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Dynamic Coast - National Coastal Change Assessment: Cell 7 - Mull of Galloway to the Inner Solway Firth

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National Coastal Change Assessment
Steering Committee

Coastal Change & Vulnerability Assessment

Dynamic Coast – Scotland's National Coastal Change Assessment

Executive Summary

- Cell 7 extends along the Dumfries and Galloway coast stretching between the Mull of Galloway and Gretna.
- In Cell 7 Mean High Water Springs extends to 546 km which makes up around 3% of the Scottish coastline. Of this length, 53% (291 km) has been categorised as soft, 45% (247 km) as hard and mixed and 2% (8 km) as artificial.
- Within the historical period 1890-1970s (74 years), a little less than half of the soft shoreline has not changed significantly (43 %), accretion (advance) has occurred along 31% of soft coasts and erosion(retreat) occurred along 26%.
- The period from the 1970s to modern spans 37 years, so the historical period data has been normalised to 37 years to allow comparisons with the modern period.
- When this adjustment is applied the extent of erosion increased from 13% historically to 21% post 1970s, the extent of stability reduced from 73% to 60% and the extent of accretion increased from 15% to 19%.
- In addition to the increases in the extents of erosion and accretion in Cell 7, there has been a substantial increase in the rate of erosion, with the fastest rates (30m+ over 37 years) now affecting 12% of the retreating shore, up from 6% historically.
- Accretion rates also increased with the fastest rates (30m+ over 37 years) now affecting 11% of the advancing shore from 9% historically. perhaps a reflection of the dynamic and extensive sandflats and saltmarshes found in Cell 7.
- This trend is consistent with a move toward erosion (increasing), through a transitional condition of no change (decreasing) with the average rate of erosion increasing from the historical to the recent period.

Disclaimer

The evidence presented within the National Coastal Change Assessment (NCCA) must not be used for property level of scale investigations. Given the precision of the underlying data (including house location and roads etc.) the NCCA cannot be used to infer precise extents or timings of future erosion.

The likelihood of erosion occurring is difficult to predict given the probabilistic nature of storm events and their impact. The average erosion rates used in NCCA contain very slow periods of limited change followed by large adjustments during storms. Together with other local uncertainties, not captured by the national level data used in NCCA, detailed local assessments are unreliable unless supported by supplementary detailed investigations.

The NCCA has used broad patterns to infer indicative regional and national level assessments in order to inform policy and guide follow-up investigations. Use of these data beyond national or regional levels is not advised and the Scottish Government cannot be held responsible for misuse of the data.

Contents

Document Structure

This document outlines the Historical Change Assessments and Vulnerability Assessment for Scotland's soft coastline. The methodologies used within the NCCA are detailed in a separate report. The document is structured to conform to the Scottish coastal sediment cell and sub-cell boundaries that were first delimited by Ramsay and Brampton (2000) in a series of 11 reports. The concept of coastal cells as a science based management unit for the coast is based on a recognition that the processes that shape and alter the coast, while unrelated to administrative boundaries are related to changes in sediment availability and interruptions to that availability. As a management unit, the coastal cell can be seen to fulfil a similar function to that of a catchment area of a river for terrestrial flood management. Changes in erosion, accretion and sediment supply in one coastal cell are seen to be largely unrelated to, and unaffected by, conditions in adjacent coastal cells, and are therefore seen as self-contained in terms of their sediment movement. For example, at many sites net sediment movement is in one direction and may pass around a headland (the major cell boundaries) only in very small volumes. Within a cell, any engineering structures that interrupt alongshore sediment delivery on the updrift side of a coast may impact on the downdrift coast but not vice versa given the "one-way" nature of net sediment movement. As sediment sinks, estuaries might be suitable cell boundaries, however subdivision of an estuary where sediment may circulate freely between both banks is inconvenient and so the inner portions of major firths and estuaries have been defined as sub-cells (Ramsey and Brampton, 2000). Whilst the cell system is ideal from a scientific perspective, it remains that Local Authorities may straddle a cell boundary. The results and statistics for each Local Authority area and for Marine Planning Regions are contained in a separate report.

Commencing with a national overview, this report summarises key locations whose positions of Mean High Water Springs (MHWS) have changed between the periods 1890s to 1970s and 1970s to modern time, although the exact time of survey may vary slightly around those dates and between coasts. The locations are arranged within sub-cells, which progress around Scotland in an anticlockwise direction, followed by the Western Isles, Orkney and Shetland. A short narrative summarises the historical changes and current situation at each location, followed by a vulnerability assessment which considers the implications of assets adjacent to areas of erosion. This narrative is to allow the reader to appreciate the overall findings from the evidence on coastal changes. The report is concluded by a series of tables summarising the statistics for cell one. Each of the 11 coastal cells has a similar report to this, which sits alongside a national overview to collate the national picture and consider the implication for Scotland's coastal assets. Where appropriate, mention is made of the existence of a shoreline management plan for a particular section of coast.

The full results of each cell are available on the webmaps (www.dynamiccoast.com) and have been designed to be highly accessible. Within the webmaps the user can navigate across the whole country, display various shorelines and click on each of the shorelines, to quantify the changes.

The National Context

For a full national overview of the aims, methodology, characteristics and underlying factors that control Scotland's coastline, the reader is directed to the National Overview report where a Whole Coast Assessment and results from the historical and recent changes are presented. Here only a short summary of the national changes identified are presented to place this individual coastal cell report into context.

Since the 1970s, 12% of the soft coast length across Scotland has retreated landwards (erosion), 11% has advanced seawards (accretion) and 77% stable or has shown insignificant change (Figure 1). National comparisons from the historical period (1890 to 1970) to recent period (1970-modern), accounting for the different time periods, show an increasing proportion of erosion (8% to 12%), similar stability (from 78% to 77%) and falling accretion (14% to 11%). Where coastal changes occur, they are faster than before. Nationally, average erosion rates after the 1970s have doubled to 1.0 m/yr whilst accretion has almost doubled to 1.5 m/yr.

The national pattern is an aggregation of different results from different parts of the country (Figure 2). The more exposed mainland east coast cells (1,2,3) and Solway Firth (7) have greater proportions of soft coast erosion and accretion (i.e. significant change) and lower proportions of stability. On the rock-dominated cells (for example cells 8,9,10, 11), soft coast stability is far higher and the extent of erosion and accretion lower. Whilst the natural level of protection offered to the soft sections of coast by the surrounding rocky coast has not changed through time, the proportion of soft coast experiencing erosion and accretion has. Considering the changes through time, the exposed coastal cells of the east coast have seen greater increases in change, with more modest changes occurring on the rock-dominated cells.

