5. SOLWAY FIRTH

5.1 OVERVIEW

Futurecoast (Halcrow, 2002) provides the following general description of the Solway Firth.

This is a Type 5, Embayment estuary, which is mostly natural and undeveloped. The mouth gradually widens towards the west, but the mouth appears to be best situated between Southerness Point and Dubmill Point. It has many similarities with Morecambe Bay and the Duddon. There are extensive sandbanks, mudflats, and saltmarshes, and some rocky shores on the Scottish side. Altogether the intertidal areas are very large. There has been considerable reclamation on the southern shores. The banks and channels are mobile with channel shifting, and there is evidence of extensive erosion and deposition of sediment. This appears to be mainly internal redistribution, rather than new material input. The combined river flows are very high, but the sediment loads are small.

The cross sectional area ratio is on the lower line, showing a sedimentary dominance. However, the mouth width is large compared with the channel length, indicating the tendency for a further reduction in mouth width. The intertidal ratio is comparatively low at 0.66 for the tidal range, and further sediment deposition is likely. Though the river flow is very high, the flow ratio is low. The tidal currents should be flood dominant.

The estuary is likely to be a strong sink for fine and coarse sediment should any be available.

5.2 HISTORY AND BACKGROUND

The Solway Firth is a funnel shaped estuary whose present configuration has been formed during the Holocene by various physical processes including retreat of the ice sheets following the last glaciation, post glacial sea level rise and fluvial erosion.

Large quantities of predominantly fine sediment accumulated as sea levels rose following the end of the last ice age (HR Wallingford 2005). Furthermore, the area is slowly rising in response to isostatic uplift, which over time will reduce the storage capacity of the estuary (Halcrow, 2011).

The Firth is orientated generally SW/NE over the majority of its length, before turning east/west for a short distance in its inner estuary, upstream of a line between Bowness on the Cumbrian shoreline and Annan on the Scottish side.

The inner estuary is fed by a number of rivers – the Eden, Esk and Sark at the head of the estuary; the Annan and Nith on the Scottish side and the Waver and Wampool which flow through the tidal inlet of Moricambe Bay, and thence into the Firth on the English side.

The overall extents of the Firth and particular its seaward boundary with the Irish Sea are a matter for some debate, with St Bees Head on the Cumbrian coast and Burrow Head on the Dumfries and Galloway shoreline generally recognised as the outer limits. The boundary between the outer and inner section is generally agreed to run between Dubmill Point (between Maryport and Silloth) on the English side and Southerness Point on the Scottish Side. From a geomorphological perspective the Grune Peninsula, north of Silloth, is probably a more appropriate boundary on the English side. Upstream of this geomorphological boundary finer sand and mud sediments predominate whilst in the outer parts of the estuary the beaches are characterised by a mixture of sand and coarser shingle and cobble deposits.

Shoreline behaviour and change within the confines of the estuary has in the past and continues in the present, to be highly influenced by the movement of channels. Changes in channel position occur mainly due to variations in river discharges and movement of sediments, however, in the past human intervention has also influenced behaviour (Halcrow, 2011). Construction of the Solway Viaduct in 1868, between Annan and Bowness, resulted in the main Solway channel moving closer towards the southern shore (Bullen Consultants Ltd, 1998). Consequently, erosion dominated the area east of the viaduct and a number of coastal defence structures were built, whilst to the west accelerated accretion occurred. Since removal of the structure in the 1930s, the shoreline in this location appears to have stabilised.

5.3 GENERAL PROCESS UNDERSTANDING

An overview of process behaviour is provided in the Dumfries and Galloway SMP (HR Wallingford, 2005) and the North West And North Wales SMP2 (Halcrow, 2011). The following provides a brief summary of behaviour taken from these and other sources.

The Solway Firth is a shallow estuary, with water depths generally less than 20m and large areas lying within the intertidal zone. The funnel shape of the inner Firth increases the spring tidal range, to approximately 8.4 metres at the boundary between the inner and outer estuary. There are no tidal range predictions upstream of this boundary. Recent estimates of extreme water levels are available on the English side of the estuary upstream as far as Bowness, together with a number of locations in the centre of the estuary.

The maximum velocity of the flood current is greater than the maximum velocity of the ebb current. The ebb and flood tidal currents follow different courses in the estuary, resulting in a complex and constantly evolving pattern of changing channel courses and shifting sandbanks.

