

**DUDDON ESTUARY TO TARN POINT****Baseline Information**

<b>Start co-ordinate:</b>	319958, 485598	<b>Finish co-ordinate:</b>	307568, 489746
<b>Total length:</b>	28.5km	<b>Defended length:</b>	10.6km
<b>Earth Embankment:</b>	5.7km	<b>Rock Armour:</b>	1.5km
<b>Concrete Barrier:</b>	1.5km	<b>Sea Wall:</b>	1.0km
<b>Slag Waste Tip:</b>	0.6km	<b>Gabions:</b>	0.3km
<b>Saltmarsh:</b>	5.7km	<b>Sand Dunes:</b>	4.0km
<b>Clay Cliff:</b>	12.3km	<b>Other:</b>	2.4km

**Environmental designations:**

- SSSI
- SAC
- SPA
- Ramsar
- LNR

**Monitoring carried out:**

- 35 beach profiles
- Topographic survey (Silecroft only)
- Dune toe survey (Haverigg only)
- Coastal defence inspection
  - Haverigg to Hodbarrow
  - Haverigg Village
  - Silecroft

**Site overview:**

This section runs from the boundary between the inner and middle sections of the Duddon Estuary (ref SMP2), at Foxfield Viaduct, to Tarn Point. At the start of this section, the middle estuary has been influenced by reclamation of saltmarsh and construction of sea defences. In addition the Barrow to Whitehaven railway line and associated embankment, constructed in the mid 19<sup>th</sup> century, run along the eastern bank of the estuary providing a potential constraint on shoreline position. From Millom to Haverigg shoreline modifications have been primarily as a result of the 19<sup>th</sup> century mining and quarrying in the area. Various piers and jetties and the Haverigg barrier were built to accommodate this industry. In addition waste from the mining was deposited on the foreshore. Mining ceased in the 1960s and the area behind the barrier was flooded to provide a lagoon which is a local nature reserve and is used for water sports.

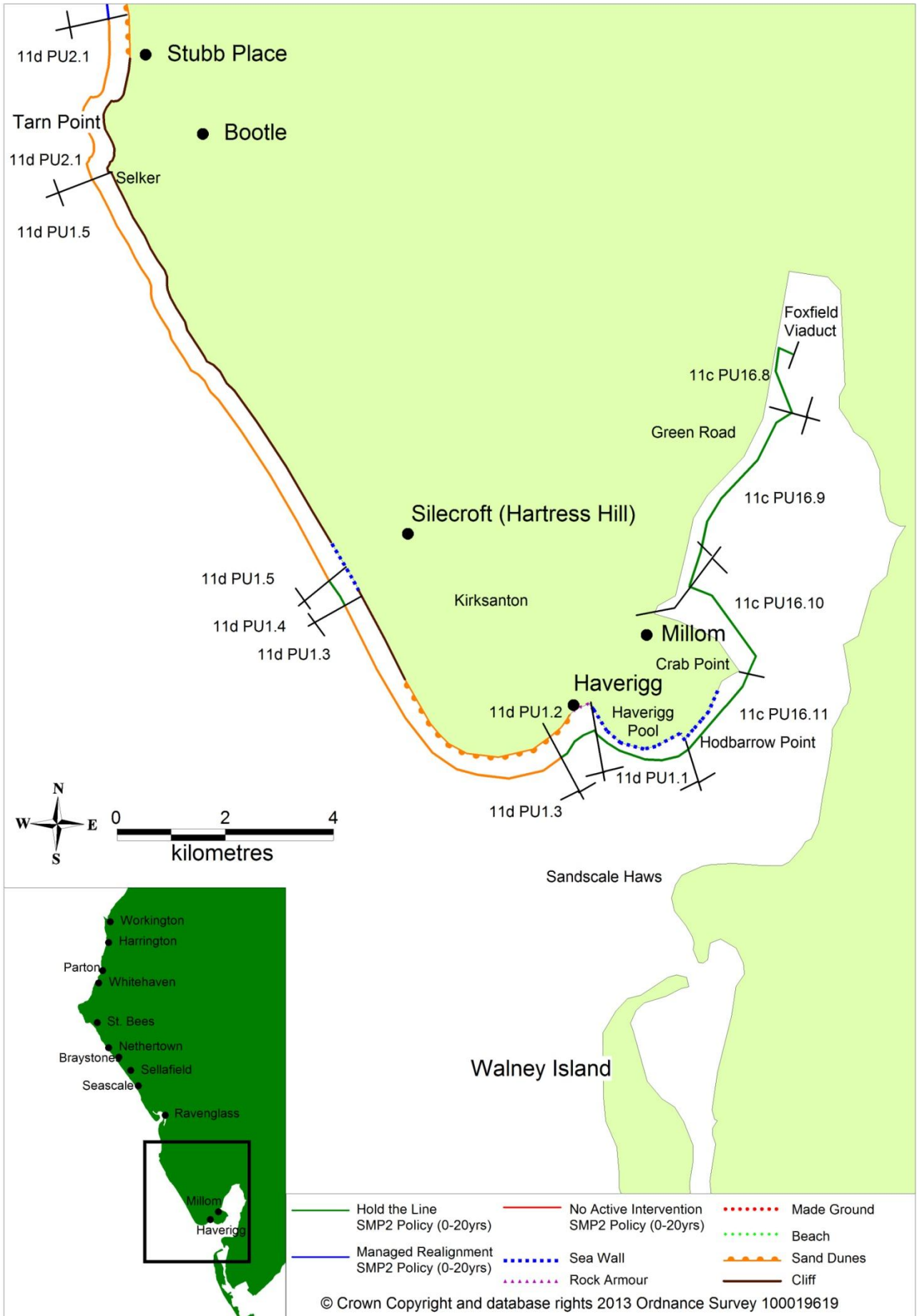
Beach conditions from Haverigg northerly comprise generally a steep upper beach of shingle deposits and a flatter lower beach of sand. The Haverigg beach and dunes section consists of the natural dune belt to the west of Haverigg town, which have developed over the natural shingle deposits. The final part of this section from Kirksanton to Tarn Point consists of natural low till cliffs, which are of varying heights and stability. The cliffs between Kirksanton and Silecroft reduce in height from south to north and are generally stable. Further north the cliffs are less stable with landslides, slumps and rock falls evident.

