form as the cliffs eroded landward. Small pockets of sediment from cliff erosion would be trapped in coves along the foot of the cliff. The rate of cliff erosion would slow as this platform and the pockets of sediment developed. Clifftop erosion of approximately 40m could occur by 2105. Sediment released by the failure of the Shoreham Harbour western breakwater and carried east by longshore transport would slow shoreline retreat temporarily during this period but would not have a long term effect.

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	not be expected to retreat significantly during this period.	Debris from the marina would provide some protection to the foot of the cliffs, slowing cliff erosion. Once this debris was removed, cliff erosion in the marina area could be rapid as the cliff would be exposed to direct wave attack. The cliffs could retreat by some 20m by 2055, due to marine erosion, although it is expected that sub-aerial weathering processes would also be responsible for cliff top erosion. Cliff erosion and beach retreat/narrowing would release some sediment into the system for longshore transport eastwards.	
Brighton Marina to Saltdean	**Beach recharge at Rottingdean and Saltdean would cease. The concrete and rock groynes (Rottingdean and Saltdean Park), rock armour revetment (Saltdean) and seawall (along the entire frontage) would remain.**	**The seawall would fail at the beginning of this period apart from areas at Rottingdean, Saltdean Park and Saltdean East, which would fail from approximately year 35 onwards. It is also expected that and the rock armour revetment (Saltdean) and some of the concrete and rock groynes (Rottingdean and Saltdean Park)**	**The remaining groynes at Rottingdean and Saltdean Park would fail during this period.**

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
		would fail during this period.	
	The cliffs would protected from marine erosion at the cliff toe, although the wave-cut platform seaward of the seawall would continue its historical trend of lowering. Cliff top retreat, however, is expected to continue in response to sub-aerial weathering processes, giving some 0-20m of retreat by 2025. The existing beaches would steepen and narrow. Beaches presently protected by concrete and rock groynes would narrow rapidly once these groynes failed and would probably be completely lost. This beach narrowing/steepening/groyne failure would release sediment into the coastal system for transport eastwards. Adjacent to the concrete and rock groynes, the beaches would narrow more slowly as the remaining groynes trapped the sediment	Along most of the frontage, the cliffs would begin to retreat from the start of this period as the seawall and groynes failed. As a result, the cliffs at Rottingdean, Saltdean Park and Saltdean East would probably become offset (seaward) from the rest of the frontage. Cliff erosion would commence at these latter locations once their seawalls failed in the second half of this period. Cliff top retreat, due to sub-aerial weathering processes would continue and potentially increase due to a higher rate of rainfall resulting from climate change. Around 10m of retreat could take place by 2055. The cliff erosion would provide sediment for local beaches and for transport eastwards along the coast. As the cliffs eroded, the wave-cut platform at their foot would widen, but it would also lower due to sea level rise. Early in this period, pockets of sediment	The cliffs would continue to erode, with the wave-cut platform widening as the cliffs retreated inland. Clifftop erosion of 40m could be possible by 2105, resulting from sub-aerial weathering processes, the rate of which could increase due t higher rainfall brought about by climate change. Pockets of sediment would be trapped within the small coves formed in the cliffs. Once the groynes at Rottingdean and Saltdean Park failed, the cliffs in these areas might erode faster than the surrounding areas as the coastline realigned itself.

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	released from groyne failures/beach narrowing to their east. These beaches would benefit from the sediment released towards the end of this period when the western breakwater of the marina failed. However, it is possible that these beaches could be completely lost, as they would no longer be renourished.	would be expected to remain adjacent to groynes. As the groynes failed through this period, this sediment would be released into the coastal system and transported eastwards. The remaining groynes at Rottingdean and Saltdean Park might continue to trap sediment released from cliffs and beaches east of them, slowing the erosion of the cliff behind them. These areas of cliff might remain offset seaward of the rest of the frontage as a result. Pockets of sediment would then be expected to build up on the eastern sides of these areas. At the end of this period, the coastline would appear similar to the existing coastline at Telscombe cliffs, with small coves containing pockets of sediment forming in the cliffs.	
Telscombe Cliffs	**It is assumed that the concrete seawall and groynes protecting Portobello Outfall would remain.**	**It is assumed that the concrete seawall and groynes protecting the Portobello Outfall would fail during this period.**	**No defences.**

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	The unprotected cliffs would continue to erode and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. Clifftop retreat of 0-10m is estimated by 2025, except in the protected outfall area. This area would not be expected to retreat significantly and might form a small promontory, trapping sediment on its western side. Sediment released by the cliff erosion and wave-cut platform lowering would be available for transport eastwards by longshore drift and for local pocket beaches.	Sea level rise would increase the rate of cliff erosion along the entire frontage. The wave-cut platform would widen as the cliff retreated inland, but would be subject to platform lowering. 15-20m of clifftop retreat could occur by 2055, which may increase further as greater rainfall occurs with climate change. The cliffs at the outfall might erode more rapidly than the surrounding cliffs once their protection failed, as the coast realigned itself Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves. The sediment held by the Portobello Outfall groynes, which extends for some two hundred metres westward of the outfall, would be released into the system as the groynes fail. The beach in this area would rapidly narrow and steepen. It would be likely to break down	Cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise. The clifftop could retreat 25-30m by 2105. The coastline position would be expected to erode parallel to its present alignment. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves.

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		into pockets of sediment trapped in the coves as the beach retreated faster under sea level rise than the cliffs behind it.	
Peacehaven	**The concrete groynes would fail during this period. The concrete seawall would remain along the full length of the frontage.**	**Central and eastern sections of the concrete seawall would fail at the beginning of this period. The remaining concrete wall would fail during the second half of this period.**	**No defences.**
	The wave-cut platform seaward of the seawall would continue its historical trend of lowering. The cliffs would be protected at their base by the seawall, although the cliff top would be expected to retreat at its historical rate, which by 2025 is anticipated to be in the order of 0-10m. The existing beaches would steepen and narrow, and then would probably be lost as the groynes failed. This beach narrowing and steepening and the groyne failure would release sediment into the coastal system for	Along the central and eastern parts of the frontage, the cliffs would begin to retreat from the start of this period as the seawall failed. As a result, the western cliffs would probably become offset (seaward) from the rest of the frontage during the first half of this period. Cliff erosion would commence at these latter locations once their seawalls failed in the second half of this period. The western cliffs might initially erode more rapidly as the coastline realigned itself parallel to its present alignment.	The cliffs would continue to erode, with the wave-cut platform widening as the cliffs retreated inland, parallel to their present alignment. Clifftop erosion of 20-30m could be possible by 2105, and may increase further as rainfall increases with climate change and/or episodic events occur. Pockets of sediment would be trapped within the small coves formed in the cliffs.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	transport eastwards.	The rate of cliff erosion would be expected to increase over this period as sea levels rise and rainfall increases with climate change. Clifftop retreat of 10-20m could take place by 2055. The wave-cut platform at the foot of the cliffs would widen, but it would also lower due to sea level rise. The cliff erosion would provide sediment for local beaches and for transport eastwards along the coast. At the end of this period, the coastline would probably appear similar to the existing coastline at Telscombe cliffs, with small coves containing pockets of sediment forming in the cliffs.	
Peacehaven Heights to Newhaven Harbour	**No defences to the west of the frontage. Harbour entrance dredging would continue for the purpose of navigation. Newhaven Harbour west pier and breakwater (eastern end of the frontage) would remain.**	**The Newhaven Harbour west pier and breakwater would fail at the beginning of this period. Harbour entrance dredging would continue for the purpose of navigation.**	**No defences. Harbour entrance dredging would continue for the purpose of navigation as long as the port continues to be active.**