Wave conditions in the outer part of the estuary are predominantly generated by wind fields blowing across the Irish Sea from directions between 190° and 250° WCB with swell waves also capable of penetrating into this section.

Nearshore wave conditions within the inner Firth are limited by the effects of the extensive inter-tidal sandbanks and flats that have developed here. These features act to attenuate waves approaching the shoreline from offshore, to generally < 1 metre in height. Waves generated by local wind fields predominate (HR Wallingford, 2005)

The inner Firth is an area of extensive intertidal sandflats, with sandbanks exposed during the ebb tide. Saltmarsh occurs along the flanks of the inner Firth notably on the English side, in Moricambe Bay, around the western flank of the Cardurnock peninsula, east of Drumburgh and between the mouths of the River Esk and Eden. The behaviour of the marsh is subject to the movement of the channels with particularly the section between Drumburgh and the River Eden vulnerable to erosion from the adjacent river channel, which runs along the marsh boundary. There are also extensive marsh deposits on the Scottish side, to either side of the outlet from the River Nith.

The character and evolution of the Scottish shoreline is greatly influenced by both the solid rock strata and the more recent and softer "drift" deposits of gravel, sand and mud that overlie them. The older harder rocks, sometimes exposed at the coastline as cliffs, form the overall "framework" for the coast. The drift deposits, which were mainly laid down at the end of the last Ice Age, form the raised beaches along much of the coast, and some boulder clay cliffs, as well as providing some of the gravel, sand and mud that make up the beaches and inter-tidal flats (HR Wallingford, 2005).

An updated quaternary geology of the Solway was completed in 2011 (BGS, 2011).

The Firth is a net sink for sediment, and much of the sediment may have been sourced from quaternary deposits in the northern Irish Sea (Perkins, 1974). Longshore drift is carrying sand and gravel further into the estuary. The rivers entering the Firth now contribute little sedimentary material, apart from some mud at times of flood.

Despite numerous studies on the ecology and sedimentology of the intertidal flats and banks, little is known about the thickness of sediments within the Firth, or the Quaternary sediment fill of the Firth. No seismic surveys have been undertaken in the inner Firth (BGS, 2011).

5.4 AVAILABLE DATA AND CURRENT MONITORING

As identified above, in relation to the geology and geomorphology of the Solway, there is little data available to support definition of change within the Solway.

Wind, Waves and Tides

Modelled wind and wave data is available from the Met Office archive at the outer boundary of the Solway, off St Bees Head for the period April 2000 – March 2010 (ref Appendix II).

The Dumfries and Galloway SMP (HR Wallingford, 2005), identifies the following definition of historical wave conditions within the Solway:

- Waves in the outer Solway were measured at a wave-rider buoy that was deployed for one year (October 1991-1992) approximately 18km west of Maryport (Black et al 1994)
- A wave climate was derived on the 20m CD contour to the south east of Dundrennan (HR Wallingford, 2000) using 12 years of wind data from Chapelcross and calibrated against wave measurements at the same location

No wave monitoring is currently carried out.

Wind data from the Robin Rigg wind farm (see attached location plan), is available/ can be purchased.

Tide levels are recorded by the Environment Agency in the inner estuary at Silloth and Metal Bridge on the English side of the Solway (EA). There are no other tide gauge records in the inner estuary. In the outer estuary there is a Class A gauge at Workington and a radar gauge at Whitehaven harbour. There are no tide gauges located on the Scottish section of the estuary.

Estuary and Shoreline Response and Change
The current Admiralty Chart (1346) of the area provides only a small amount of data in relation to bathymetry of the inner estuary, recording conditions in and around the Silloth channel between Dubmill Point and Silloth harbour. Elsewhere in the inner estuary there is no survey data.

It is understood that a hydrographic survey of the estuary was carried out by the Maritime and Coastguard Agency in 2009/10 but neither the extents of this are known nor has the data been acquired by the NWRMF.

Previous remote sensing information has been collected e.g. LiDAR, oblique aerial photographs etc but not on an estuary wide basis.

Data relating to the response of the beaches to changes in forcing conditions (wind, waves and tides) is available along the English shoreline, as reported in the relevant sections above (ref sections 4.4-4.10)

There is currently no shoreline monitoring undertaken along the Dumfries and Galloway shoreline.

Details of the present locations where data is available are provided on Figure 5.1.