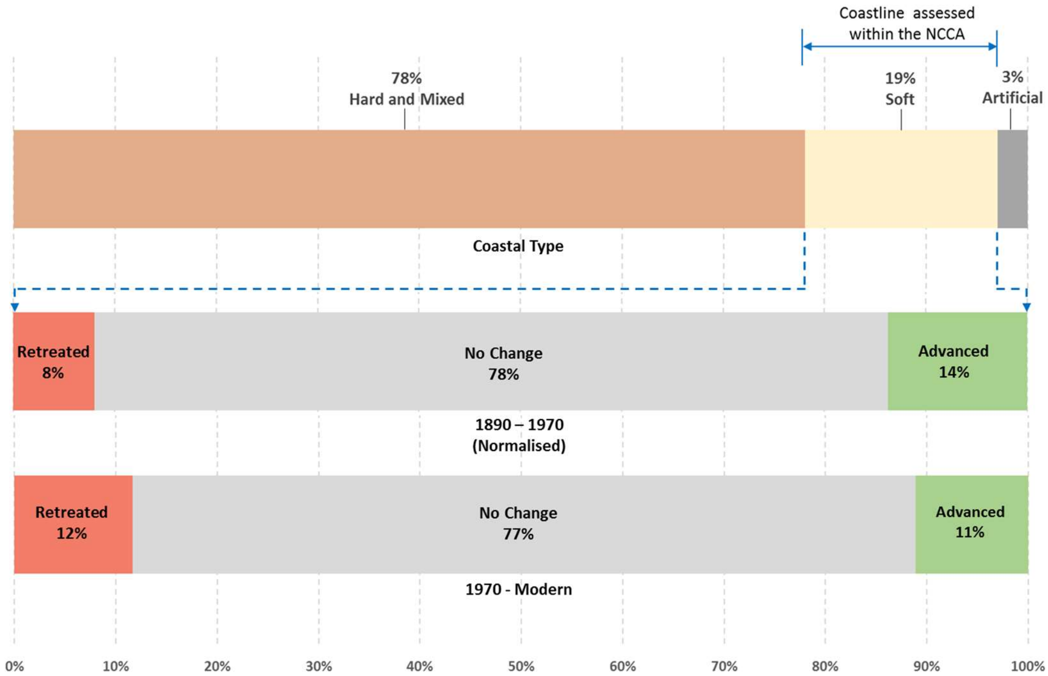

Figure 1: National coastal change results showing the proportion of soft coast retreating, stable and advancing within each change category in the historical (ca. 1890-1970 normalised for time period) and recent (ca. 1970-Present) time periods.

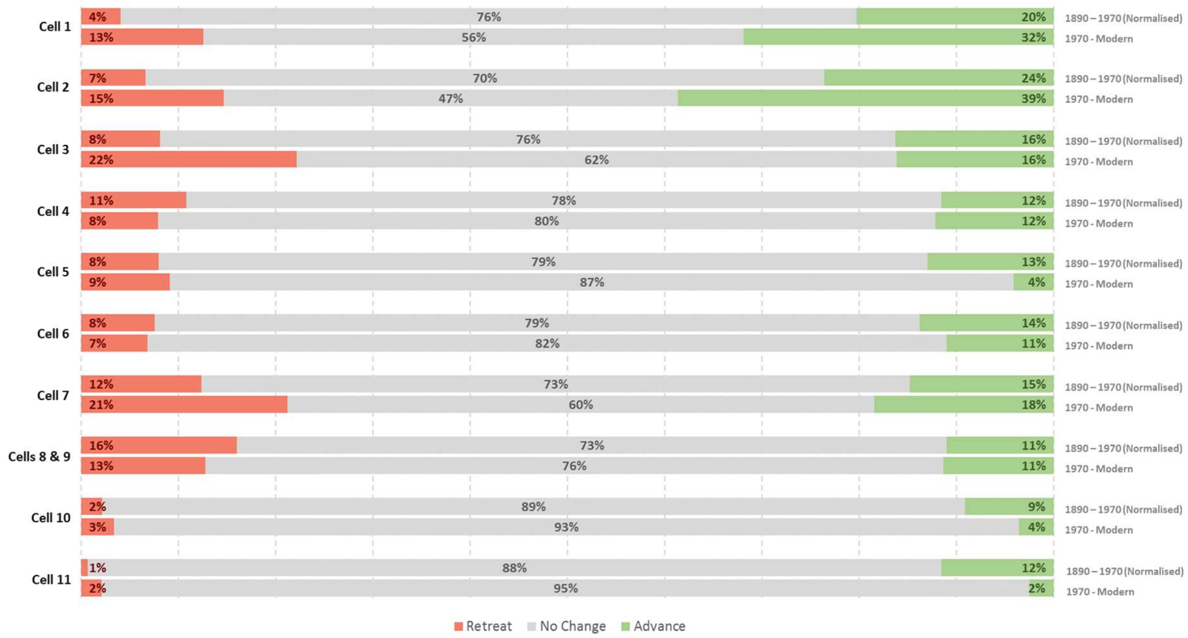

Figure 2: National coastal change results showing historical (ca. 1890-1970, normalised for time period) and recent (ca. 1970 Present.) % of coastal cell showing retreat (red), stability (grey) and advance (green) for soft coast within each cell.

Two other trends are worthy of mention here. The first relates to the propensity for the outer coast to be more exposed to wave impact than the inlets, bays and firths of the inner coast and so the potential for wave-driven erosion is greater along the outer coast. This is exacerbated by a reduction in sediment supply to the outer coast from the higher levels experienced a few thousand years ago. These outer coasts constantly lose sediments to inlet infilling via longshore drift (currents that transport sediment from a source area updrift to an accepting area downdrift). As such, erosion has progressively become the dominant trend on the outer coast in all places except where the import of longshore drift sediments feeds downdrift beaches. Conversely inlets, embayments and firths are sediment sinks that accept soft coastal sediments derived from erosion of the outer coast (the sediment sources) in addition to sediment freshly delivered by rivers. The result is that whilst the inner coast has a bias toward accretion, the outer coast, hard or soft, has a bias toward erosion.

A second trend is the close coincidence between coastal defences and erosion of the adjacent coast. Unsurprisingly, the insertion of defences is in response to a coastal erosion or flooding event, yet there are many instances where the defences themselves have exacerbated the pre-existing erosional condition, either on-site or on adjacent coastline downdrift. The reasons are three-fold. First, a defence structure is aimed at halting or slowing an existing erosion condition and so a successful structure not only halts erosion but also the supply of eroded sediment that had previously reached the fronting beach. The result is a reduced sediment supply and beach lowering. Second, most structures reflect wave energy and, indirectly, sediment leading to beach lowering. Third, the insertion of a defence structure on a coast that is affected by longshore currents not only prevents the supply of sediment to the fronting beach, it also reduces the supply of sediment previously exported leading to downdrift beach lowering and erosion.

Cell 7 - Mull of Galloway to the Inner Solway Firth

Cell 7 extends along the Dumfries and Galloway coast stretching between the Mull of Galloway and Gretna. No sub-cells exist within this cell (Figure 7.1). Further contextual information about the processes operating in Cell 7 can be found in Ramsay & Brampton (2000).

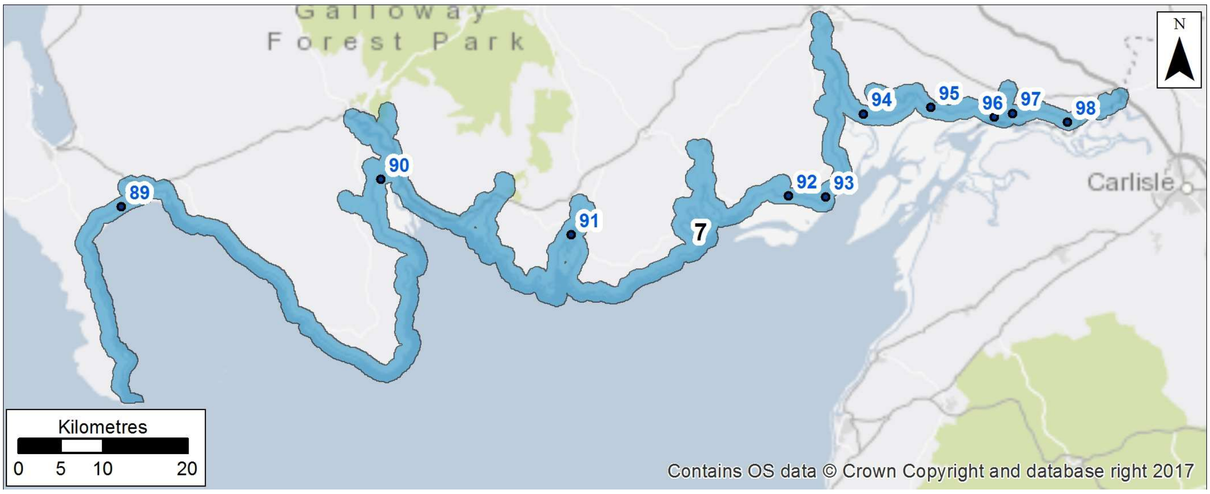

Figure 7.1: The cell boundary of Cell 7.