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The unprotected western cliffs would continue to erode and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. Clifftop retreat of 10m could occur by 2025 for these western cliffs. The eastern cliffs, protected by the harbour works and the beach that has built up against the breakwater, would be expected to remain as at present. Sediment released by the cliff erosion and wave-cut platform lowering would be available for local pocket beaches and transport eastwards by longshore drift, where the harbour breakwater would trap it. The harbour entrance would become shallower.	In general along the frontage, sea level rise would increase the rate of cliff erosion. The wave-cut platform would widen as the cliff retreated inland, and would be subject to platform lowering. The western clifftop could retreat by 25-30m by 2055, due to both marine erosion and sub-aerial weathering processes. The beach west of the breakwater would narrow and steepen from the beginning of this period, when the harbour works failed. As a result, the eastern cliffs would become exposed to wave attack, probably around the middle of this period, and would begin to erode. The wave-cut platform at the base of the cliffs would be exposed and would widen as the cliffs retreated inland. The different geology of these eastern cliffs (chalk lower cliff with an upper cliff of softer sands and clays) means that initial erosion might be more rapid than for the pure chalk cliffs	Cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise and higher rainfall. The coastline position would be expected to erode parallel to its present alignment, with some 50m of retreat by 2105. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves at the foot of the cliffs. The spit would be expected to remain at the harbour entrance, and might have periods of instability (closure and breaching). Longshore transport eastwards across the new harbour entrance would be expected to be episodic, with pulses of sediment supplied to the eastern side of the entrance.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
		further to the west. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported to the eastern end of the frontage by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves at the foot of the cliffs. With the failure of the western breakwater and pier, and the release of the sediment trapped by these structures, a small spit would be likely to develop westwards across the present harbour entrance. The harbour/river entrance would be expected to be deflected eastwards by this spit.	
Newhaven Harbour to Seaford	**Beach recharge for recycling would cease. The seawall, timber breastwork and concrete block armouring would fail during this period. The east pier at Newhaven Harbour and the eastern**	**The east pier at Newhaven Harbour and the sheet piled groyne (eastern end of frontage) would fail at the beginning of this period. It is assumed that the outfall would fail during this period. The eastern**	**No defences.**

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	groynes and outfall would remain.	**terminal groyne would fail towards the end of this period.**	
	The beach would narrow and steepen along most of its length. Once the seawall, breastwork and armouring failed, the beach would be expected to stop narrowing and steepening and begin to move landward. This would be expected to be more pronounced in the central section of the beach than the western and eastern ends of the beach, which would be protected by the east pier and the outfall/groyne. Retreat of some 0-20m could occur by 2025. The land presently behind the beach would be exposed to coastal erosion as the shingle ridge retreated landward. The fine sediments eroded would be carried by longshore drift and currents and ultimately deposited in tidal inlets and offshore areas. Beach-sized material that was eroded would be used for local beach building and carried eastward by	In general terms, erosion and retreat of the beach might temporarily slow at the start of this period, as a pulse of sediment is released by the failure of the harbour piers and breakwater. However, at the western end of the frontage, adjacent to the harbour entrance, there would probably be a rapid retreat of the beach as the protecting east pier failed. The eastern end of the beach would also narrow and steepen when the outfall/groyne failed but the terminal groyne would be expected to prevent retreat of the beach until the end of this period. Beach erosion and retreat would be expected to occur episodically rather than in a continuous manner, corresponding to storm events and flood-related changes at the harbour entrance/spit. Shoreline retreat of 2-	The beach would continue to retreat landward in response to sea level rise. The coastline might realign to form a deeper embayment between the rocky headlands at Newhaven and Seaford. Shoreline retreat of approximately 50-70m could occur by 2105.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	longshore transport.	40m could take place by 2055.	
Seaford Head	**The gabions at Hope Gap would fail in the first half of this period.**	**No defences.**	**No defences.**
	The unprotected cliffs would continue to erode due to both marine erosion and sub-aerial weathering processes, and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. The gabions at Hope Gap would temporarily delay cliff erosion until their failure. Clifftop retreat of 10m could take place by 2025. Sediment released by the cliff erosion and wave-cut platform lowering would be available for local pocket beaches and transport eastwards by longshore drift.	Sea level rise and increased rainfall, due to climate change, would increase the rate of cliff erosion along the entire frontage. The wave-cut platform would widen as the cliff retreated inland, but would be subject to platform lowering. The clifftop could retreat by 20m by 2055. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves.	Cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise and higher rates of rainfall resulting from sea level rise. Pockets of sediment would be expected to remain in the coves in the cliffs, similar to some parts of the present frontage. The coastline position would be expected to erode parallel to its present alignment. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves. 30m of clifftop retreat could occur by 2105.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Cuckmere Haven	**Recycling of sediment from the river entrance would cease. The concrete revetment and timber groynes (west side of entrance) would fail in the first half of this period. The concrete seawall (west side of entrance) is expected to fail towards the end of this period. It is assumed that the training walls would also fail towards the end of this period.**	**No defences.**	**No defences.**
	The coastline would be expected to remain similar to its present configuration until the revetment and groynes failed. There would be likely to be narrowing, steepening and possibly slow landward retreat of the beach once the groynes failed. The cliffs at the western end of the frontage would begin to erode once the revetment fails. The wave-cut platform would widen as the cliffs retreated landward.	Eastward growth of the spit would be expected to continue but the entrance would be likely to be unstable and might close completely. Sediments from upriver and from the present tidal delta would tend to move towards the entrance, blocking it. The entrance might reopen during floods or with storm breach of the shingle beach, but would be unlikely to reopen in the same location each time. Sea level rise would cause the shingle beaches to narrow, steepen and retreat	The entrance regime established in the previous period would be expected to continue (i.e. entrance closure and occasional reopening). Landward movement of the beach and west cliffs would also be expected to continue as sea level continued to rise. Clifftop retreat of 30m by 2105 could occur.

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The tidal inlet entrance and eastern beach would be expected to remain as at present until the training walls and seawall failed. The spit would be expected to continue to grow eastwards once the training walls failed, deflecting the river entrance east. The low cliffs protected by the seawall would begin to retreat once the seawall fails. As with the cliffs to their west, the wave-cut platform at would widen as the cliffs retreat landward. On average, the clifftop of the frontage could retreat by 5-10m by 2025.	landward. The land presently behind the beach would be exposed to coastal erosion as the shingle ridge retreated landward. The fine sediments eroded would be carried by longshore currents and ultimately deposited in tidal inlets and offshore areas. Beach-sized material that was eroded would provide a natural source of sediment for local beach building and carried eastward by longshore transport. The low cliffs immediately west of the beach would continue to erode landwards, with a widening wave-cut platform being formed at their base. Clifftop retreat of 20m by 2055 could occur.	
Cuckmere Haven to Beachy Head	**No defences**	**No defences**	**No defences**

	SCENARIO REF: BASELINE SCENARIO 1 – NO ACTIVE INTERVENTION		
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The unprotected cliffs would continue to erode and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. Clifftop retreat of 10m (10-20m at Birling Gap) could take place by 2025. Sediment released by the cliff erosion and wave-cut platform lowering would be available for local pocket beaches and transport eastwards by longshore drift.	Sea level rise and higher rates of rainfall, due to the sea level rise, would increase the rate of cliff erosion along the entire frontage. The wave-cut platform would widen as the cliff retreated inland, but would be subject to platform lowering. The clifftop could retreat by 25-30m (30-40m at Birling Gap) by 2055. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves.	Cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise and increased amounts of rainfall brought about by climate change. Pockets of sediment would be expected to remain in the coves in the cliffs, similar to some parts of the present frontage. The coastline position would be expected to erode parallel to its present alignment. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves. 35-40m (40-50m at Birling Gap) of clifftop retreat could occur by 2105.

