REPORT

Whitburn Coastal Footpath Adaptation Strategy

Client: South Tyneside Council

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Royal HaskoningDHV
Enhancing Society Together

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P01	Phase 1 Interim Issue	Nick Cooper	08/02/2022
P02	Full Issue (Phase 1 and 2) Incorporating Drone Survey Data	Nick Cooper	21/03/2022
P03	Addressing Client Comments	Nick Cooper	12/04/2022

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1 Introduction

In some locations along the Whitburn coastline, the coastal footpath is under threat from ongoing erosion causing undercutting, caving, and slumping of the clifftop. Whilst current monitoring data demonstrates that cliff erosion rates are fairly low in this location, this does not reflect the episodic erosion that occurs from time to time when relatively large sections of cliff can be lost (locally) in a single failure event. There are a number of pinch points where such events have caused parts of the footpath to fall away in the past, triggering footpath closures.

South Tyneside Council requires definitive advice on thresholds and actions to be undertaken in situations where erosion or cave formation threatens to compromise the safety of the members of the public using the clifftop footpath. Royal HaskoningDHV has been commissioned to address this in the form of an Adaptation Strategy (incorporating an Emergency Response Plan). The Adaptation Strategy considers:

1. Threshold for when planning for an alternative route should be instigated, taking into consideration the time to carry out the options appraisal and carry out any necessary improvements that may be required such as an alternative route while options for roll back are considered.

2. Thresholds for footpath diversions to ensure public safety in the event that erosion increases risks to unacceptable levels.

In the event that threshold 2 is exceeded, emergency responses are also considered.

In line with the brief, the study area has been split into two phases, Phase 1 covering approximately 1.1 km of coastline from Whitburn Bents Car Park to the southern boundary of the historic firing range and Phase 2 covering approximately 1.15 km from the southern boundary of the firing range to the southern edge of the Nature Reserve. The extents of the Phases are presented in *Appendix A*.

Phase 1 was reported in an Interim Report issued 08/02/2022,this report extends the Interim Report to now also cover Phase 2.

2 Data Gathering

2.1 Cell 1 Regional Coastal Monitoring Programme

The Cell 1 Regional Coastal Monitoring Programme covers approximately 300 km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales. Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial till to varying thicknesses, softer rock cliffs, and extensive landslide complexes.

The work commenced with a three-year monitoring programme in 2008 that was managed by Scarborough Borough Council on behalf of the North East Coastal Group. This initial phase was followed by a series of five-year programmes from 2011-2016, 2016-2021 and the current six-year programme due for completion in 2027.

The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

1. beach profile surveys
2. topographic surveys
3. cliff top recession surveys
4. real-time wave data collection
5. bathymetric and sea bed characterisation surveys
6. aerial photography
7. walkover inspection surveys
8. laser scan surveys (at key locations)

Elements of data acquired from this ongoing regional-scale monitoring programme have been used to help substantiate the recommendations made in this Adaptation Strategy.

2.2 Walkover Survey

On Friday 21st of January 2022, Royal HaskoningDHV undertook a walkover inspection along the foreshore and cliff top of the study area in Whitburn. Due to the lead times for the aerial drone survey, coupled with the time constraints proposed for Phase 1, the purpose of the walkover survey was to inform the interim report, issued on February 8th, 2022.

2.3 Aerial Drone Survey

Following the walkover survey, *Academy Geomatics Ltd* completed an aerial drone survey of the study area on Thursday 3rd of February 2022. By flying a drone at varying altitudes, a series of overlapping images were captured of the cliff top, cliff face (including any areas of undercutting / caving) and foreshore. The overlapping imagery was then used to produce a RGB (Red, Green and Blue) colour point cloud allowing full analysis of the frontage. The footpath position and level were also captured during this process allowing the caving to be analysed relative to the position of the path. Notes from the walkover were used to corroborate the findings and ‘fill in’ any minor gaps from the drone survey.