Physical Overview

In Cell 7 Mean High Water Springs (MHWS) extends to 546 km which makes up around 3% of the Scottish coastline (excluding tidal inlets). Of this length, 53% (291 km) has been categorised as soft, 45% (247 km) as hard and mixed and 2% (8 km) as artificial (Table 7.1). Within the historical period 1890-1970s (74 years), a little less than half of the soft shoreline has not changed significantly (43 %), accretion (advance) has occurred along 31% of soft coasts and retreat (erosion) along 26% (Figure 7.2). The period from the 1970s to modern spans 37 years, so the historical period data has been normalised to 37 years to allow comparisons with the modern period.

When this adjustment is applied the extent of erosion increased from 13% historically to 21% post 1970s, the extent of stability reduced from 73% to 60% and the extent of accretion increased from 15% to 19%. In addition to the increases in the extents of erosion and accretion in Cell 7, there has been a substantial increase in the rate of erosion, with the fastest rates (30m+ over 37 years) now affecting 12% of the retreating shore, up from 6% historically. Accretion rates also increased with the fastest rates (30m+ over 37 years) now affecting 11% of the advancing shore from 9% historically (Figure 7.2).

This trend is consistent with a move toward erosion (increasing), through a transitional condition of no change (decreasing) with the average rate of erosion increasing from the historical to the recent period. However, accretion also increased in extent and rate, perhaps a reflection of the dynamic and extensive sandflats and saltmarshes found in Cell 7. Further statistics for Cell 7 can be found in Table 7.2 and Table 7.3 the end of this report.

Table 7.1: Proportion of each coastal type within Cell 7.

Modern Coastal Type	Length	
	km	%
Soft	290.6	53%
Artificial	8.2	2%
Hard and Mixed	246.9	45%
Total Length (excluding tidally influenced inlets)	545.7	100%

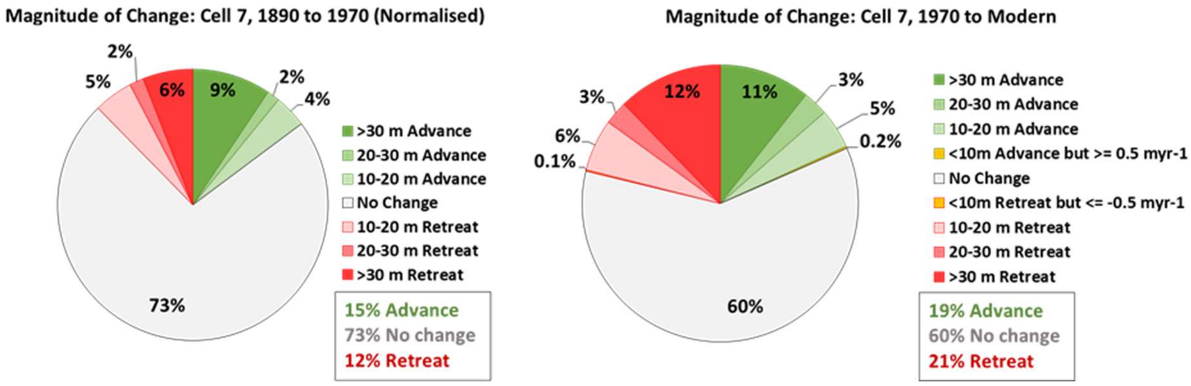

Figure 7.2: Coastal change results for Cell 7 showing the proportional amount of change in the historical (ca. 1890-1970 normalised) and recent (ca. 1970-Present) periods. Rounding errors may produce small % differences between Figure 2 and Figure 7.2.

Asset Vulnerability Overview

The Vulnerability Assessment methodology serves to project the known past erosion rates forward into the future to the year 2050 and is viewable on the online webmaps at www.dynamiccoast.com. Within Cell 7, a total land area of 110.2Ha, which supports various assets, is anticipated to be lost by 2050, this includes seven residential properties within the areas expected to be eroded by 2050. When areas that erosion may influence are included then a further three residential properties are anticipated to be affected. For a full summary of vulnerable assets see Table 7.4 at the end of this report.

Cell Summary

7a.1 Luce Sands (Site 89)

Historical Change: The 1970s mapping of Luce Sands was undertaken between 1976 and 1989. Comparisons with the 1893 map however, show remarkable similarity between the two surveys along the central section of the beach. While small sections here have retreated, most of the shoreline has remained largely stable, with modest accretion (normally less than 15 m, but occasionally up to 20 m) over the 80 or 90 years. Most of the change is associated with the exits of small streams into the beach area. At the western end of the bay, at Sandhead, the changes are related to the southwards movement of the Sandmill Burn where gains and losses of up to 30 m occurred on each bank (Figure 7.3). The coastline adjacent to the Culmore and Clayshant burns experienced substantial erosion between 1893 and 1976, with up to 240 m of losses in the intervening 83 years (2.9 m/yr) (Figure 7.4). At the eastern end of Luce Sands, Ringdoo Point has remained stable with the 1970's shore aligning with that of the 1890s (Figure 7.5). However, larger changes have occurred at the mouth of the Piltanton Burn, where northern sections have retreated up to 90m and southern sections advancing up to 65 m.

Figure 7.3: MHWS position in 1890, 1970s, and Modern datasets at Sandhead, Luce Sands. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Since the 1970s, the entire frontage of Luce Sands has advanced seawards and regained much of the losses experienced prior to this time. To the east of the Clayshant Burn, up to 260 m has been gained between 1976 and 2005 (8.3 m/yr) (Figure 7.4). Along the main southeast facing section of Luce Sands, the gains in the last 29 years have been between 20 and 40 m (1.4 m/yr). Accretion at Ringdoo Point (Figure 7.5) has resulted in the 2005 MHWS moving up to 200 m seaward of its 1889 position (part of the 1970s mapping). Interpretation of aerial photography suggests that this accretion has led to dune and salt marsh development, but that most of the accretion is intertidal sand. Overall, this gels with evidence from earlier research. This identified Luce Bay as a sediment sink bounded by twin headlands oriented such that once within the bay, sediments cannot escape and thus accumulate at its head along the beaches of Luce Sands. The shoreline at Luce Sands is part of the Luce Bay and Sands Special Area of Conservation, Loch of Inch and Torrs Warren Special Protection Area and Torrs Warren - Luce Sands Site of Special Scientific Interest.

Figure 7.4: MHWS position in 1890, 1970s, and Modern datasets at Clayshant Burn, Luce Sands. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