C.5 SCENARIO REF: BASELINE CASE 2 – WITH PRESENT MANAGEMENT

C.5.1 INTRODUCTION

This summary report provides an analysis of shoreline response assuming the scenario of "With Present Management". This scenario has considered that all existing defence practices are continued accepting that in some cases this will require considerable improvement to present defences in order to maintain their integrity and effectiveness.

C.5.2 SUMMARY

The following text provides a summary of the analysis of shoreline response, with details specific to each location and epoch contained within the Scenario Assessment Table. In addition to this, maps illustrating the position of the shoreline under a WPM scenario are located in Annex C2.

C.5.2.1 Epoch 0-20 years (to 2025)

For most of the Selsey Bill to Beachy Head coastline changes during this period will be subtle and generally consistent with historical rates.

Existing linear structures will help to hold the current shoreline position. As the coastal system continues respond to climate change and sea level rise, intertidal zone will be squeezed where defences prevent the natural landward movement of the shoreline and nearshore areas deepen. This will result in narrower and steeper beaches and continued wave-cut platform erosion. At locations where sediment renourishment takes place (e.g. through recycling) the current input should be sufficient to maintain beaches. Along undefended stretches of coast there will be shoreline retreat, which may result in shallow embayments beginning to form between the defended stretches. Where defended, cliff retreat will continue to take place via cliff top erosion, resulting from sub-aerial weathering processes, including:

- Percolation of rain water through joints in the cliffs. Subsequent freeze thaw within joints leads to their expansion and failure;
- Wedge failure along joints;
- Corrosion of soft chalk via salt laden sea spray; and
- Cliff face failure via avalanching (chalk cliff slides).

It is important to note that, due to the nature of cliff failures, cliff top retreat can occur episodically, with up to 5-10m of retreat at a time. Where cliffs are undefended, marine erosion at the cliff toe will take place. Together, marine and sub-aerial processes cause erosion, and provide some sediment input, but this will not be sufficient along most of the coast to build beaches at the toe of the cliffs.

Accreting shorelines, such as Aldwick and Cuckmere, are expected to continue accreting throughout this period, although this may slow down due to the pressure of continued sea level rise.

C.5.2.2 Epoch 20-50 years (to 2055)

During the period 20 to 50 years there will be increased pressure on the shoreline due to accelerated sea level rise and diminishing sediment supply and coastal changes will become more pronounced.

Beaches backed by linear structures, including seawalls, revetments and breastwork, will generally be lost during this period due to deeper water and greater wave exposure at the seawalls, although the structures would hold the shoreline position. Even in areas where renourishment takes place, the present volumes of input would be insufficient to maintain beaches in their present state. This means that, along much of the coast, groynes will start to become redundant during this period.

Retreat of beaches not backed by these structures would continue, supplying sediment to the coastal system. Where beaches front low-lying areas, there would be increased potential for breaching and inundation of the hinterland.

Cliffs not protected by seawalls and revetments would continue to erode, probably at increased rates due to sea level rise. Cliffs protected by seawalls would be protected from marine erosion at the base, however, they will be subject to continued cliff top erosion due to sub-aerial weathering processes. Sub-aerial erosion is expected to increase during this and the next epoch, as the predicted increase in rainfall resulting from climate change enhances the sub-aerial weathering processes and, with that, cliff failure. This will result in the formation of promontories lying seaward of adjacent unprotected cliffs. Any beaches in front of these protected cliffs will disappear during this period.

Cliff retreat would supply some sediment to the coastal system but, overall, sediment supply would be expected to reduce and would not significantly build beaches at the toe of the cliffs. The promontories formed along the coast may also start to inhibit sediment transfer between areas.

C.5.2.3 Epoch 50-100 years (to 2105)

The situation described for the 20-50 year epoch would continue to develop with retreat of unprotected shorelines at accelerated rates due to sea level rise and the fixing of the shoreline by defences, resulting in the formation of promontories and embayments. Cliff top erosion will continue along lengths of defended coastline at a rate that is determined by the amount of sub-aerial activity, which itself is determined by weathering forcing factors such as the amount of rainfall.

Where there are shingle barrier beaches, these will become more difficult to maintain in position through present management methods due to the increased water levels and wave energy at the shoreline. Consequently, it is likely that these will experience much more frequent overtopping and breaching, with flooding of low-lying areas behind.

Linear defences, including seawalls, harbour training walls, revetments and breastwork, would require an increased commitment to maintenance and could need to be upgraded to withstand sea level rise, increased wave attack (due to beach loss), undermining (due to wave-cut platform lowering and beach loss) and outflanking (as unprotected shorelines retreat adjacent to isolated sections of defence).

The natural movement of sand and shingle will have been seriously interrupted and it is unlikely that along the defended stretches there will be any beaches due to the exposure conditions. It will become impossible to hold any beaches in front of these defences due to the increase in water depth and wave height, with the consequence that most of the shingle on the present beaches may be lost offshore and from the beaches permanently, rather than transported alongshore to other frontages. The overall picture would be one of a concrete coastline with no beaches, interspersed with areas of eroding shoreline and minor beaches.

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Selsey Bill to Church Norton	**The concrete seawalls, fronted by groynes would remain.**		**The continuous length of seawall at the south-west would remain. The sections of seawall to the north-east could become redundant. The groynes would be redundant.**
	The landward limit of the beach along most of this frontage would be fixed by the seawalls, while the seaward section of the beach would start to erode landwards in response to sea level rise. As a result, the beach would be 'squeezed' between the fixed landward limit and the retreating seaward boundary and cut off from a supply of sediment from the land. The beach would therefore begin to narrow and steepen and beach levels would begin to lower. At the north-easternmost end of the frontage, where the sections of seawall are not continuous, the beach would narrow and steepen and the shoreline would begin to retreat landward. Where undefended, retreat of 0-20m might occur by 2025, resulting in	Along most of this frontage, the beach would continue to narrow, steepen and lower as sea level rise continued. It would be expected that, by the end of this period, the beach would be lost and the shoreline would lie at the foot of the seawalls. The groynes would therefore become redundant at the end of this period. At the northern end of this frontage, outflanking could become an issue, requiring extension of the sections of seawall. Landward retreat of the shoreline would continue at the sections of beach not backed by seawalls, with some 100-200m of retreat potentially taking place by 2055. As the beach narrowed and sea level rise continued, the shingle beach ridges could breach, flooding areas behind the beach. In addition,	Upgrading and an increased commitment to maintenance of the seawalls would be required in order to maintain their integrity, as they would be exposed to more wave attack (due to the loss of the beach and sea level rise) and outflanking. If the seawalls were not upgraded for the more exposed conditions and outflanking to the north, then their failure could result in flooding of the hinterland of east Selsey Bill. To the northeast, it could prove technically infeasible to continue to maintain the sections of seawall. These areas would then be expected to erode rapidly, with the shoreline retreating landwards to realign with the adjacent embayments.