3 Cliff Profiles

Following the walkover inspection, and subsequent drone survey, it is apparent that the cliff form varies along the 2.25km study area. At the southern extent, fronting Whitburn Bents car park, the sloping cliff is well vegetated and fronted by a small dune. It is believed that the dunes are offering protection to the backing cliffs against marine erosion as this section of cliffs appears stable.

Northwards of the dunes, the cliffs are formed of a thin magnesian limestone shelf, mantled with a thick deposit of glacial till. The till layer is angled at its natural angle of repose, approximately 45°. The slopes are much more sparsely vegetated indicating that the cliffs are more active. This erosion has resulted in the ‘scalloping’ of the cliff top as local sections have differentially suffered small erosion events.

Moving further northwards, past Whitburn Academy, the limestone strata gradually rises in elevation, in turn reducing the glacial till thickness. As a result, the cliffs are steeper and begin to become undercut at the toe, often creating an overhang in the cliff face. Some limited caving is noted in the protruding rocky headlands, although due to the angle of incision (parallel to the general cliff alignment, indenting into the protruding headland), it is thought the majority pose limited threat to the footpath.

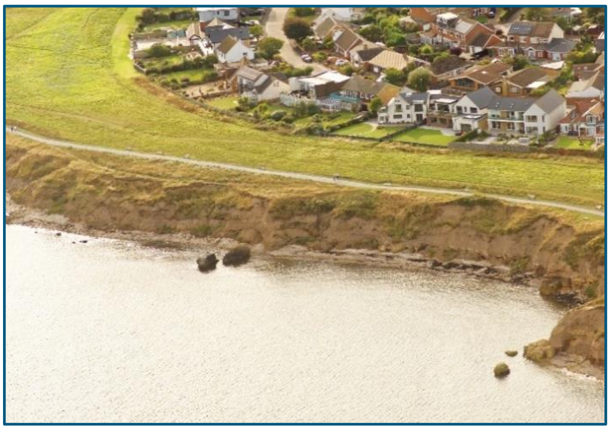
At the former firing range, at the corner of the first earth butt, the cliffs begin to reduce in height from approximately 10m to 4m towards Souter Point. This is a result of the lowering of the cliff top rather than the raising of the foreshore. In this area a stratum of weathered rock can also be seen above the magnesian limestone layer. A combination of the reduction in height of the cliff and addition of a weathered rock stratum has resulted in an apparent reduction in undercutting of the cliffs in this section. Within this area, local low spots in the topography appear to be funnelling water over the cliff top resulting in the scouring back of the glacial till layer.

North of Souter point, the cliffs backing Whitburn (Jackie’s) beach are well vegetated and fronted by a raised grassed platform homing Finns Labyrinth (a stone maze monument). It is believed this grassed area has detached the cliffs from marine erosion as the cliffs appear stable.

From the northern end of Whitburn beach to the end of the study area, at the boundary of the nature reserve, the cliffs once again compromise a thin glacial till layer mantled on magnesian limestone cliff. Caving and undercutting is again noted along this section.

The variance in cliff form along the Whitburn frontage will result in differences in failure mechanisms and erosions rates. Therefore, for the purposes of analysis and reporting, the frontage has been divided into six sub-sections, namely Area A to F. Each area is marked on drawings PC1950-0001 and PC1950-0002 (*Appendix B*) and sample photographs are shown in *Figure 1.*


Area A – Well vegetated sloping cliff fronted by dune of increasing width.
(Left) Image from drone survey (Right) Oblique Aerial Image from Cell 1 monitoring programme

Area B – Thick glacial till deposits mantled on thin limestone shelf.
(Left) Image from site walkover (Right) Oblique Aerial Image from Cell 1 monitoring programme


Area C – Magnesian limestone rising in elevation, resulting in steeper, harder cliffs.
(Left) Image from site walkover (Right) Oblique Aerial Image from Cell 1 monitoring programme.