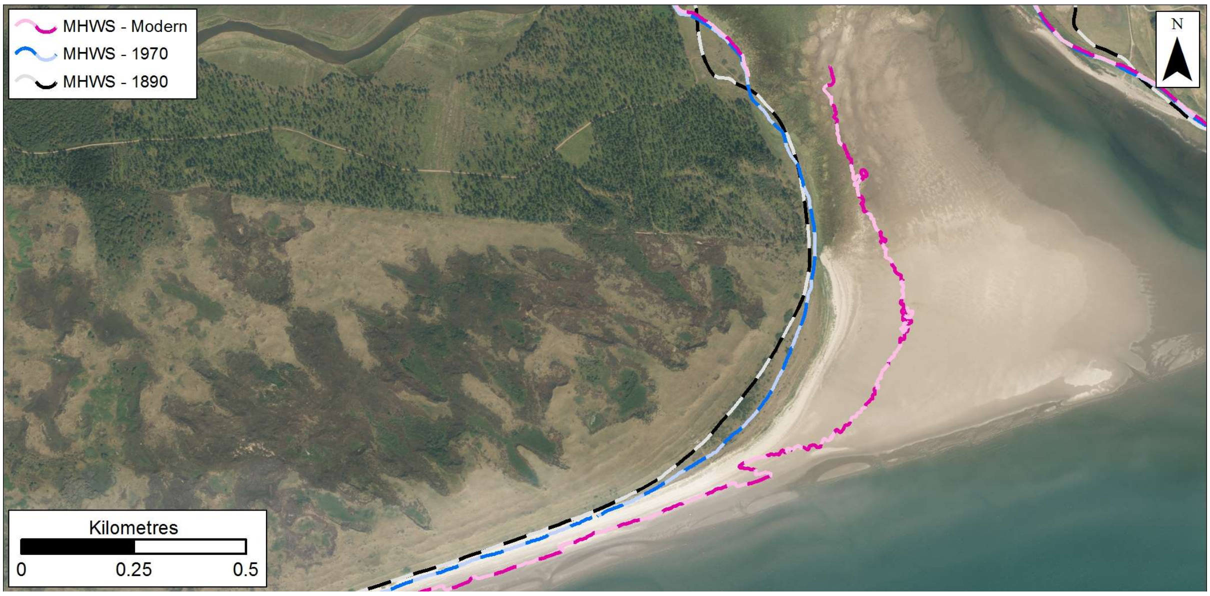

Figure 7.5: MHWS position in 1890, 1970s, and Modern datasets at Ringdoo Point, Luce Sands. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: No areas within this stretch experienced significant coastal erosion to merit inclusion within the future coast assessment.

7a.2 Wigton Sands (Site 90)

Historical Change: Wigton Sands has seen substantial amounts of accretion following the 1894 survey of the foreshore. North of Baldoon Sands, up to 350 m of land has been gained (4.1 m/yr) (Figure 7.6). This is principally due to salt marsh development, although an oblique breakwater evident in the 1894 map was extended prior to 1979 indicating that at least some of this gain is land claim. North of the river Bladnoch, changes over the 20th century are even more impressive with MHWS moving seawards up to 1 km due to saltmarsh development. Whilst the accretion reduces to 350 m of advance towards the River Cree 4.5 km to the north, this has resulted in around 170 ha of new land above MHWS being created over 85 years (2 ha/yr) (Figure 7.7). The left-hand (eastern) bank of the River Cree has seen substantial accretion, with MHWS moving 250 m between 1894 and 1992 (2.6 m/yr). There have also been substantial channel changes in the Ferry Burn (Figure 7.7).

Figure 7.6: MHWS position in 1890, 1970s, and Modern datasets at Wigtown. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Figure 7.7: MHWS position in 1890, 1970s, and Modern datasets at Creetown. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

The Scottish Government LiDAR survey of 2011 shows a continued advance immediately south of the River Bladnoch exit (Figure 7.6), where a further 210 m has been added since 1979 (5.3 m/yr) possibly due to the extension of the southerly breakwater. The remaining parts of Wigton Sands (north of the River Bladnoch and west of the River Cree) can be divided into three sections. The southern section has experienced up to 50 m of erosion between 1975 and 2011, probably related to changes in the Bladnoch exit. Whilst the central part experienced gains of up to 175 m between 1975 and 2011, the northern part remained stable. On the eastern bank of the River Cree, the modern MHWS line shows some 50 m of retreat, most likely related to the movement of the main river channel. The saltmarsh here is part of the Cree Estuary Site of Special Scientific Interest.

Future Vulnerability: Erosion is anticipated within the Wigton Sands section of the Cree Estuary Site of Special Scientific Interest (SSSI) north of the Bladnoch exit, with over one ha of saltmarsh expected to be lost by 2050, assuming past rates continue unchanged (Figure 7.8). No assets are nearby and the losses are confined to saltmarsh. On the east bank of the River Cree, some nine ha of land may be lost by 2050, assuming past rates remain unchanged (Figure 7.9). Given the proximity of tributaries and adjacent road assets at Creetown, future erosion and erosion-related flooding may cause issues that require attention.

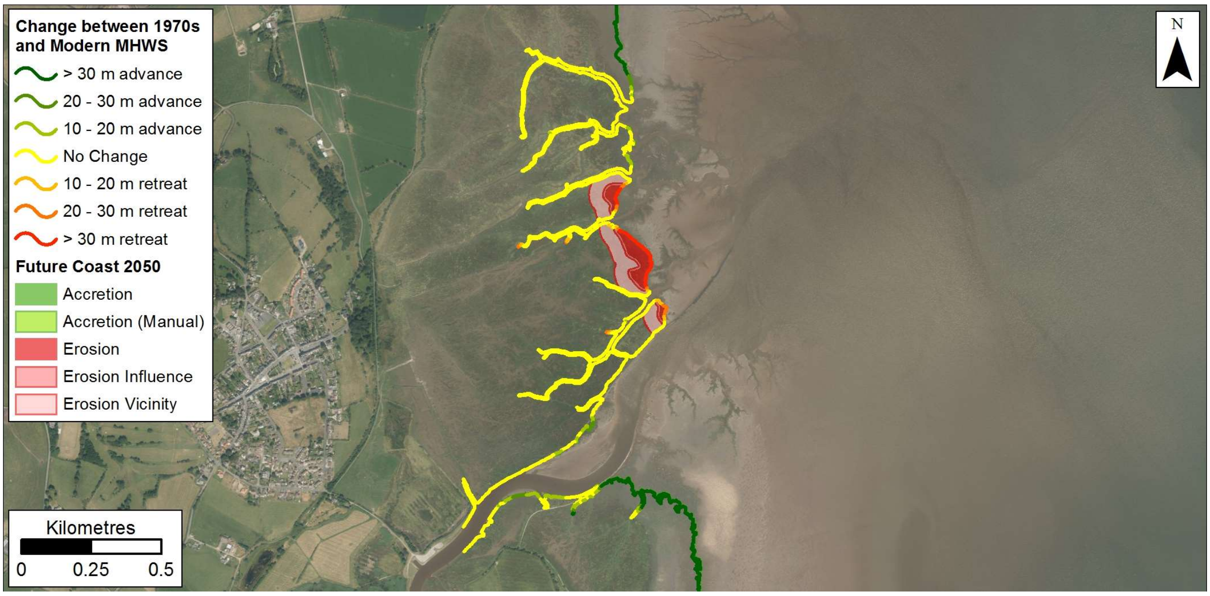

Figure 7.8: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data at Wigton Sands. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

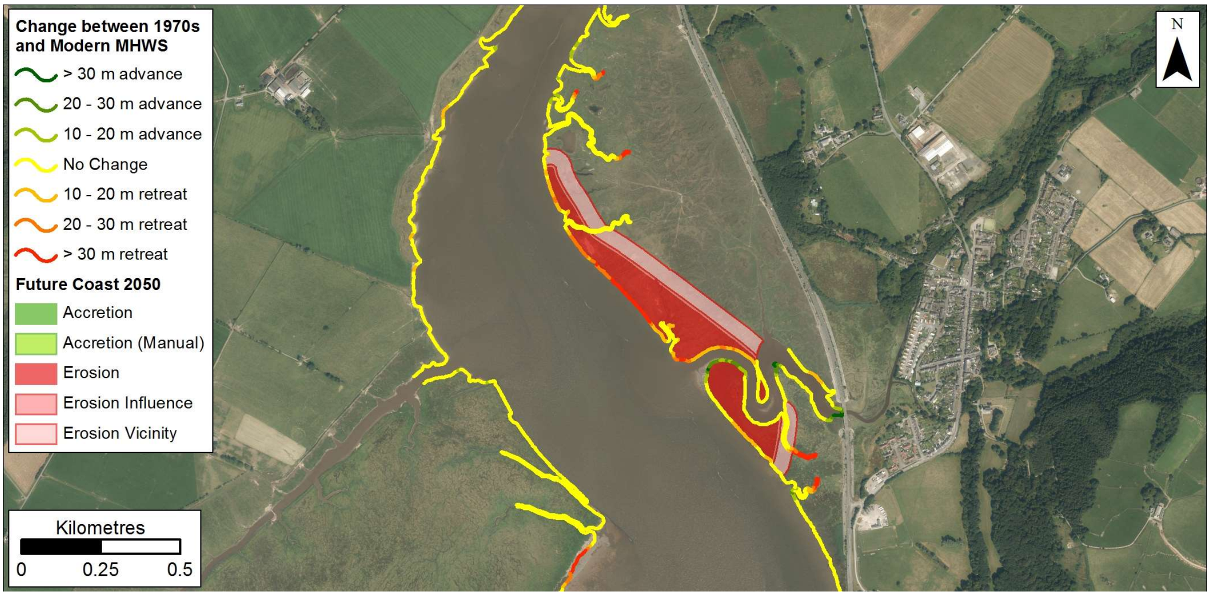

Figure 7.9: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data Creetown. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