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	embayments between the defended beach sections. Groynes in these embayments would become redundant and would need to be rebuilt in landward positions in order to continue to function and hold the beach. The beach erosion and shoreline retreat would release sediment into the coastal system at a similar rate to that released presently. This sediment would be moved eastwards by longshore transport or remain temporarily on local beaches.	flooding from overtopping would be likely to occur more frequently due to sea level rise. The embayments on the north-eastern coastline would become more pronounced. There would be an ongoing requirement for removal and reconstruction of the groynes, as they were rendered redundant by shoreline retreat. The beach loss and shoreline retreat would continue to release limited sediment into the coastal system. The seawalls would prevent release of material from the land behind the structures, eventually resulting in a greatly reduced sediment supply to the east.	The undefended, north-eastern section of the frontage, could retreat some 190-200m by 2105. Flooding of areas behind the beaches due to breach of the shingle beach ridges and overtopping would be expected to increase in frequency and extent. Sediment transport from Selsey Bill to the east would be reduced and minimal.
Church Norton to Pagham Harbour	**Rock and timber groynes on the western/southern spit and the eastern/northern spit would remain. There is presently one active in training wall in the harbour mouth (the south western side is free to move). It is assumed that this training wall will fail towards the end of this period. This training wall at Pagham Harbour entrance would remain. Annual recycling of sediment to maintain south westen spit.**		**The groynes would become redundant. The training wall might become redundant. Annual recycling of sediment would continue.**
	There would not be expected to be significant changes to the existing situation during this	The training wall and recycling would be expected to continue to maintain the harbour	Sea level rise and the lack of sediment supply from the west would be expected to

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	period. The entrance to Pagham Harbour would be held in its present position by the training wall. The groynes on the spits would continue to trap material transported from the south-west. Recycling of material from the harbour entrance would continue to sustain the beach on the western/southern spit. However, the beaches would continue to retreat and rollback at a rate similar to the historical rate.	entrance in its present condition and location. The groynes on both spits would also continue to trap sediment from the south-west, although this supply would diminish towards the end of the period. Sea level rise would begin to have a significant effect during this period with the spit beaches steepening, narrowing and retreating landward. The groynes would slow this process on the beaches immediately to their west. It is anticipated that recycling would not be sufficient to address shoreline retreat. Rollback could occur due to the reduction in sediment supply from further west and sea level rise. This frontage would be expected to continue to lie landward of the Selsey Bill frontage, to its south-west. The shoreline retreat would provide an increased supply of sediment to the coastal system for transport further east along the coast.	result in: • Rollback of the spit beaches, which would cause the spits to narrow. Rollback of more than 120m could occur by 2105. This retreat would continue to provide a sediment supply to the coastal system. • Redundancy of the groynes as the beaches retreated. The groynes would need to be reconstructed in retreated positions in order to continue to function. Potential changes, which have a medium to high level of uncertainty are: • Potential breach of the spits, particularly the western/southern spit, as supply of sediment to the frontage reduced. This could result in the formation of a new harbour entrance and closure of or significant sedimentation in the existing harbour entrance. A new harbour entrance would interrupt longshore transport to the east.

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
			• If the spit does not breach, then the distal ends of the spits (the 'unattached' ends at the harbour entrance) could erode, widening the harbour entrance. Extension of the training wall would become necessary in order for the entrance to continue to operate effectively. • Changes to channels and banks within the harbour as a result of changes to the harbour entrance.
Pagham to Aldwick	**No defences.**		
	With limited sea level rise and a continuation of sediment supply from the west, this frontage would be expected to continue its historical trend of beach-building for the next 20 years. Up to 5m of foreshore accretion could occur. The volumes of sediment moving from this frontage to areas further east would be similar to present.	Where the rate of sediment supply is greater than the rate of sea level rise, the beach may widen slightly. However, over this period, the beach would be expected to stabilise as the increasing effects of sea level rise balance the increased supply of sediment from the west. The supply of sediment from this frontage to areas further east would be similar to present. Flooding from overtopping would be likely to occur more frequently due	The beach would narrow, steepen and would begin to retreat landward as sea level continued to rise. Net retreat of around 20m could occur by 2105. Sea level rise would continue to increase the frequency of overtopping and breaching of the beach ridge could occur as the shoreline retreated. Material from behind the existing beach would start to be eroded as the shoreline

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
		to sea level rise.	retreated, providing sediment input to the coastal system. Beach-sized sediments would be moved eastwards by longshore transport or remain temporarily on local beaches. Finer sediments would be transported offshore or deposited in the tidal inlets along the coast.
Aldwick to Middleton-on-Sea	**The seawall (along the entire frontage), rock groynes (Felpham and Bognor) and timber groynes (along the entire frontage) would remain. Renourishment at Felpham would continue.**		**The seawall (along the entire frontage) and rock groynes at Felpham would remain. The rock groynes at Bognor Esplanade and timber groynes (along the entire frontage) would be redundant. Renourishment at Felpham would cease.**
	The landward limit of the beach would be fixed by the seawall. The beach would begin to narrow and steepen and beach levels would begin to lower (except at Felpham) but, overall, the beach would not appear significantly different from the present. The groynes would slow the rate of narrowing/lowering of the beach.	The beach would continue to narrow, steepen and lower as sea level rise continued, except, possibly, at Felpham. Present renourishment at Felpham would be insufficient to maintain its present width and height. It would be expected that, by the end of this period, the beach (except at Felpham) would be lost and the shoreline would be held at the foot of the seawall. The groynes	The seawall would continue to hold the position of the shoreline. Upgrading and an increased commitment to maintenance of the seawall would be required in order to maintain its integrity, as it would be exposed to more wave attack and outflanking to the west and east of this frontage. In the absence of renourishment, the beach at Felpham would continue to reduce and eventually

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The beach erosion would release sediment into the coastal system at a similar rate to that released presently. This sediment would be moved eastwards by longshore transport and remain temporarily on local beaches.	(except at Felpham) would therefore become redundant at the end of this period. The beach loss and erosion of renourishment material would continue to release limited sediment into the coastal system. However, the seawall would prevent release of material from the land behind the structures, eventually resulting in a greatly reduced sediment supply to the east.	become lost by the end of this period and the seawall would become more exposed. If the seawalls were not upgraded for the more exposed conditions and outflanking, then their failure could result in flooding of the hinterland. Sediment supply from the frontage to the east would be significantly less than at present.
Middleton-on-Sea	**The seawall and timber groynes would remain.**		**The groynes would be redundant. Most of the seawall would remain. However, it could become technically impossible to maintain the seawall at some locations.**
	The beach would begin to narrow and steepen and beach levels would begin to lower during this period, due to sea level rise. Overall, however, the beach would not appear significantly different to its present state. The groynes would slow the rate of	The beach would continue to narrow, steepen and lower with ongoing sea level rise. It would be expected that, by the end of this period, the beach would be lost and the shoreline would lie at the foot of the seawall. The groynes would therefore become	The seawall would continue to hold the position of the shoreline if it was upgraded and maintained to withstand increased wave attack and sea level rise. At Middleton Point, however, it would be

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	narrowing/lowering of the beach. The narrowing and steepening of the beach would supply sediment to the coastal system at a similar rate to the present. Much of this sediment would be moved eastwards by longshore transport, with some remaining temporarily on local beaches.	redundant at the end of this period. At Middleton Point (Old Point Rd), the length of seawall/breastwork that presently has no beach seaward of it would require significant commitment to maintain its integrity. The beach erosion would continue to release limited sediment into the coastal system. However, the seawalls would prevent release of material from the land behind the structures, eventually resulting in a greatly reduced sediment supply to the east.	expected that it would become infeasible to maintain the seawall. Construction of a retired line defence along this part of the frontage would therefore be likely to be required during this period, with the shoreline allowed to retreat landward to the retired line. Material from behind the existing shoreline would start to be eroded as the shoreline retreated, providing a small amount of sediment input to the coastal system.
Elmer (Breakwaters)	**The detached rock breakwaters, rock armour revetment (between breakwaters 5 and 6), terminal groyne and assorted backshore defences (seawall, breastwork, revetment, groynes) would remain. Beach renourishment/recycling would continue.**		
	The detached breakwaters, terminal groyne and renourishment/ recycling would maintain the present shoreline position. The breakwaters and groyne would continue, as at present, to interrupt longshore transport,	The primary defence structures and practices (detached breakwaters, terminal groyne and renourishment/ recycling) would continue to maintain the present shoreline position. Increased renourishment would be required to sustain the beaches at their present width	The primary defence structures and practices would require upgrading and increased maintenance in order to function effectively but would then maintain the present shoreline position. Measures would need to be taken to