Area D – Decreasing cliff heights fronting firing range, stratum of weathered rock present
(Left) Image from drone survey (Right) Oblique Aerial Image from Cell 1 monitoring programme


Area E – Well vegetated sloping cliffs backing Whitburn (Jackies) Beach, detached from marine processes by grassed platform.
(Left) Image from site walkover (Right) Oblique Aerial Image from Cell 1 monitoring programme


Area F – Undercutting Magnesian limestone cliffs
(Left) Image from drone survey (Right) Oblique Aerial Image from Cell 1 monitoring programme

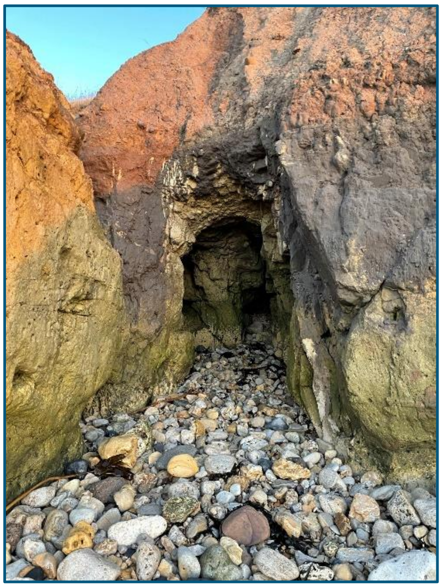
Figure 1 – Study area divided into six sub-sections due to variance in cliff form

3.1 Notable Caves

Phase 1

As discussed above, only a limited number of caves were observed along Phase 1. Along the majority of Areas A and B, the limestone strata is too thin for caves to form. More caving was observed in Area C, as the limestone strata increased, however the caving was largely limited to the protruding rocky headlands and so posed limited threat to the coastal footpath. A general overhang in the order of 1 to 2m was observed along the length of Area C. *Figure 2* shows two of the most notable caves observed in Phase 1, the position of the caves are marked on the drawings PC1950-0001 and PC1950-0002 found in Appendix B.

It may be that the true extent some of the caves/undercutting was obscured by high beach sediment on the day of the inspection, but this is unlikely.




Cave 1 (Area B) - Approximately 2m wide, 2.5m high and 4m deep
(Left) Image from drone survey (Right) Annotated RGB point cloud

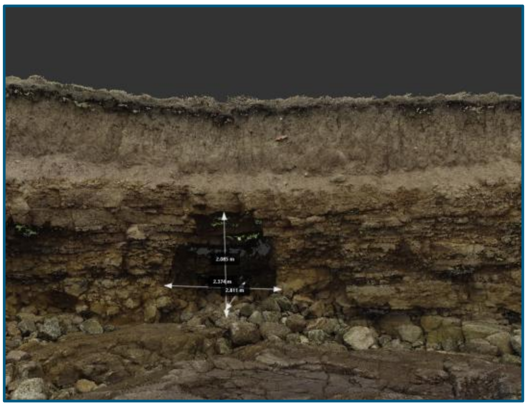

Cave 2 (Area C) – Approximately 4m wide, 4m high and 2m deep
(Left) Image from drone survey (Right) Annotated RGB point cloud

Figure 2 – Significant caves in Phase 1

Phase 2

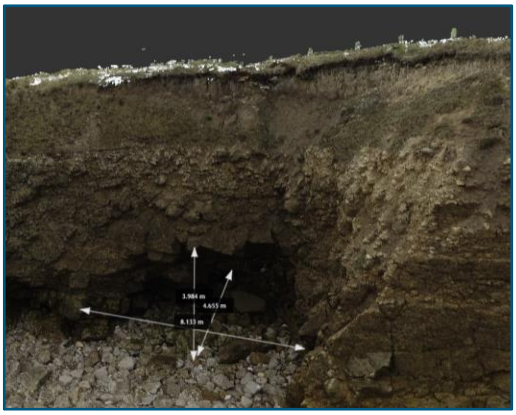
Similarly, in Phase 2, the caving was largely limited to Areas C and F where the magnesian limestone strata was at its highest. *Figure 3* shows a selection of the most notable caves observed in Phase 2, the position of the caves are marked on the drawings PC1950-0001 and PC1950-0002 found in *Appendix B.*