5.5 SHORELINE MANAGEMENT PLANNING

Shoreline Management Planning within the Solway Firth is provided by the following documents:

- On the English side of the estuary by the North West and North Wales SMP2 (Halcrow 2011)
- On the Scottish side of the estuary by the Dumfries & Galloway SMP (HR Wallingford, 2005)

The following table provides a résumé of the policies applying:

Location		Shoreline Management Policy		
Unit Ref	**Boundaries**	**Short Term**	**Medium Term**	**Long Term**
English Side				
11e 5.1	Dubmill Point to Silloth	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 6.1	Silloth Harbour	Hold the Line	Hold the Line	Hold the Line
11e 6.2	Silloth to Skinburness (Open coast)	Hold the Line	Hold the Line	Hold the Line
11e 6.3	The Grune	No Active Intervention	No Active Intervention	No Active Intervention
11e 7.1	Skinburness (east)	Hold the Line	Hold the Line	Hold the Line
11e 7.2	Skinburness to Wath Farm	Hold the Line	Managed Re-alignment	Hold the Line
11e 7.3	Wath Farm to	Managed	Managed	Managed

Location		Shoreline Management Policy		
Unit Ref	**Boundaries**	**Short Term**	**Medium Term**	**Long Term**
	Saltcoates including Waver to Brownrigg	Re-alignment	Re-alignment	Re-alignment
11e 7.4	Newton Marsh	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 7.5	Newton Marsh to Anthorn including Wampool to NTL	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 7.6	Anthorn	Hold the Line	Hold the Line	Hold the Line
11e 7.7	Anthorn to Cardurnock	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.1	Cardurnock to Bowness-on-Solway	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.2	Bowness-on-Solway	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.3	Bowness-on-Solway to Drumburgh	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.4	Drumburgh to Dykesfield	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.5	Dykesfield to Kingsmoor (Eden Normal Tidal Limit)	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.6	Kingsmoor (Eden Normal Tidal Limit) to Rockcliffe	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.7	Rockcliffe	Hold the Line	Hold the Line	Hold the Line
11e 8.8	Rockcliffe to Demesne Farm	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.9	Demesne Farm to Metal Bridge (Esk)	Managed Re-alignment	Managed Re-alignment	Managed Re-alignment
11e 8.10	Metal Bridge (Esk) to the River Sark	Managed Re-alignment	Managed Re-alignment	Hold the Line
Scottish Side				
MU1	A74(T) - Mouth of Sark	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas
MU2	Mouth of Sark – Annan Waterfoot	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas
MU3	Annan Waterfoot - Barnkirk Point	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas
MU4	Barnkirk Point -Pow Water	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas
MU5	Pow Water - Scar Point	Generally No Active Intervention but limited intervention in individual areas	Generally No Active Intervention but limited intervention in individual areas	Generally No Active Intervention but managed re-alignment in individual areas
MU6	Scar Point - Airds Point	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas
MU7	Airds Point - Borron Point	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas	Generally No Active Intervention but hold the line in individual areas

Location		Shoreline Management Policy		
Unit Ref	**Boundaries**	**Short Term**	**Medium Term**	**Long Term**
MU8	Borron Point - Castlehill Point	Generally No Active Intervention but hold the line or limited intervention in individual areas	Generally No Active Intervention but hold the line or limited intervention in individual areas	Generally No Active Intervention but hold the line or limited intervention in individual areas
Notes 1. There is an overlap between these policy/management units. This section of frontage is located in England and accordingly the policy for 11e 8.10 is representative for this section of frontage. 2. The short term for the English shoreline units is defined as 0-20 years from present. For the Scottish units it is defined as 0-10 years from present.				

Details of the short term SMP policy within the inner Solway are shown on Figure 5.2.

5.6 FUTURE DATA REQUIREMENTS

Generally the shorelines of the inner Solway are considered at low risk with only intermittent property and infrastructure at risk. However the impacts of future sea level rise could have a significant effect on that level of risk. Therefore the collection of data, now rather than waiting for change to take place, will be invaluable in implementing Shoreline Management Policies and mitigating against that risk in the future.

As identified in the individual report sections, future monitoring within the inner Solway Firth will be primarily focused on the collection of remote sensing (RS) data e.g. LIDAR, Aerial Photography, Bathymetric Surveys etc, to inform coastal change. The use of Satellite Imagery to provide a broad scale identification of change and movement in the location of sandbanks and channels should be considered, utilising the expertise that has been developed by Lancaster City Council in association with the British Space Agency, in Morecambe Bay. This provides a relatively low cost way of obtaining information in the first instance.

The RS data will be supported by the shoreline monitoring.