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	affecting the coast further east.	and height as the supply of sediment from the west reduced and sea level rose. Measures would need to be taken to prevent outflanking to the east. The defence structures on this frontage would continue to interrupt longshore transport eastwards.	prevent outflanking to the east. The breakwaters and terminal groyne would continue to interrupt longshore transport eastwards.
Poole Place to Littlehampton Harbour (River Arun)	**The seawalls, timber groynes (west section of frontage) and western harbour training wall would remain. Recycling at Climping from the west side of the harbour entrance would continue.**		**Some timber groynes and western harbour training wall would remain. The seawalls could become redundant. Recycling at Climping from the west side of the harbour entrance would continue.**
	The beach at Climping would not be expected to change during this period, because recycling would be expected to be sufficient to offset the effects of sea level rise in the short term. In areas backed by seawalls, the beach would begin to narrow and steepen and	The beach at Climping (subject to increased recycling) and the eastern beach adjacent to the harbour training wall would be expected to maintain their present condition. Where present, the seawalls would fix the landward limit of the beach. The beach in these areas would continue to narrow,	The beach at Climping and the eastern beach adjacent to the harbour training wall would be expected to begin to steepen and narrow, as sediment supply/recycling would be unlikely to be able to sustain both areas against sea level rise. Upgrading and an increased commitment to

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	beach levels would begin to lower during this period, due to sea level rise. For most of the frontage, these changes would be small and the beach would not appear significantly different to its present state. However, at Poole Place, immediately east of the Elmer breakwaters, the beach would not receive a supply of sediment from the west and could be lost completely by the end of this period. In areas without seawalls, the beach would narrow and steepen and the shoreline would begin to retreat landward, although this would not be at a detrimental rate to the shoreline. These retreated sections of the frontage would form embayments between the areas with seawalls. The beach erosion and shoreline retreat would release sediment into the coastal system at a similar rate to the present. This sediment would be moved eastwards by longshore transport and become trapped by the western harbour training wall, as	steepen and lower with ongoing sea level rise. It would be expected that, by the end of this period, these beaches would be lost and the shoreline would lie at the foot of the seawalls. The groynes in these areas would therefore become redundant at the end of this period. Landward retreat of the shoreline would continue at the sections of beach not backed by seawalls, with some 20m of retreat potentially taking place by 2055. The embayments would become more pronounced. There would be an ongoing requirement for removal and reconstruction of the groynes in the embayments, as they were rendered redundant by shoreline retreat. As the beaches retreated and sea level rise continued, the shingle beach ridges could breach, flooding areas behind the beach. Flooding from overtopping would be likely to	maintenance of the seawalls and the harbour training wall would be required in order to maintain their integrity against wave attack and outflanking. It could prove technically infeasible to continue to maintain the seawalls. These areas would then be expected to erode rapidly, with the shoreline retreating landwards to realign with the adjacent retreated shoreline. Breaching and overtopping, with associated flooding, could occur. Landward retreat of the shoreline would continue on the sections of beach not backed by seawalls, with some 30m of retreat potentially taking place by 2105. Reconstruction of the groynes in retreated areas would be necessary as the shoreline retreat rendered them redundant. The extent and frequency of flooding due to breaching of shingle beach ridges and overtopping would increase. The shoreline retreat would continue to

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	presently occurs.	occur more frequently due to sea level rise. The beach loss and shoreline retreat would continue to release sediment into the coastal system, which would be trapped by the harbour training wall. The seawalls would prevent release of material from the land behind the structures, reducing the sediment supply to the east during this period.	release sediment into the coastal system. This sediment would continue to be trapped by the western harbour training wall.
Littlehampton to Angmering-on-Sea	**The timber groynes (along the entire frontage), the rock groynes (Rustington) and the sections of seawall would remain.**		**Some timber groynes and the rock groynes would remain. The sections of seawall could become redundant.**
	In areas backed by seawalls, the beach would begin to narrow and steepen and beach levels would begin to lower during this period, due to sea level rise. The groynes would slow the rate of narrowing/lowering of the beach. These changes would be small and the beach would not appear significantly different to its present state.	Where present, the seawalls would fix the landward limit of the beach. The beach in these areas would continue to narrow, steepen and lower with ongoing sea level rise. It would be expected that, by the end of this period, these beaches would be lost and the shoreline would lie at the foot of the seawalls. The groynes in these areas would therefore become redundant at the end of	Upgrading and an increased commitment to maintenance of the seawalls would be required in order to maintain their integrity against wave attack and outflanking. It could prove technically infeasible to continue to maintain the seawalls. These areas would then be expected to erode rapidly, with the shoreline retreating landwards to realign with the adjacent retreated shoreline. Breaching

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	In areas without seawalls, the beach would narrow and steepen and the shoreline would begin to retreat landward. These retreated sections of the frontage would begin to form embayments between the areas with seawalls. The beach erosion and shoreline retreat would release sediment into the coastal system at a similar rate to the present. This sediment would be moved eastwards by longshore transport.	this period. Landward retreat of the shoreline would continue at the sections of beach not backed by seawalls, with some 20m of retreat potentially taking place by 2055. The embayments would become more pronounced. There would be an ongoing requirement for removal and reconstruction of the groynes in the embayments, as they were rendered redundant by shoreline retreat. As the beach retreated and sea level rise continued, the shingle beach ridges could breach, flooding areas behind the beach. Flooding from overtopping would be likely to occur more frequently due to sea level rise. The beach loss and shoreline retreat would continue to release sediment into the coastal system. The seawalls would prevent release of material from the land behind the structures, reducing sediment supply to the	and overtopping, with associated flooding, could occur. Construction of a retired line defence may be required to prevent large scale flooding of the hinterland. Landward retreat of the shoreline would continue at the sections of beach not backed by seawalls, with some 30m of retreat potentially taking place by 2105. Progressive rebuilding of groynes in the retreated areas would be required, as the groynes became redundant. As sea level rise continued, the shingle beach ridges could breach, flooding areas behind the beach. In addition, flooding from overtopping would be likely to occur more frequently due to sea level rise. The shoreline retreat would continue to release sediment into the coastal system.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
		east during this period.	
Kingston/ Ferring	**The timber breastwork (Ferring Rife) and timber groynes (along the entire frontage) would remain.**		**The timber groynes would remain along most of the frontage but would be redundant at Ferring Rife. The timber breastwork (Ferring Rife) could become redundant.**
	At Ferring Rife, where timber breastwork protects the land behind the beach from erosion and flooding, the beach would begin to narrow and steepen and beach levels would begin to lower during this period, due to sea level rise. There would also be increased flooding. These changes would be small and the beach would not appear significantly different to its present state. This section of the frontage, would, however, begin to form a small promontory. The promontory would be expected to form as the shoreline on the remainder of the frontage retreated. This retreat would be associated with beach narrowing and steepening.	The breastwork at Ferring Rife would continue to fix the landward limit of the beach, but would require an increasing commitment to maintenance and upgrading to avoid outflanking. The beach here would continue to narrow, steepen and lower with ongoing sea level rise. The beach could be lost by the end of this period (i.e. the shoreline could lie at the toe of the breastwork). If this occurred, the groynes at Ferring Rife would become redundant. The Ferring Rife promontory would become more pronounced as the surrounding shoreline continued to retreat. Some 50m of	It would be expected that it would become infeasible to upgrade and maintain the Ferring Rife breastwork to withstand the increased wave attack, outflanking and sea level rise. Construction of a retired line defence at Ferring Rife would therefore be likely to be required during this period, with the shoreline allowed to retreat landward. The Ferring Rife promontory would be eroded as the shoreline returned to a linear form through this period. Landward retreat of the shoreline would continue on the remainder of the frontage, with some 110m of retreat potentially taking