Cave 3 (Area C) – Approximately 8m wide, 3m high and 4m deep
(Left) Image from drone survey (Right) Annotated RGB point cloud

Cave 4 (Area D) - Approximately 2.5m wide, 2m high and 3m deep
(Left) Image from drone survey (Right) Annotated RGB point cloud


Cave 5 (Area F) – Approximately 7m wide, 5m high and 4.5m deep
(Left) Image from drone survey (Right) Annotated RGB point cloud



Cave 6 (Area F) - Approximately 8m wide, 4m high and 4.5m deep
(Left) Image from drone survey (Right) Annotated RGB point cloud

Figure 3 – Significant caves in Phase 2

One of the most significant caves noted during the walkover survey is shown in *Figure 4*. The large cave is located just north of the southern boundary of Whitburn nature reserve and therefore falls outside of the current study area. It is recommended the council undertake a similar study in this area to assess the risk of undercutting to the English Coastal Footpath.

Cave 7 (Out of Study Area) - Approximately 8.5m wide, 3m high, 6m deep.
(Left) Image from drone survey (Right) Annotated RGB point cloud

Figure 4 – Significant cave observed outside of study area

3.2 Surface Water Erosion

In Area D local low spots in the topography are channelling water over the cliff top, resulting in the scouring back of the glacial till layer. This is clearly demonstrated in *Figure 5*, where the areas of increased erosion correspond with low spots in topography shown in red and yellow. It is thought these areas will continue to locally retreat at a greater rate than the adjacent cliffs unless the drainage in these areas is formalised.