Due to the physical scale of the undertaking, any collection of other RS data will require a multi-agency approach involving amongst others:

- North West Regional Monitoring Framework
- Dumfries and Galloway Council
- British Geological Survey
- Maritime Management Organisation
- Admiralty
- Developers e.g. wind farms
- CEFAS

Where appropriate NWRMF should lead, with such data that can be procured under present funding arrangements being done so, this could include:

- Deployment of AWAC recorders or Wave Buoys to identify wave conditions along the inner Solway boundary
- Collection of local wind data, that could potentially be used in producing modelled wave climates, once suitable long term data sets have been collected
- Inclusion of data from the EA's Silloth tide gauge into the NWRMF database
- Capture of vertical aerial photography – a similar arrangement to that adopted with the North Wales Local Authorities could be adopted to provide coverage of the Scottish side of the estuary
- An estuary wide LiDAR survey, similar to that carried out in Morecambe Bay in 2010

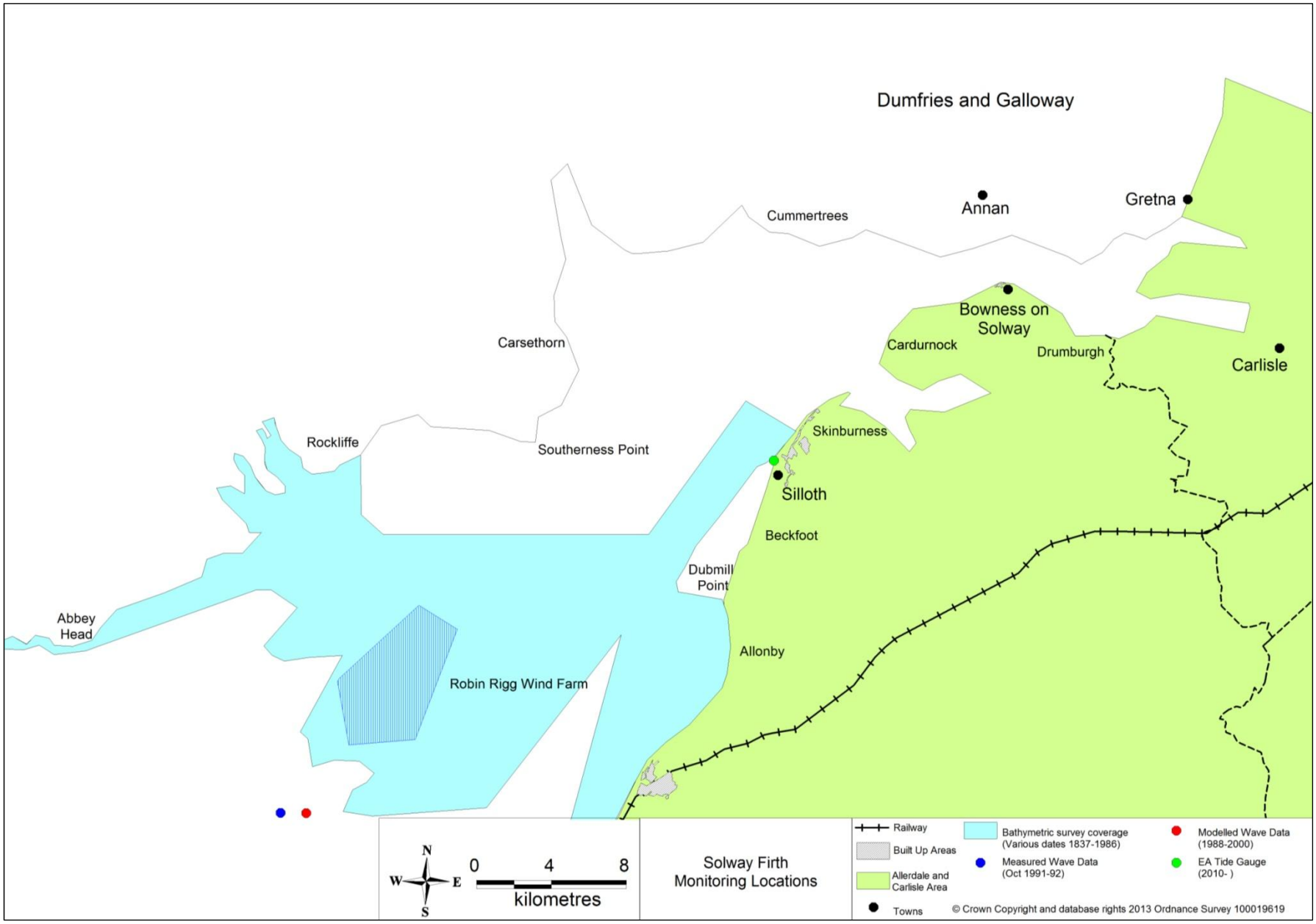

Figure 5.1 – Solway Firth Monitoring Locations

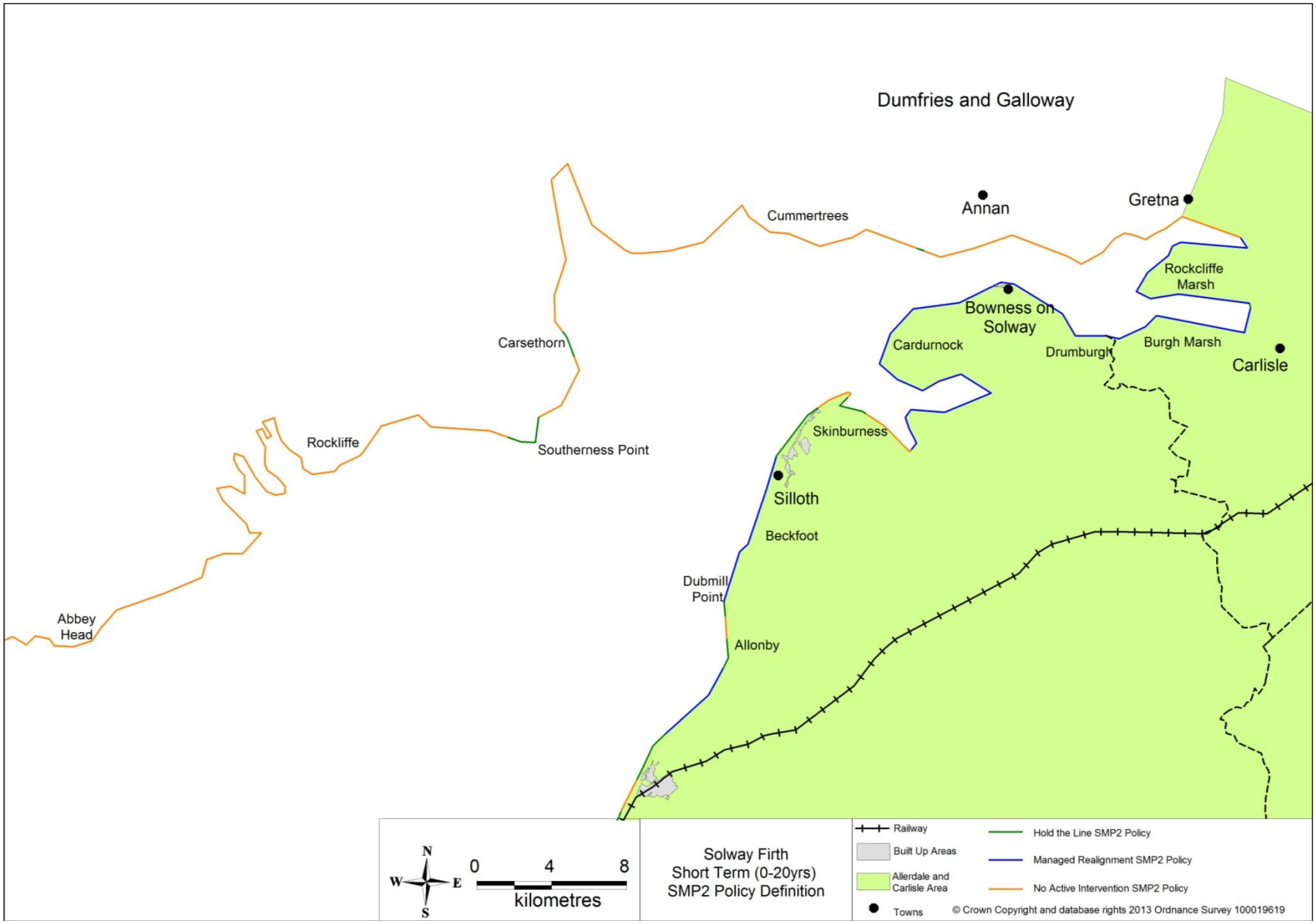

Figure 5.2 – Solway Firth Short Term SMP2 Policy Definition