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	Retreat of 20m could occur by 2025. The beach erosion and shoreline retreat would release sediment into the coastal system at a similar rate to that released presently. This sediment would be moved eastwards by longshore transport.	retreat could take place by 2055 (except at Ferring Rife). In these retreating areas, there would be an ongoing requirement for removal and reconstruction of the groynes, as they are rendered redundant by shoreline retreat. The beach loss and shoreline retreat would continue to release sediment into the coastal system. The breastwork would prevent release of material from the land behind the structures, slightly reducing the sediment supply to the east. As the shoreline retreated and sea level rise continued, the shingle beach ridges could breach, possibly flooding areas behind the beach. In addition, flooding from overtopping would be likely to occur more frequently due to sea level rise.	place by 2105. As sea level rise continued, the shingle beach ridges would be more likely to breach, flooding areas behind the beach. In addition, flooding from overtopping would be likely to occur more frequently due to sea level rise. The shoreline retreat would continue to release sediment into the coastal system.
Goring-by-Sea to Worthing	**The timber groynes (west and east sections of frontage) and the rock groynes (centre of frontage) would remain.**		

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The beach would narrow and steepen as sea levels rise, and the shoreline would begin to migrate landwards. Retreat of 10m could occur by 2025. Material from behind the existing beach would start to be eroded as the shoreline retreated, providing sediment input to the coastal system.	Beach retreat would continue, driven by sea level rise. By 2055, the shoreline could have retreated by 70m. Increased water depths, foreshore retreat and increased wave exposure due to sea level rise would reduce the ability of the groynes to retain sediment and render them redundant by the end of this period. The groynes would need to be reconstructed in retreated positions in order to continue to function effectively. As the shoreline retreated and sea level rise continued, the shingle beach ridges could breach, flooding areas behind the beach. In addition, flooding from overtopping would be likely to occur more frequently due to sea level rise.	There would be ongoing shoreline retreat during this period, with some 110m of retreat by 2105. Progressive reconstruction of groynes would be necessary. The shoreline retreat would provide a supply of sediment to the local beaches and for longshore transport to the east.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Worthing to Shoreham Harbour (River Adur)	**The timber groynes, rock groynes, sections of seawall at Splash Point, Merton Road and Ham Road (Worthing) and older defences behind, including rock revetment (Ham Rd), timber breastwork and western harbour breakwater would remain. Renourishment at Lancing and bypassing across the harbour entrance would continue.**		**Some of the groynes would become redundant. The sections of seawall, revetment and breastwork could become redundant. The western harbour breakwater would remain. Renourishment at Lancing and bypassing across the harbour entrance would continue.**
	Beaches backed by seawalls/breastwork/ revetment would narrow, steepen and lower, exposing the older defences behind. Beaches not backed by seawalls/breastwork/ revetment would narrow and steepen slightly. Less retreat would occur in areas with groynes. The retreated sections of the frontage would begin to form embayments between the defended areas. At Lancing, renourishment would maintain the beach in its present condition. Shoreham Beach, west of the western harbour breakwater, would also be expected to maintain its present condition due to the balance achieved by the effective trapping of	Shoreline retreat at beaches without seawalls/ breastwork/ revetment would continue. A maximum of 30m of retreat would be expected to occur by 2055. The embayments would therefore become more pronounced. There would be an ongoing requirement for removal and reconstruction of the groynes in the embayments, as they are rendered redundant by shoreline retreat. Where present, the seawalls/breastwork/ revetment would fix the landward limit of the beaches. Beaches in these areas would continue to narrow, steepen and lower with ongoing sea level rise. It would be expected that, by the end of this period, these beaches	Upgrading and an increased commitment to maintenance of the seawalls/breastwork/ revetment would be required in order to maintain their integrity against increased wave attack and outflanking. It could prove technically infeasible to continue to maintain the structures. These areas would then be expected to erode rapidly, with the shoreline retreating landwards to realign with the adjacent retreated shoreline. Breaching and overtopping, with associated flooding, could occur. The retreated areas of the shoreline would continue to move landward. An estimated maximum of 40m of retreat could occur by

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	sediment by the breakwater and the bypassing. The beach narrowing/steepening, shoreline retreat and erosion of renourishment sediment at Lancing would provide a supply of sediment to the coastal system. This sediment would be carried eastwards by longshore transport and trapped on Shoreham Beach by the harbour breakwater. Bypassing would provide an important feed of sediment eastwards across the harbour entrance.	would be lost and the shoreline would lie at the foot of the seawalls/breastwork/ revetment. The groynes in these areas would therefore become redundant at the end of this period. Flooding from overtopping would be likely to occur more frequently due to sea level rise. As beaches narrowed and sea level rise continued, the shingle beach ridges could breach in low-lying areas such as Brooklands Park and Widewater Lagoon, flooding areas behind the beaches. This could result in the formation of tidal inlet(s) with unstable entrance(s), prone to cycles of closure and breaching. When open, such entrances would interrupt longshore transport and reduce the supply of sediment to eastern areas. Under the 'with present management' scenario, formation of a new harbour entrance is considered unlikely. It is anticipated that any breach that threatened to create a connection with Shoreham Harbour would be repaired rapidly and addressed	2105. Flooding of areas behind the beaches due to breach of the shingle beach ridges and overtopping would be expected to increase in frequency and extent. Small tidal inlets could form in low-lying areas (Brooklands Park, Widewater Lagoon), if they had not already done so. An increased commitment to beach management (renourishment and bypassing) would be required to sustain Lancing/west Shoreham and Shoreham beaches. Shoreline retreat would continue to provide sediment to the coastal system. The harbour breakwater would continue to trap most of this sediment. Longshore transport would also be interrupted by any tidal inlets that formed. Bypassing across the harbour entrance would remain an important means of sustaining longshore transport eastwards.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
		through extension of the existing Shoreham to Lancing beach renourishment and groyne construction scheme. Lancing and Shoreham beaches would be expected to remain stable, with careful management. Increased renourishment would be required at Lancing and might need to be extended to the groynes at Shoreham West to maintain the beach's stability against the effects of rising sea level. Increased extraction from Shoreham East beach would be required in order to balance beach growth. Shoreline retreat would continue to provide sediment to the coastal system, most of which would be trapped at the harbour breakwater or interrupted by tidal inlets (if these formed). Bypassing across the harbour entrance would remain an important means of sustaining longshore transport eastwards.	

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Location	**Predicted Change for**		
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Shoreham Harbour to Brighton Marina	**The following structures would remain: the east pier and eastern harbour breakwater, concrete seabee revetment, splash wall (all at the harbour entrance), the steel sheet-piled wall at Basin Rd, the concrete seawall at Portslade on Sea, the rubble defences at Aldrington, the timber groynes, the rock groynes, the concrete groynes, the West Hove to Brighton seawall and the Brighton Marina structures (breakwaters, sheet-piled walls, artificial shingle beach). Sediment bypassing across the harbour entrance and renourishment (West Hove to Brighton) would continue.**		**As for the previous period, except that the timber groynes and rock groynes backed by seawall/revetment would be redundant.**
	Most of the frontage is backed by seawall or revetment. These structures would fix the landward limit of the beaches while the beaches would begin to narrow, steepen and lower. The short sections of beach without seawall or revetment would steepen and narrow and the shoreline would retreat landward by around 0-5m by 2025. These retreated sections of the frontage would begin to form embayments between the areas with seawalls/ revetment. At Basin Rd and West Hove to Brighton, bypassing and renourishment would maintain the beach in its present condition. Immediately west of Brighton Marina, the	The seawalls/ revetment would continue to fix the landward limit of the beaches. Beaches in these areas would continue to narrow, steepen and lower with ongoing sea level rise. It would be expected that, by the end of this period, these beaches would be lost and the shoreline would lie at the foot of the seawalls/ revetment. The groynes in these areas would therefore become redundant at the end of this period. Flooding from overtopping would be likely to occur more frequently due to sea level rise. Shoreline retreat at beaches without seawalls/ revetment would continue. Approximately 10m of retreat would be	Upgrading and an increased commitment to maintenance of the seawalls/ revetment would be required in order to maintain their integrity against increased wave attack and outflanking. The shoreline could retreat by 40m by 2105 within the small embayments (areas not backed by seawalls/ revetment). Flooding of areas behind the beaches due to overtopping would be expected to increase in frequency and extent. An increased commitment to beach management (renourishment and bypassing)