The defence across this section vary in nature. The middle estuary shoreline is predominantly protected by earth flood banks, which are managed by the Environment Agency, and the part natural part artificial headland of Hodbarrow Point and Crab Point. Between Millom and Haverigg the frontage is defended by the rock and concrete block wall of the Haverigg outer barrier. Between Haverigg lagoon and Haverigg Pool there are rock armour defences, followed by a mostly undefended natural shoreline to Tarn Point. Approximately 60% of the Silecroft frontage is now defended by a mixture of concrete sea walls and gabion baskets.

**The Current (SMP2) Policy:**

- **Middle Duddon Estuary:** Hold the Line in the short term (0-20yrs), Managed Realignment in medium term (20-50yrs) and long term (50-100yrs);
- **Millom to Haverigg:** Hold the Line in the short term (0-20yrs), Managed Realignment in medium term (20-50yrs) and Hold the Line in long term (50-100yrs);
- **Haverigg Beach and Dunes:** Hold the Line in the short term (0-20yrs), medium term (20-50yrs) and long term (50-100yrs);
- **Kirksanton to Tarn Point (not Silecroft):** No Active Intervention in the short term (0-20yrs), medium term (20-50yrs) and long term (50-100yrs); and
- **Silecroft (Subject to private funding):** Hold the Line in the short term (0-20yrs), medium term (20-50yrs) and long term (50-100yrs).

The plan below summaries the above information graphically:



**Summary of behaviour**

The middle section of the estuary is protected from waves propagating upstream by the headland of Hodbarrow Point and Crab Point. Exposure conditions are therefore relatively benign and largely driven by the level of the tide, although local waves from the east can be generated across the estuary.

The boundary between the middle and outer parts of the estuary is located between Crab Point on the west side and Marsh Farm on the east. Predominant waves entering the estuary are generally from the south west. As they move up the estuary, they are significantly modified in direction and reduced in energy by a combination of the shape of the estuary, the shoreline location and the bank and channel arrangements. Upstream of this divide there is net potential sediment transport in an upstream direction, whereas downstream the net potential transport is in a downstream direction. Therefore the middle part of the estuary, in this section of frontage, is acting as a sediment sink (Halcrow, September 2010). Further out in the estuary at Haverigg beach sediment generally moves landward towards the shoreline.

The open coast section to Tarn Point is aligned at right angles to the direction waves are coming from. This results in most of the sediment movement being cross shore (from the sea to the land and the land to the sea). There is also some movement of sediment up and down the coastline. North of Silecroft sediment moves north and south of Silecroft sediment moves south.