7a.3 Kirkcubright (Site 91)

Historical Change: Whilst the western bank of the River Dee has remained remarkably stable between 1896, 1989 and 2011, the eastern bank saw minor accretion before 1989, but more substantial accretion between 1986 and 2011. Here MHWS has advanced seawards with 135 m of saltmarsh developing at 6 m/yr immediately south of the town limits (Figure 7.10). Similar amounts of saltmarsh accretion on the south side of the neck of the linear peninsula that extends south of the town has also occurred (Figure 7.10).

Figure 7.10: MHWS position in 1890, 1970s, and Modern datasets at Kirkcubright. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: As only accretion is present in this area, no future vulnerability due to coastal erosion is identified or anticipated.

7a.4 Mersehead Sands and Southerness (Site 92)

Historical Change: The coast west from Southerness to the exit of Southwick Water at Mersehead has seen remarkable changes over the last 123 years with the 1893 shoreline retreating up to 820 m over the period 1978 to 1893 (9.6 m/yr), with the loss of 320 ha (3.7 ha/yr). Despite the outcrop of intertidal rock at Southerness, 20 m was lost between 1883 and 1978 and a further 20 m since, leading to short sections of boulder protection being inserted (Figure 7.11). Substantial evidence of the recession over the expanse of Mersehead Sands is evident in the upper intertidal area where extensive networks of land drains have been exposed on the lower beach sandflat by erosion. Some of this loss of sediment can be accounted for by the westwards extension of the MHWS line from 2016 (OS ground survey), where up to 900 m of spit extension has occurred at the mouth of Southwick Water. However, the remainder of the beach at Mersehead continues to retreat, with 4.5 km of beach eroding by up to 100 m between 1978 and 2016 (2.6 m/yr). Mersehead Sands is part of the Upper Solway Flats and Marshes Special Protection Area and Site of Special Scientific Interest.

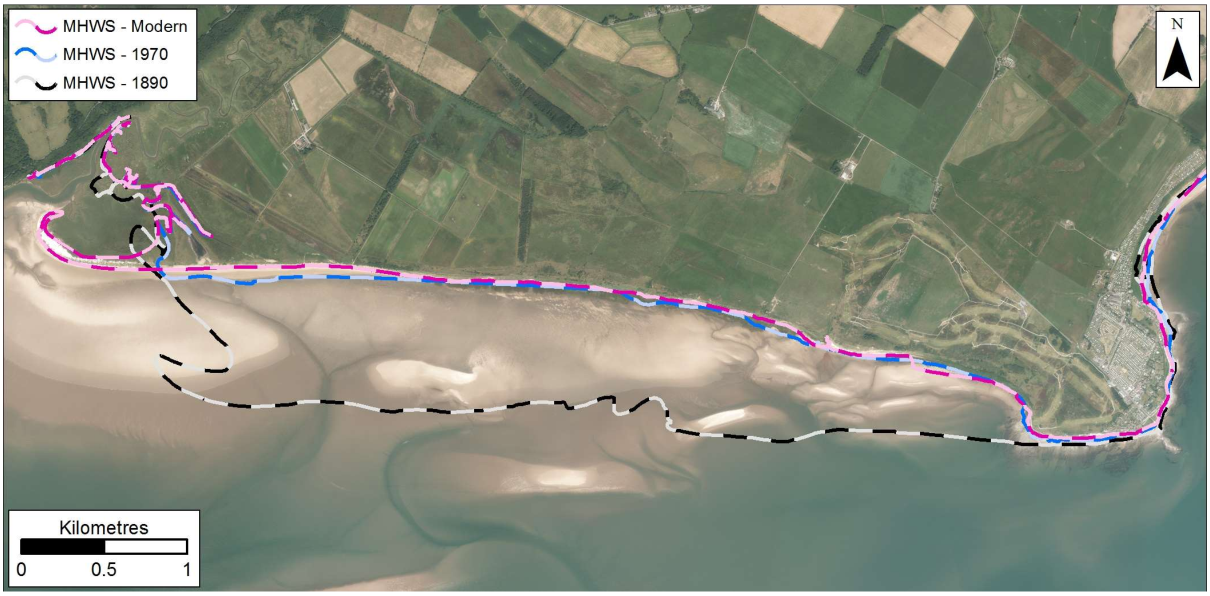

Figure 7.11: MHWS position in 1890, 1970s, and Modern datasets from Mersehead Sands to Southerness. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: The 2050 future projected shoreline shows the beach at Mersehead to potentially lose up to 90 m with MHWS moving inland along 4.6km of the coastal edge between Mersehead Plantation and Southerness Golf Course (Figure 7.12). The projection of past rates into the future suggest that 75 m (13 ha) of mainly farmland will be lost be 2050. This includes the loss of sections of coastline which may influence flood risk and whose areas are part of the Solway Firth Special Area of Conservation (SAC), Special Protection Area (SPA) and SSSI.

Figure 7.12: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data from Mersehead Sands to Southerness. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

7a.5 Southerness (Site 93)

Historical Change: To the north east of Southerness the shore has receded by up to 50 m over a 500m length between 1894 and 1966. This erosion has occurred despite the village of Southerness being fronted by a rocky intertidal platform albeit capped by erodible glacial till and sand. North of this, about 1.3km of coast accreted between those dates by up to 30 m (Figure 7.13). At this location, the shore receded between 1966 and 2014 back to its 1894 position based on modern OS MHWS positions. To the south at Southerness, the modern line has been updated by the OS, and aerial photography confirms up to 40 m recession of the shore along 400 m of the frontage of the caravan park. The foreshore to the north of Southerness is part of the Upper Solway Flats and Marshes Special Protection Area and Site of Special Scientific Interest.

Figure 7.13: MHWS position in 1890, 1970s, and Modern datasets at Southerness. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