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	beach would be expected to widen. The coastal cliffs at the eastern end of this frontage would be protected from wave attack by the marina. They would therefore not be expected to retreat significantly. The beach narrowing/steepening, shoreline retreat and erosion of renourishment sediment would provide a supply of sediment to the coastal system. This sediment would be carried eastwards by longshore transport and trapped on east Brighton Beach by the marina breakwater.	expected to occur by 2055. The embayments would therefore become more pronounced. There would be an ongoing requirement for removal and reconstruction of the groynes in the embayments, as they were rendered redundant by shoreline retreat. Increased renourishment would be required between West Hove and Brighton to maintain the existing beach condition. Similarly, bypassing to Basin Rd might need to be supplemented by renourishment from offshore sources to maintain this beach. The beach immediately west of Brighton Marina would continue to widen. The cliffs at Brighton Marina would continue to be protected by the marina. No significant retreat would be expected to occur during this period. Through beach narrowing/steepening, the small amount of shoreline retreat and erosion of renourishment sediment would continue to	would be required to maintain the Basin Rd and West Hove to Brighton beaches. The beach immediately west of Brighton Marina would continue to widen. The cliffs at Brighton Marina would continue to be protected by the marina and no significant retreat would be expected to occur during this period. However, upgrading of the marina structures (breakwaters, artificial beach, quays, etc.) would be likely to be required in order to accommodate sea level rise. The small amount of shoreline retreat and erosion of renourishment material would continue to provide sediment to the coastal system. The marina breakwater would continue to trap most of this sediment.

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		provide sediment to the coastal system, most of which would be trapped at the marina breakwater as it moved eastwards.	
Brighton Marina to Saltdean	**The timber/blockwork groynes, concrete and rock groynes, rock revetment and seawall would remain.**	**The groynes would be redundant. The rock revetment and seawall would remain.**	
	The existing beaches would begin to steepen, narrow and lower while the shoreline position would be held by the seawall/revetment. The cliff top, protected by the seawall, would not be expected to retreat significantly by 2005, although it will be subject to sub-aerial weathering processes and therefore be at risk from episodic failure. The eroding beaches would provide limited sediment input into the coastal system. This material would progressively be moved eastwards by longshore transport, with some being temporarily trapped by groynes.	The seawall/ revetment would continue to hold the position of the shoreline, by preventing erosion of the cliff base. Any cut back would be limited provided that the seawall was upgraded and maintained as required. Retreat of the cliff top (via cliff failure, slumping and cliff falls), however, is inevitable due to sub-aerial weathering processes. The beaches would continue to narrow, steepen and lower with ongoing sea level rise. It would be expected that, during this period, these beaches would be lost and the shoreline would lie at the foot of the seawall/	The seawall/revetment, assuming that it is upgraded and maintained, would continue to hold the shoreline position and protect the cliffs from wave attack. Any cut back would also be limited provided that the seawall was upgraded and maintained as required. Further upgrading of the groynes at Rottingdean and Saltdean would also be necessary to maintain the beaches and help prevent erosion of the cliff toe. Cliff top retreat will continue to take place due to sub-aerial weathering and erosion, although the rate at which this will take place is

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		revetment. The groynes in these areas would therefore become redundant. Along the entire frontage, the wave-cut platform seaward of the seawall/revetment would lower, exposing the seawall/revetment to increased wave attack and potentially threatening the structures' foundations. Upgrading and increased maintenance would be necessary to preserve the integrity and function of the seawall/revetment. As the beaches were lost during this period, the limited sediment supply to the frontage would reduce further. By the end of the period sediment derived from wave-cut platform lowering would provide the only source of sediment.	unpredictable. Renourishment of the western frontage could be used to reduce the maintenance and upgrading requirement by providing protection to the seawall/revetment. The groynes along the western frontage would therefore become functional again. Sediment supply would remain limited to that provided by erosion of renourishment material and wave-cut platform lowering.
Telscombe Cliffs	**It is assumed that the concrete seawall and groynes protecting Portobello outfall would remain. Otherwise, there are no defences.**		
	The unprotected cliffs would continue to erode at the toe and the wave-cut platforms	Sea level rise and increased rainfall, due to climate change, would increase the rate of	Cliff erosion and widening and lowering of the wave-cut platform would be expected to

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	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	would continue to lower at a rate similar to that which has taken place in the past. Cliff top retreat of 0-10m would be expected by 2025, as a result of sub-aerial weathering processes, except in the protected outfall area. This area would not be expected to retreat significantly and might form a small promontory, trapping sediment on its western side. Sediment released by the cliff erosion and wave-cut platform lowering would be available for transport eastwards by longshore drift and for local pocket beaches.	cliff erosion along the frontage, via erosion of the toe and sub-aerial weathering processes. The wave-cut platform would widen and lower as the cliff retreated landward. 20m of cliff top retreat could occur by 2055, except at Portobello outfall, where it would not be expected to experience significant erosion. Increased cliff erosion would provide a slightly greater supply of sediment to the coastal system.	continue, possibly at a faster rate due to sea level rise and increased rainfall. Cliff erosion and wave-cut platform lowering would provide a slightly greater supply of sediment to the coastal system. Pockets of sediment would be expected to remain in the coves in the cliffs, similar to some parts of the present frontage, and west of the Portobello outfall promontory. The coastline would be expected to retreat landward parallel to its present alignment, except at Portobello outfall. The cliff top could retreat 25-30m by 2105.
Peacehaven	**The concrete groynes and concrete seawall would remain.**		
	The existing beaches would begin to steepen, narrow and lower while the landward limit of these beaches was fixed by the seawall. The cliff toe, protected by the seawall, would not be expected to retreat significantly by 2005, although sub-aerial	The seawall would continue to protect the cliff toe from marine erosion, whilst fixing the landward limit of the beaches. While cliff top erosion via sub-aerial weathering is inevitable, any cut back would be limited provided that the seawall was upgraded and	Upgrading and an increased commitment to maintenance of the seawall would be required in order to maintain its integrity against increased wave attack and undermining.

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	processes would be expected to continue. The eroding beaches would provide limited sediment input into the coastal system, supplementing that supplied from Telscombe Cliffs. This material would progressively be moved eastwards by longshore transport, with some being temporarily trapped by groynes.	maintained as required. The beaches would continue to narrow, steepen and lower with ongoing sea level rise. It would be expected that, during this period, these beaches would be lost and the shoreline would lie at the foot of the seawall. The groynes in these areas would therefore become redundant. Along the entire frontage, the wave-cut platform seaward of the seawall would lower, exposing the seawall to increased wave attack and potentially threatening the structure's foundations. Upgrading and increased maintenance would be necessary to preserve the integrity and function of the seawall. Sediment supply to the frontage would reduce, as beaches are lost during this period.	The seawall, assuming that it is upgraded and maintained, would continue to hold the shoreline position and protect the cliff toe from wave attack. It is expected, however, that cliff top retreat will continue due to sub-aerial weathering and erosion. Any cut back would be limited provided that the seawall was upgraded and maintained as required. Sediment supply would remain limited to that provided by wave-cut platform lowering and from Telscombe Cliffs.