The following key points arise from analysis of the contemporary monitoring data:

**Offshore Wave Climate:**

Historic wave data from the Met Office & CEFAS identifies:

- Approximately 70% of waves < 1 metres high; <1% of waves > 3 metre high.
- Max wave height recorded = 4.73 metres (Nov 2010 – CEFAS wave buoy)

**Wind Climate:**

Historic wind data from the Met Office identifies:

- 40% of wind greater than 9 metres per second (Force 5 and above) & 60% of wind coming from offshore directions (NW to SE)

**Sea Levels:**

- Maximum tide level recorded at Barrow (1993-2007) = +6.27 (m ODN) in February 2002, which equates to approximately a 1 in 50 return period.
- Maximum tide level recorded at Workington in the last 20 years = +5.76 (m ODN) in February 1997, which also equates to approximately a 1 in 50 return period.
- The following predicted extreme tide levels apply (m ODN):

Return Period (years)	Workington	Haverigg	Silecroft
10	5.49	5.69	5.56
100	5.84	6.07	5.91
1000	6.18	6.43	6.24

**Foreshore & Shoreline Changes:**

Middle Duddon Estuary:

- Some erosion of saltmarsh on east bank between Green Rd and Foxfield Viaduct
- Profile change: 67% – accretion, 0% – erosion, 33% – no change

Millom to Haverigg:

- Changing sandbank and channel arrangements
- Profile change: 33% – accretion, 0% – erosion, 67% – no change

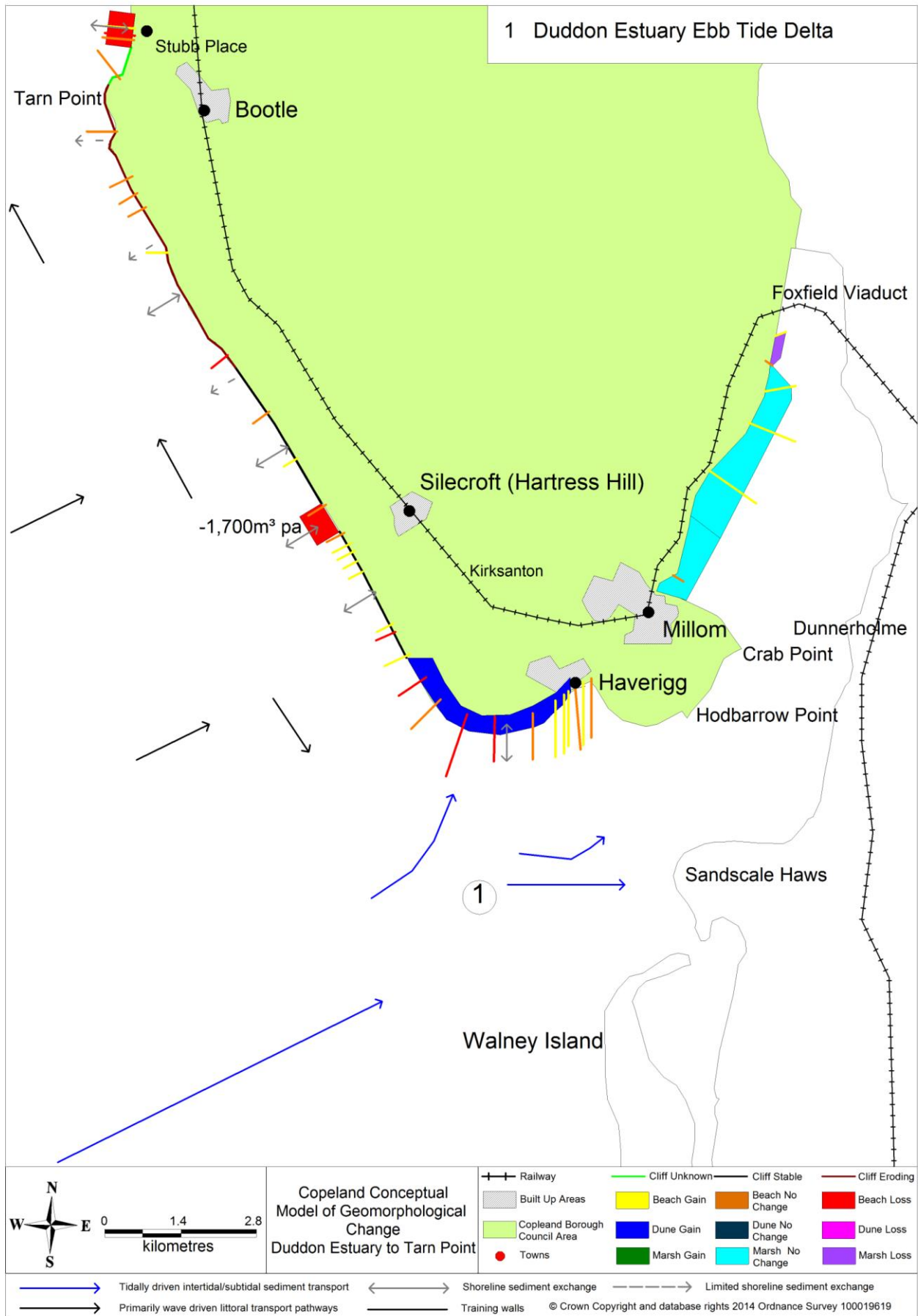
Haverigg Beach and Dunes:

- Profile change: 50% – accretion, 33% – erosion, 17% – no change

Kirksanton to Tarn Point:

- Cyclical behaviour - no overall change generally
- Localised cyclical change in lower beach levels at Silecroft
- Upper shingle beach profile altered under storm conditions
- Average volume decrease of -1,700m<sup>3</sup> per annum, equivalent to a decrease in beach height of 7mm across the area monitored, based on 2004-2013 data. Alternative reversed shorter term trend of +6,700m<sup>3</sup> per annum for 2009-2013 equivalent to a increase in beach height of 26mm across the area monitored.
- Profile change: 42% – accretion, 16% – erosion, 42% – no change

This behaviour is illustrated graphically on the plan below.



**Risk Assessment**

The primary risks arising from the behaviour of coastal forcing processes (wind, waves and tides) and the reaction of the shoreline (beach and cliff changes, artificial defence conditions) across this frontage are:

- Overtopping of artificial defences causing flooding of the hinterland,
- Breaching of artificial coastal defences, causing erosion of the shoreline
- Erosion of dunes and cliffs providing potential pathways for water penetration into the hinterland
- Wind blown sand nuisance to people and property

The primary consequences of this behaviour are:

- Damage to and/or loss of property and infrastructure
- Damage to environmental habitats.

The table below shows the overall risk rating(s) that apply within this section of frontage. Overall risk is defined from the probability of conditions/behaviour occurring and the consequences the conditions/behaviour would have.

<b>Duddon Estuary to Tarn Point Overall Risk Rating</b>				
<b>SMP Policy Unit (11c)</b>	<b>Section of Frontage</b>	<b>Probability Index</b>	<b>Consequence Index</b>	<b>Overall Risk Rating</b>
16.8	Duddon Estuary (Both banks upstream of Viaduct and right bank south to Green Rd Station)	Low	Medium/High	Medium
16.9	Millom Marshes	Low	Medium	Low
16.10	Red Hills (Industrial area)	Low	Medium	Low
16.11	Hodbarrow Mains	Low	Medium/Low	Low
<b>SMP Policy Unit (11e)</b>	<b>Section of Frontage</b>	<b>Probability Index</b>	<b>Consequence Index</b>	<b>Overall Risk Rating</b>
1.1	Hodbarrow Point to Haverigg	Low	Medium/Low	Low
1.2	Haverigg	Low	High	Medium
1.3	Haverigg to Hartrees Hill	Medium	Medium/High	Medium
1.4	Silecroft (Hartrees Hill)	Low	High	Medium
1.5	Hartrees Hill to Selker	Low	Medium/High	Low

**Current Behaviour**

Analysis of the monitoring data collected in 2013 provides the following key points:

**Offshore Wave Climate:**

- No new data available for analysis

**Wind Climate:**

- No new data available for analysis

**Sea Levels:**

- Maximum tide level recorded on Workington tide gauge = +4.808 (m ODN) on 25<sup>th</sup> July 2013, equivalent to a level that would be expected to be exceeded at least once per year.