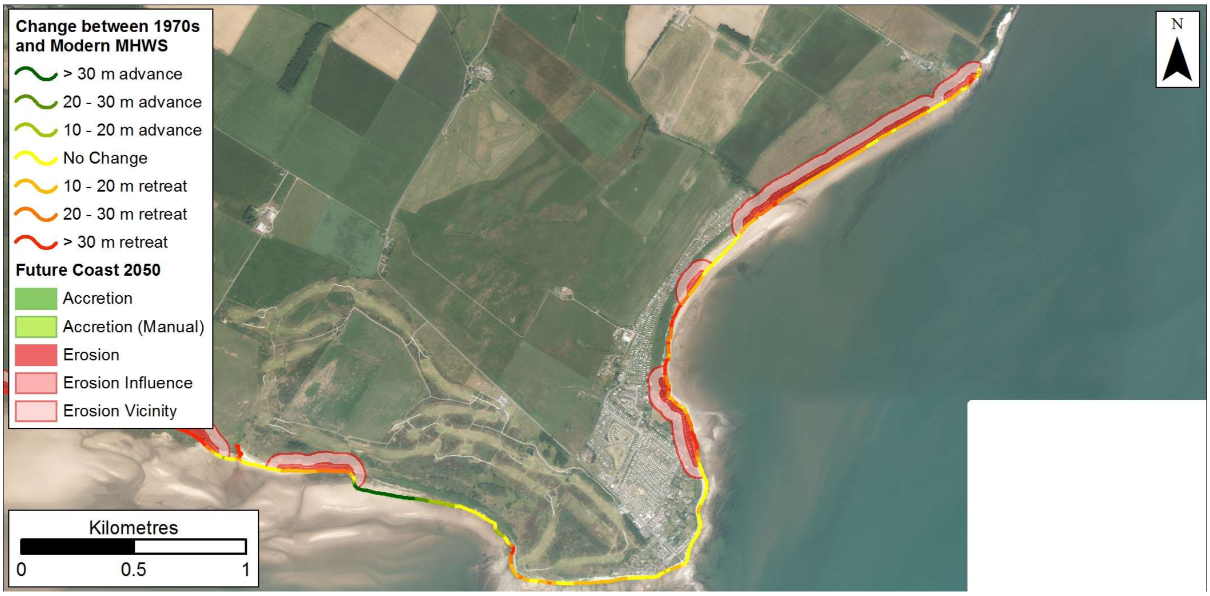

Figure 7.14: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data at Southerness. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: Extension of the known rates at Southerness up to 1966 indicates future recession of up to 30 m over 400 m of shore is possible (Figure 7.14). As the most recent position of MHWS is not available, the rate has been predicted from aerial photography. Approximately 12 residential properties and their access road lie within the erosion affected area as well as some sand dune frontage to the north of the houses. To the north, about 1.4 km of recessional coast is predicted based on past rates up to 2014, most of this affecting farmland, although the southernmost part of the predicted erosion area impinges on sand dunes fronting the caravan park where 20 m of losses are possible.

7a.6 Caerlaverock (Site 94)

Historical Change: Substantial changes to the salt marshes areas at Caerlaverock have occurred between 1898 and 1956, indeed moving east from the mouth of the River Nith there are very few areas which have not changed (Figure 7.15). In general, between 1898 and 1956 there has been gain of area in the west and loss of area in the east. From the west, 4 km of coast has advanced up to 490 m seawards (12 m/yr) resulting in the gain of 170 ha. This area of advance petered out and was replaced by stability south of Caerlaverock Castle for 800m before erosion dominated the main section of the eastern marsh for around 4 km. Along this stretch, MHWS retreated up to 340 m between 1898 and 1956 (5.6 m/yr), resulting in the loss of 85 ha. The losses reduce gradually and changed to gains towards the mouth of the Lochar Water, where MHWS moved seawards by up to 590 m in the 60 years (9 m/yr), producing 43 ha of salt marsh in the 60 years preceding 1958. In total, in the 60 years between 1898 and 1958, based on the movement of MHWS, there has been a net gain of around 128 ha (2 ha/yr), with losses within the central section and accretion to the west and the eastern extremities. Caerlaverock Castle is a Scheduled Monument and the marshes form part of the Upper Solway Flats and Marshes Special Protection Area, Site of Special Scientific Interest and the Solway Firth Special Area of Conservation.

Between 1956 and 2015, the changes at Caerlaverock have been equally impressive. Historic gains in the west have been replaced by 330 m of loss up until 2015 (5 m/yr), although MHWS still lies seaward of its 1989 position (Figure 7.15). These losses stretch over 2 km eastwards of Caerlaverock Castle and consumed saltmarsh that existed before 1898 so that about 200 ha of salt marsh have been lost over the 57 years (4 ha/yr) in its western extent. In the eastern part of Caerlaverock, the trend has been predominantly an accretional one, with the 2015 shoreline reoccupying that of the position in the 1898 maps. In some places the gains are up to 200 m (3 m/yr). Further eastwards however, the accretional gains reduce and are replaced by retreat in and around the mouth of the Lochar Water, where up to 60 m have been lost (1 m/yr).

Figure 7.15: MHWS position in 1890, 1970s, and Modern datasets at Caerlaverock. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

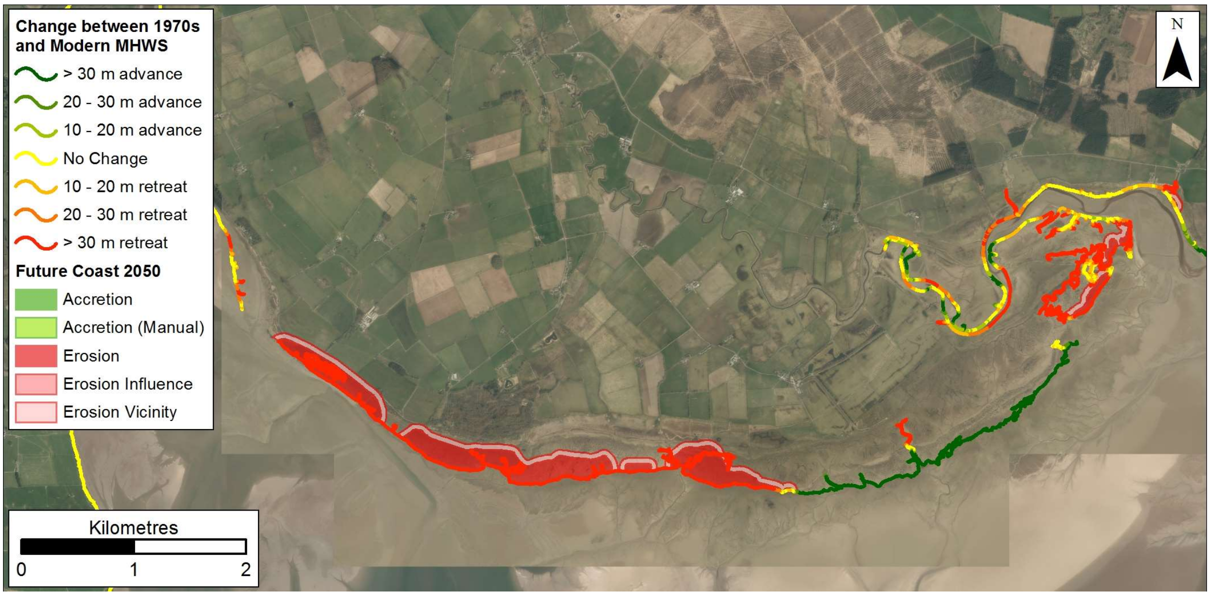

Figure 7.16: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data at Caerlaverlock. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: Projecting the recent rates (1956 to 2015) forwards, the anticipated position of MHWS in 2050 would lie up to 200 m inland of its current position in the western third, and up to 300 m inland in the central section of Caerlaverock (Figure 7.16). Over substantial stretches of the western half of the marsh this simply reoccupies the approximate 1898 position. Assuming uniform rates, by 2050 the coastal road would be within 30 m of MHWS. If the recent rates continue then these losses would reduce the area of salt marsh by 57 ha by 2050 (1.6 ha/yr). Within the vicinity of the Lochar Water, a further 3 ha of salt marsh is expected to be lost by 2050, based on the continuation of uniform recent rates. Excluding the coastal road, the other notable assets are the designated Solway Firth saltmarsh sites but there are no fixed industrial, housing or transport assets.

7a.7 Priestside Bank (Site 95)

Historical Change: Priestside bank has experienced early losses prior to 1956, with MHWS moving landwards up to 130 m since 1898 (2 m/yr), resulting in 14 ha of land being lost (Figure 7.17). Between 1956 and 2015 the eastern two-thirds of the marsh has advanced up to 115 m (2.5 m/yr), with the creation of up to 19 ha of new salt marsh and land. There is evidence however, from aerial photography and ground observations that, at several places on this shore, the MHWS has been located seaward of the 2015 line at some time in the period between 1956 and 2015 (Figure 7.17). These marshes form part of the Upper Solway Flats and Marshes Special Protection Area, Site of Special Scientific Interest and the Solway Firth Special Area of Conservation.