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Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
Peacehaven Heights to Newhaven Harbour	**No defences to the west of the frontage. Newhaven Harbour west pier and breakwater (eastern end of the frontage) would remain. Harbour entrance dredging would continue.**		
	The unprotected western cliffs would continue to erode and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. Cliff top retreat of 10m could occur by 2025 for these western cliffs. The eastern cliffs, protected by the harbour works and the beach that has built up against the breakwater, would be expected to remain as at present. The harbour entrance would not be expected to alter from its present condition and location. Sediment released by the cliff erosion and wave-cut platform lowering would be available for local pocket beaches and transport eastwards by longshore drift, where	Sea level rise would increase the rate of cliff erosion along the frontage. The wave-cut platform would widen and lower as the cliff retreated landward. 25-30m of cliff top retreat on the western cliffs could occur by 2055. Increased cliff erosion would provide a slightly greater supply of sediment to the coastal system. The harbour pier and breakwater would continue to trap sediment. However, sea level rise could partly offset this, with the beach at the eastern end of the frontage beginning to narrow and steepen during this period. The eastern beach would be expected to continue to protect some of the eastern cliffs from direct wave attack. The Drive/Court Farm Rd area could retreat by 30m, but no significant erosion of the	On the western cliffs, cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise. Cliff erosion and wave-cut platform lowering would provide a slightly greater supply of sediment to the coastal system. Pockets of sediment would be expected to remain in the coves in the cliffs, similar to some parts of the present frontage. The coastline would be expected to retreat landward parallel to its present alignment. The western cliff top could retreat 50m by 2105. The harbour pier and breakwater would be expected to require upgrading and greater maintenance with sea level rise. Provided that this was undertaken, the structures would continue to hold the position of the

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	the harbour breakwater would trap it. Harbour entrance dredging (and renourishment of Seaford Beach, refer to next frontage) would transport sediment eastward past the breakwater.	easternmost cliffs would be expected to occur. Harbour entrance dredging would continue to provide an important supply of sediment to areas east of the frontage.	harbour entrance and trap sediment on the beach at the eastern end of this frontage. This beach would continue to narrow, however, in response to sea level rise, exposing more of the eastern cliffs to wave attack. It would therefore be expected that, by 2105, The Drive/Court Farm Rd cliff top could retreat by 50m, while the easternmost section of cliff would experience less erosion. Harbour entrance dredging would continue to provide an important supply of sediment to areas east of the frontage.
Newhaven Harbour to Seaford	**The seawall, timber breastwork, concrete block armouring, east harbour pier and the eastern groynes and outfall would remain. Renourishment of Seaford Beach would continue.**		
	Most of the frontage is backed by seawall/ breastwork/ armouring. These structures would fix the landward limit of the beach. Renourishment (using sediment dredged from the harbour entrance) would maintain	Increased renourishment would be required in order to maintain the beach's condition. Without such renourishment, the beach would steepen, narrow and lower, particularly in the central section of the frontage. The	The harbour pier, groynes and outfall would be expected to require upgrading and greater maintenance with sea level rise. Provided that this was undertaken, the structures would continue to trap sediment at the ends

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	the beach in its present condition. The frontage would continue to act as a closed sediment cell. Erosion of the renourishment material would provide limited sediment input into the coastal system. This material would be moved eastwards by longshore transport and trapped by the eastern groynes and outfall. Some material would also be moved westwards, back towards the harbour entrance, where it would be trapped by the harbour pier.	landward limit of the beach would continue to be fixed by the sea defence structures. Sediment would continue to be trapped at the western and eastern ends of the beach by the pier, groyne and outfall structures.	of the frontage. Recycling of this material to the centre of the frontage could be used to supplement renourishment, as the renourishment requirements increased.
Seaford Head	**The gabions at Hope Gap would remain. There are no other defences.**		
	The unprotected cliffs would continue to erode and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. Cliff top retreat of 10m could take place by 2025. The gabions at Hope Gap would protect the cliff behind them from wave attack, although	Sea level rise would increase the rate of cliff erosion along the entire frontage. The wave-cut platform would widen as the cliff retreated inland, but would be subject to platform lowering. The cliff top could retreat by 15-20m by 2055. Hope Gap, protected by the gabions, would	Increased maintenance and upgrading of the gabions would be required if these were to continue to protect the cliffs immediately landward of them. This is unlikely to be technically justifiable for such a short section of coastline. It is expected that the gabions would be allowed to become redundant, with the Hope Gap promontory retreating

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	they will require maintenance/replacement as they reach the end of their life. No significant cliff top retreat would be expected in this area, which could begin to form a small promontory. Sediment released by the cliff erosion and wave-cut platform lowering would be available for local pocket beaches and transport eastwards by longshore drift.	be expected to form a small promontory, trapping sediment on its western side to form a pocket beach. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves.	landwards to realign with the adjacent retreated cliff top. Cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise. 30m of cliff top retreat could occur by 2105. Pockets of sediment would be expected to remain in the coves in the cliffs, similar to parts of the present frontage. The coastline position would be expected to erode parallel to its present alignment. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves.
Cuckmere Haven	**The concrete revetment, timber groynes and concrete seawall (west side of entrance) would remain. The harbour entrance training walls would remain. Sediment recycling from the harbour entrance would continue.**		

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	The condition and location of the harbour entrance, low cliffs and beaches would be expected to remain similar to their present state. Sediment supplied from the Seaford cliffs and recycled from the harbour entrance would maintain the beaches. This sediment would also be available for longshore transport eastwards.	Careful beach management would be necessary to maintain the beaches and clear the harbour entrance. Without this, the beaches would be expected to begin to narrow, steepen and retreat landwards, and the harbour entrance could be deflected eastwards by development of a spit.	An increased commitment to beach management and maintenance/upgrading of the revetment, seawall groynes and training walls would be required due to increasing sea levels. Provided that this was forthcoming, the location and condition of the frontage would remain stable. Sediment from the beaches on the frontage would continue to be available for transport eastwards.
Cuckmere to Beachy Head	**No defences.**		
	The unprotected cliffs would continue to erode and the wave-cut platforms would continue to lower at a rate similar to that which has taken place in the past. Cliff top retreat of 10m (10-20m at Birling Gap) could take place by 2025. Sediment released by the cliff erosion and wave-cut platform lowering would be available for local pocket beaches and	Sea level rise would increase the rate of cliff erosion along the entire frontage. The wave-cut platform would widen as the cliff retreated inland, but would also be subject to platform lowering. The cliff top could retreat by 25-30m (30-40m at Birling Gap) by 2055. Sediment released by the cliff erosion and wave-cut platform lowering would mainly be transported eastwards by longshore drift, but	Cliff erosion and widening and lowering of the wave-cut platform would be expected to continue, possibly at a faster rate due to sea level rise. Pockets of sediment would be expected to remain in the coves in the cliffs, similar to some parts of the present frontage. The coastline position would be expected to erode parallel to its present alignment. Sediment released by the cliff erosion and

SCENARIO REF: BASELINE SCENARIO 2 – WITH PRESENT MANAGEMENT			
Location	**Predicted Change for**		
	Years 0 – 20 (2025)	**Years 20 – 50 (2055)**	**Years 50 – 100 (2105)**
	transport eastwards by longshore drift.	some would be expected to remain as pockets of sediment trapped in small coves.	wave-cut platform lowering would mainly be transported eastwards by longshore drift, but some would be expected to remain as pockets of sediment trapped in small coves. 35-40m (40-50m at Birling Gap) of cliff top retreat could occur by 2105.

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