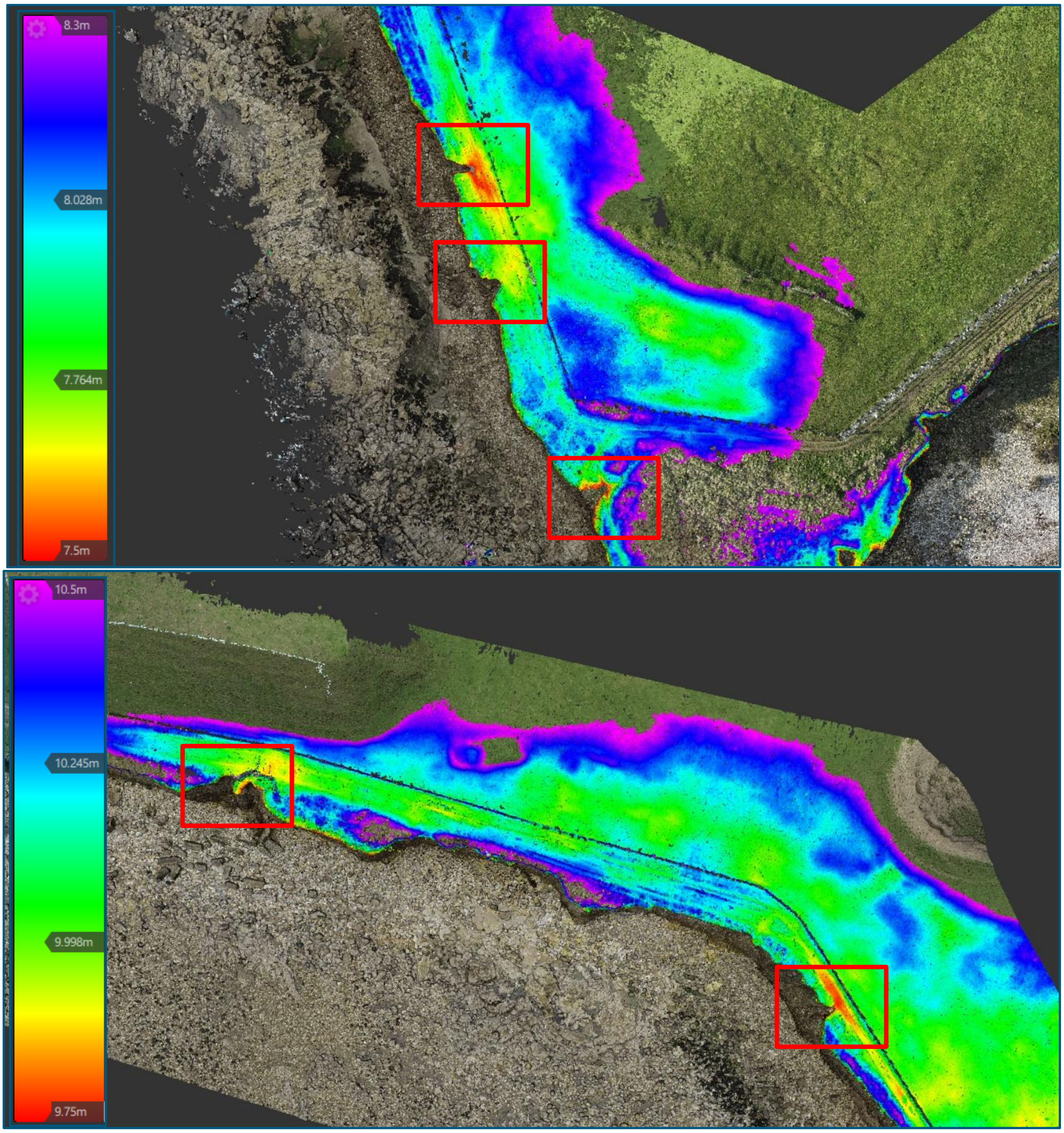


Figure 5 – Scouring of the clifftop caused by surface water

4 Review of Past Cliff Failures

In the following section, previous cliff failures along the Whitburn cliffs have been examined. The aim of the review of past failures is to establish the maximum magnitude of loss that can be expected in a single event.

4.1 Area A

The dunes are offering protection to the cliffs within Area A, so the cliffs currently are divorced from marine processes and therefore are considered dormant (i.e. stable). Whilst sub-aerial weathering may take place, the cliffs are well vegetated and such processes are unlikely to result in significant weathering. As a result, the maximum magnitude of failure in the cliffs in Area A is currently **0m.**

Once the dunes have been eroded by marine processes, recession of the cliff line is likely to reactivate. Once active, it is thought the maximum failure distance will be similar to that discussed in Area B below. The dunes should be monitored going forward for signs of recession. It is considered that the Cell 1 Regional Coastal Monitoring Programme’s surveys and inspections are of a suitable type and adequate frequency to monitor the onset of the erosion of the dunes.

4.2 Area B

Between 2018 and 2020, it is understood that in two locations within Area B, cliff failure events led to the emergency closure of the footpath and subsequent rolling back of its alignment. *Figure 3* shows a comparison plot between the most recent Lidar data available either side of the failures (2017 and 2021). This plot shows that the magnitude of loss in the two locations vary in plan form distance between 2m to 7.5m. As this loss incorporates all the changes over a 4 year monitoring period and due to the episodic nature of failure mechanism in this location (discussed further in section 5), it is estimated that the maximum magnitude of loss in a single failure is likely in the order of **3m**. This provides an indication for the maximum magnitude failure in the area which will be applied to the Whitburn Adaptation Strategy

4.3 Area C

In Area C, there is limited information available surrounding large or local scale failures. However, notable overhangs were observed along the length of the section during the walkover inspection. We therefore estimate that a single failure in the location of an overhang could cause cut back of up to **2m** at one time.