Figure 7.17: MHWS position in 1890, 1970s, and Modern datasets at Priestside Bank. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: As only accretion is present in this area, no future vulnerability due to coastal erosion is identified.

7a.8 Newbie (Site 96)

Historical Change: Between 1898 and 1956 the shore adjacent to Newbie remained stable, with a few accretional areas, some up to 20m (0.3 m/yr) (Figure 7.18). However, over the last 50 to 60 years up to 2014, the shoreline has retreated landwards mostly around 20 m but in places by up to 30 m (0.5 m/yr). The pattern of modest recent retreat extends along much of the shoreline to the east towards Barn Kirk Hill and the spit of land that extends east to mouth of the River Annan. The foreshore is designated as a Solway Firth Special Area of Conservation, Upper Solway Flats and Marshes Special Protection Area and Site of Special Scientific Interest.

Figure 7.18: MHWS position in 1890, 1970s, and Modern datasets at Newbie. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Future Vulnerability: A uniform projection of recent rates of erosion suggests MHWS would be up to 40 m inland by 2050 (Figure 7.19). In the western end of the bay this may impact on the coastal edge of the sand and gravel quarry. Towards Newbie Cottages (and surrounding buildings) the modern shoreline has retreated around 13 m at a rate of 0.4 m/yr. Based on this rate by 2050, these buildings will lie within 60 m of MHWS, as do the buildings at Newbie Mains some 600 m along the shore to the southeast. Recent air photography suggests coastal defences have been constructed to protect the access tracks fronting the farm house and buildings. Towards the east, Newbie Villa lies at the outer edge of the erosion influence (being 10 m from MHWS in 2050, based on uniform rates). The (former) petrochemical plant at Newbie has some coastal defences along its frontage that may prevent future erosion moving inland, however given their limited extent, there remains the potential of outflanking along the coast to the east.

Figure 7.19: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data at Newbie. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

7a.9 East of the Annan mouth to Seafield (Site 97)

Historical Change: Between 1898 and 1965, immediately east of the exit of the Annan Water, extensive areas of saltmarsh have undergone accretion in the west and erosion in the east as far as the pier at Seafield (Figure 7.20). The Point itself is the artificial landfall of a 2 km long viaduct of the Solway Junction Railway linking Annan in Scotland to Bowness-on-Solway in England, which was completed in 1869 (Figure 7.21). Up to 40 m of accretion in the west and up to 80 m of recession in the east toward the Point occurred over this period. Between 1965 and 2014 however, this pattern reversed to produce losses of 40 m in the west so that MHWS reoccupied its 1890 position. Over the same period, losses continued in the central section position, so that MHWS 2014 now lies 20m landward of its 1965 position. The foreshore forms part of the Solway Firth Special Area of Conservation, Upper Solway Flats and Marshes Special Protection Area and Site of Special Scientific Interest.

Figure 7.20: MHWS position in 1890, 1970s, and Modern datasets at east of the Annan mouth. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Figure 7.21: The Solway Junction Railway viaduct at Bowness on Solway, looking north toward its landfall at Annan (http://www.visitcumbria.com/car/solway-junction-railway/)

Future Vulnerability: Over 2 km of coast west of the exit of the Annan Water shows erosion across the recent period which, if these rates continue, will result in losses of up to 60 m in places by 2050 (Figure 7.22). However, the losses are mainly confined to saltmarsh with no fixed assets affected or nearby. One exception to this is at Dornock Point itself where rates of erosion have occurred over recent years to 2014 on the western side. Nevertheless, the rubble foundations of the old railway pierhead remain in place and will likely arrest any landward recession in the future.

Figure 7.22: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data position east of the Annan mouth. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

7a.10 Torduff Point (HM Factory, Gretna) to Redkirk Point (Gretna) (Site 98)

Historical Change: The shoreline between 1898 and 1956 at Torduff Point remained largely stable either side of the Point and along the frontage of the weapons manufacturing site (HM Gretna) (Figure 7.22). HM Gretna was the largest manufacturing facility for Cordite (gun powder) in World War One. In the period between 1956 to 2014 however, both sides of Torduff Point have experienced some retreat with the 2014 MHWS now lying up to 30 m landward of its 1956 position.

Figure 7.23: MHWS position in 1890, 1970s, and Modern datasets at Torduff Point. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

On both west and east sides of Redkirk Point, to the east of Torduff Point, recession of MHWS of up to 150m occurred from 1898 to 1956 and then a further 50m from 1956 to 2014, although the position of the 1890 line has been affected by substantial changes in the configuration of the intertidal sand banks here. The foreshore forms part of the Solway Firth Special Area of Conservation, Upper Solway Flats and Marshes Special Protection Area and Site of Special Scientific Interest.

Future Vulnerability: The manufacturing of Cordite in World War One at HM Gretna ceased after the war and the facility used for storage subsequently. Based on past rates, the anticipated position of MHWS is up to 30 m inland of its current position over about 3 km equally split between the west and east face of Torduff Point (Figure 7.24). Aerial photography suggests that a perimeter bund (probably earthen and thus erodible) fringes the promontory just landward of the fronting saltmarsh edge and since the entire site is low-lying there is a future erosion risk leading to additional flood risk that may release buried contaminants. This future erosion covers a further 2.5 km either side of Redkirk Point with recession of up to 40 m anticipated by 2050 of mainly saltmarsh and agricultural land with no fixed assets such as building or roadways at risk.

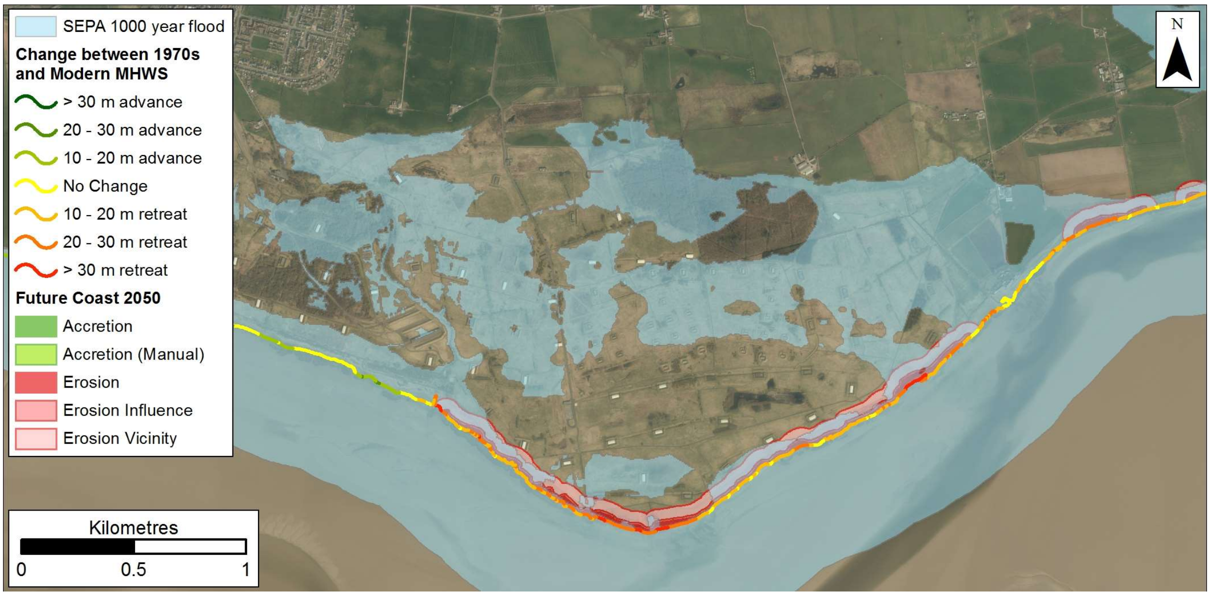

Figure 7.24: Possible future coastline position in 2050 based on rates between 1970 and Modern MHWS data at Torduff Point. Getmapping are our current providers of Scotland-wide digital aerial imagery© Getmapping plc.