**Beach Changes:**

Middle Duddon Estuary:

- Profile change: 0% – accretion, 0% – erosion, 100% – no change

Millom to Haverigg:

- Little change to beach and dunes
- Changes to seaward edge of the nearshore sandbank associated with movement of nearshore channel
- Profile change: 33% – accretion, 0% – erosion, 67% – no change

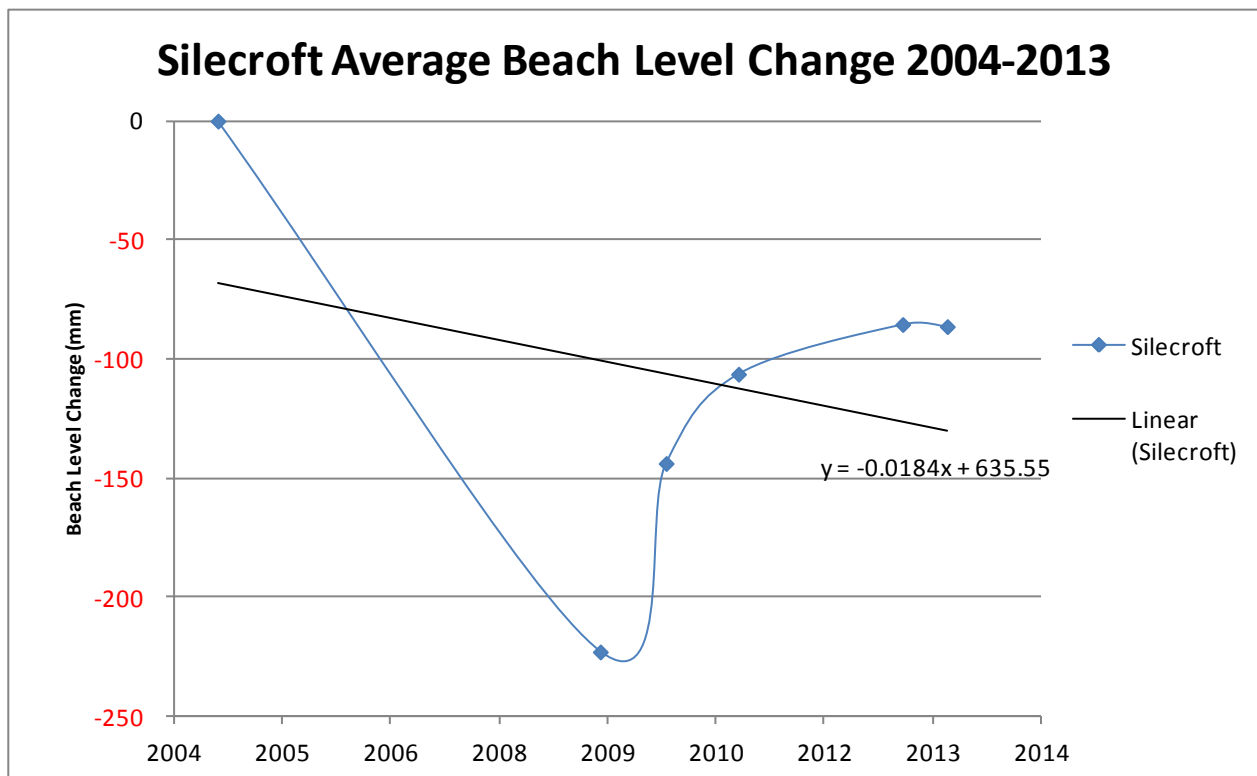
Haverigg Beach & Dunes:

- Stable to modestly accreting beach
- Profile change: 20% – accretion, 20% – erosion, 60% – no change

Kirksanton to Tarn Point:

- Little overall change
- No data to determine beach volume change at Silecroft
- Profile change: 16% – accretion, 16% – erosion, 68% – no change

The plot below shows the change in the average height of the beach across the Silecroft frontage from 2004 to 2013.



### **Uncertainties & Issues**

The following uncertainties have arisen from the data monitoring programme and analysis of the data collected:

- Quantities of sediment arriving on the beach from offshore.
- Quantities of material being transported into/out of Duddon Estuary
- Changes to bank and channel arrangements in the Duddon Estuary
- Wave conditions occurring directly in front of shore currently unknown.
- Cliff erosion Rates

### **Future Management Actions**

The following monitoring and management actions are recommended:

- Continue current monitoring regime
- Improve additional remote sensing e.g. LiDAR,
- On-going monitoring of condition of artificial defence structures
- Carry out remedial works to maintain integrity of defences, as required.
- Management of Haverigg dune frontages – fencing, access control, etc

### **Linkage(s) to Decision Making**

The monitoring provides information to support:

- Implementation of SMP2 policies, particularly; identification of timing for future capital works or capital maintenance works for artificial defences;
- Decision making process in relation to development planning control.

The plot below summarises the results from the monitoring data analysis for this section in 2013.