4.4 Area D

Figure 4 shows a comparison plot between Lidar data from 2017 and 2021 in an attempt to estimate the maximum magnitude of failure. This plot shows that the magnitude of loss in Area D varies in plan form distance between 1.9m to 2.8m. As this loss incorporates all the changes over a 4 year monitoring period and due to the episodic nature of failure mechanism in this location (discussed further in section 5), it is estimated that the maximum magnitude of loss in a single failure is likely in the order of **1.5m**.

4.5 Area E

Similar to Area A, the grassed platform is offering protection to the cliffs within Area E, so the cliffs currently are divorced from marine processes and therefore are considered dormant (i.e. stable). Whilst sub-aerial weathering may take place, the cliffs are well vegetated and such processes are unlikely to result in significant weathering. As a result, the maximum magnitude of failure in the cliffs in Area E is currently **0m.** Once the platform has been eroded by marine processes, recession of the cliff line is likely to reactivate. The platform should be monitored going forward for signs of recession.

4.6 Area F

Figure 4 shows a comparison plot between Lidar data from 2017 and 2021 in an attempt to estimate the maximum magnitude of failure. This plot shows that the magnitude of loss in Area D varies in plan form distance between 1.9m to 4m. As this loss incorporates all the changes over a 4 year monitoring period and due to the episodic nature of failure mechanism in this location (discussed further in section 5), it is estimated that the maximum magnitude of loss in a single failure is likely in the order of **2m**.