Coastal Change Statistics for Cell 7

Within the soft sections of Cell 7, **31%** has been **advancing** between **1890 and 1970**; compared with **19%** between **1970 and modern data**.
Within the soft sections of Cell 7, **26%** has been **retreating** between **1890 and 1970**; compared with **21%** between **1970 and modern data**.
Within the soft sections of Cell 7, the **average rate of advance** is **1.9 m/yr** between **1890 and 1970**, and **2.1 m/yr** between **1970 and modern data**.
Within the soft sections of Cell 7, the **average rate of retreat** is **-1.1 m/yr** between **1890 and 1970**, and **-2.2 m/yr** between **1970 and modern data**.
Within the soft sections of Cell 7, **43%** has **not changed** significantly between **1890 and 1970**; compared with **60%** between **1970 and the modern data**.

Table 7.2: A summary of the average rates, average change distances, and lengths of advance, retreat, and no change within sub-cells of Cell 7.

Coastal Cell	Overall change (1)			Advance (2)			Retreat (3)			Insignificant change (4)		
	Average 1890 to 1970 Change on Soft Coast (m)	Average 1890 to 1970 Change Rate on Soft Coast (m/year)	Length of Soft Coast (km)	Average 1890 to 1970 Soft Coast Advance (m)	Average 1890 to 1970 Advance Rate on Soft Coast (m/year)	Length of Soft Coast Advance (km)	Average 1890 to 1970 Soft Coast Retreat (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Coast Retreat (km)	Average 1890 to 1970 Soft Coast Insignificant Change (m)	Average 1890 to 1970 Retreat Rate on Soft Coast (m/year)	Length of Soft Insignificant Change (km)
Cell 7	23.2	0.31	286.4	146.8	1.91	88.4	-84.6	-1.06	73.8	-0.7	-0.01	124.3
	-	-	-	-	-	30.9%	-	-	25.8%	-	-	43.4%

Coastal Cell	Overall change			Advance			Retreat			Insignificant change (4)		
	Average 1970 to Modern Change on Soft Coast (m)	Average 1970 to Modern Change Rate on Soft Coast (m/year)	Length of Soft Coast (km)	Average 1970 to Modern Soft Coast Advance (m)	Average 1970 to Modern Advance Rate on Soft Coast (m/year)	Length of Soft Coast Advance (km)	Average 1970 to Modern Soft Coast Retreat (m)	Average 1970 to Modern Retreat Rate on Soft Coast (m/year)	Length of Soft Coast Retreat (km)	Average 1970 to Modern Soft Coast Insignificant Change (m)	Average 1970 to Modern Retreat Rate on Soft Coast (m/year)	Length of Soft Insignificant Change (km)
Cell 7	-12.5	0.07	290.6	69.1	2.08	53.7	-119.8	-2.16	61.7	0.3	0.01	175.2
	-	-	-	-	-	18.5%	-	-	21.2%	-	-	60.3%

1 Overall change shows the mean value for the whole cell / sub-cell, averaging gains and losses.
2 Advance shows the mean value for the shoreline gains, where there has been greater than 10 m of change, or change which is faster than 0.5 m/yr.
3 Retreat shows the mean value for the shoreline losses, where there has been greater than 10 m of change, or change which is faster than 0.5 m/yr.
4 Insignificant change shows the lengths of coastline which have changed less than 10 m.

NB: Avoid comparing distances of change (i.e. km) but rather use proportions (i.e. %) to avoid cartographic differences between the years.

Table 7.3: A summary of the length of change within each change distance category in the historical (ca. 1890-1970) and recent (ca. 1970-Present) time periods in Cell 7.

1890-1970	**Cell 7**	
	Length (km)	**Length (%)**
>30 m Advance	56.0	20%
20-30 m Advance	9.0	3%
10-20 m Advance	23.4	8%
No Change	124.3	43%
10-20 m Retreat	28.0	10%
20-30 m Retreat	10.2	4%
>30 m Retreat	35.7	12%
Total length	**286.4**	**100%**

Max advance (m)	887.9	Wigtown
Average change (m)	23.2	
Max retreat (m)	-792	Mersehead Sands

1970-Modern	**Cell 7**	
	Length (km)	**Length (%)**
>30 m Advance	30.9	11%
20-30 m Advance	8.5	3%
10-20 m Advance	13.5	5%
<10m Advance but >= 0.5 myr^{-1}	0.7	0%
No Change	175.2	60%
<10m Retreat but <= -0.5 myr^{-1}	0.4	0%
10-20 m Retreat	17.7	6%
20-30 m Retreat	8.0	3%
>30 m Retreat	35.6	12%
Total length	**290.6**	**100%**

Max advance (m)	536	Mersehead Sands
Average change (m)	-12.5	
Max retreat (m)	-595	Caerlaverock

Asset Vulnerability Statistics for Cell 7

Table 7.4: A summary of the number, length, or area of assets within the erosion, erosion influence, and erosion vicinity buffers of the future coastline projections for Cell 7.

Cell 7	Units	Modern to 2050				2050+			
		Erosion	Erosion Influence	Erosion Vicinity	Total	Erosion	Erosion Influence	Erosion Vicinity	Total
Community Services	Number	-	-	-	-	-	-	-	-
Non Residential Property		-	-	3	3	-	-	5	5
Residential Property		7	3	44	54	16	8	50	74
Septic Water Tanks		1	-	-	1	1	-	-	1
Utilities		-	-	-	-	-	-	-	-
Rail	Length (km)	-	-	0.2	0.2	0.0	0.0	0.9	1.0
Roads (SEPA)		-	-	1.0	1.0	0.1	0.0	1.1	1.3
Roads (OS)		-	0.1	0.8	0.9	0.2	0.2	0.8	1.2
Clean Water Network		0.1	0.3	1.5	1.9	0.8	0.5	1.0	2.3
Total Anticipated Erosion	Area (hectares)	110.2	26.3	150.7	287.2	217.2	29.3	160.2	406.7
Runways		-	-	-	-	-	-	-	-
Cultural Heritage		0.3	0.3	2.3	2.9	0.9	0.4	2.7	4.1
Environment		93.7	19.8	83.2	196.8	161.7	15.9	65.3	242.8
Flooding (200 year envelope)		100.8	18.7	89.7	209.2	177.5	18.3	86.0	281.8
Flooding (1000 year envelope)		103.8	20.3	100.7	224.7	184.9	20.3	99.3	304.4
Erosion within PVAs		84.0	17.3	97.6	198.9	161.5	19.0	104.7	285.2
Erosion outwith of PVAs		26.1	9.0	53.1	88.3	55.7	10.4	55.5	121.5
Battlefields		-	-	-	-	-	-	-	-
Gardens and Designed Landscapes		0.4	0.3	2.3	3.1	1.1	0.4	2.8	4.3
Properties in Care		-	-	-	-	-	-	-	-
Scheduled Monuments		-	-	0.1	0.1	6.0	0.5	2.5	9.0
Nature Conservation Marine Protected Areas		-	-	-	-	-	-	-	-
National Nature Reserves (NNR)		60.3	6.2	30.6	97.1	93.6	5.3	26.7	125.7
Special Areas of Conservation (SAC)		82.5	15.0	63.7	161.2	137.7	12.0	52.5	202.2
Special Protection Areas (SPAs)		82.5	15.1	64.6	162.3	138.2	12.3	53.0	203.5
Sites of Special Scientific Interest (SSSI)		93.9	17.1	75.3	186.3	158.2	14.2	64.2	236.6

References

Ramsay, D.L. and Brampton, A.H. (2000) Coastal Cells in Scotland: Cell 7 - Mull of Galloway to the Inner Solway Firth. Scottish Natural Heritage Research, Survey and Monitoring, Report No 149.

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