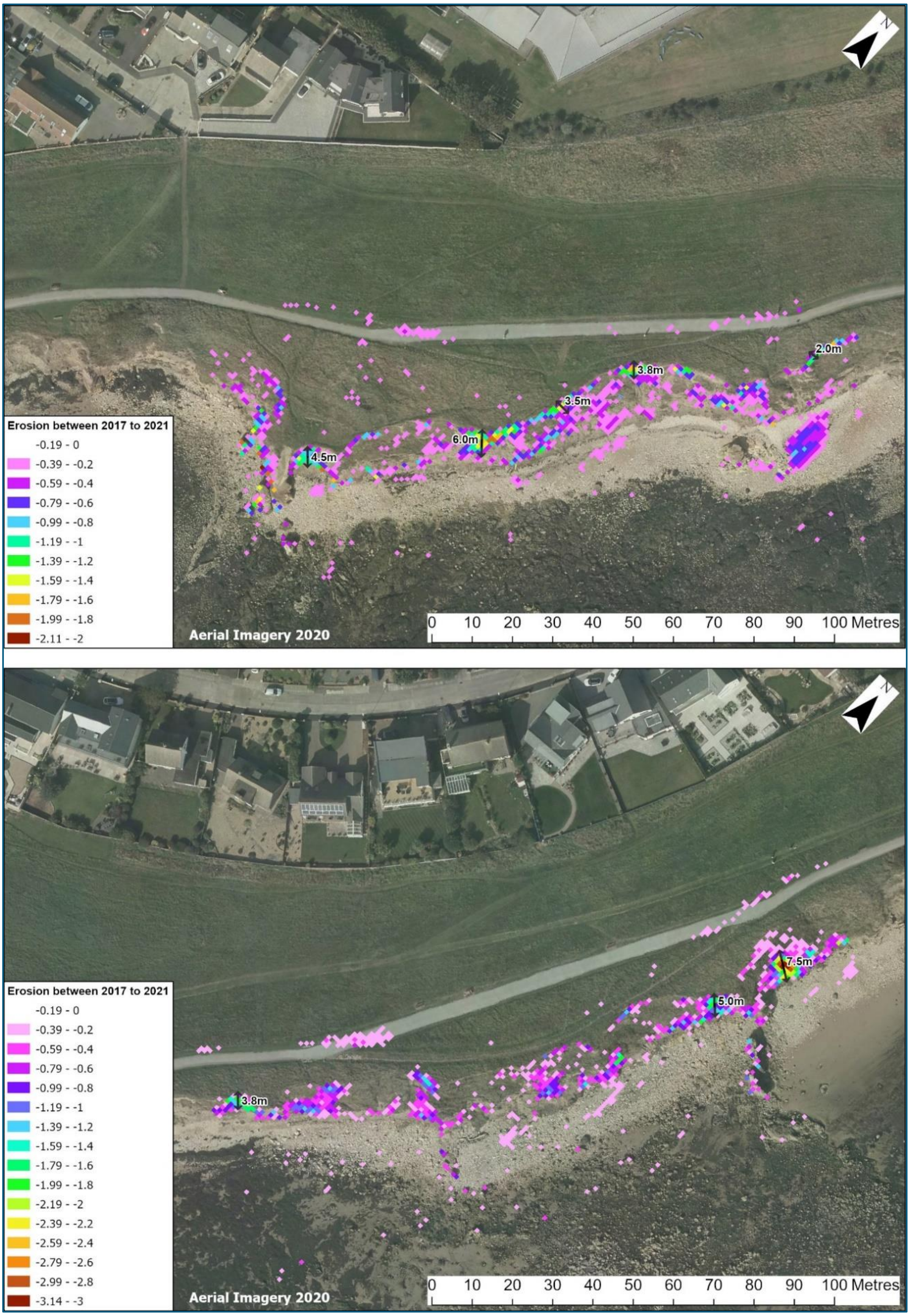


Figure 6 – Lidar comparison plot between 2017 and 2021 for footpath closures in Area B.

Figure 7 – Lidar comparison plot between 2017 and 2021 for Area D and F.

5 Failure Mechanisms

The following section demonstrates the cliff failure mechanism identified for the various cliff profiles identified along the Whitburn coastline.

As previously mentioned, whilst the dunes and grassed shelf are offering protection to Area A and Area E respectively, the cliffs are considered dormant (i.e. stable). Until this protection is eroded it is thought that it is unlikely that the cliffs within these two areas will fail.

In Area B, the typical stable position is a near-vertical face in the low limestone shelf, which is mantled by a thick glacial till layer resting at its natural angle of repose. The upper till steepens at the cliff top to a near-vertical profile, possibly due to support offered by the roots of vegetation growth (*Figure 8, step 1*). As can be seen, the toe of stable cliff begins to steepen through marine action in the till just above its intersection with the limestone (*Figure 8, step 2*). This steepening of the toe eventually leads to a local slip in the glacial till, causing the retreat of the cliff top (*Figure 8, step 3*). The cycle then repeats (*Figure 8, step 4*).

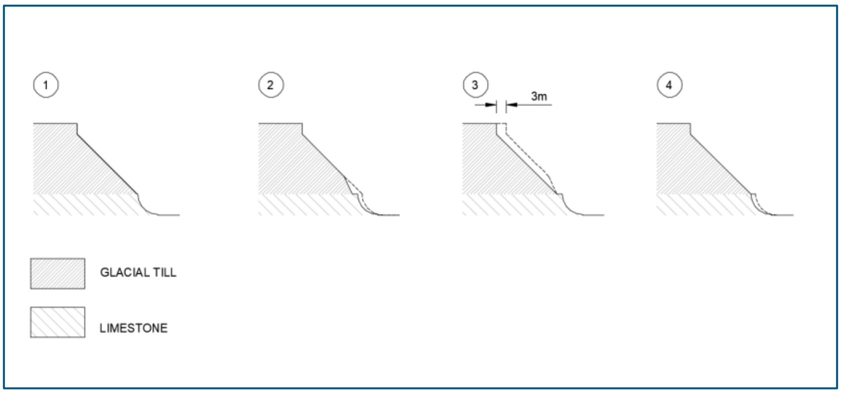


Figure 8 – Schematic diagram showing the cliff failure mechanism of Area B.

The typical stable position in Area C and Area F is a near-vertical face in the higher limestone cliffs, which are mantled with a thinner glacial till layer resting at its natural angle of repose. Again, there is a steepening to near-vertical profile in the till at the cliff top (*Figure 9*, step 1). As can be seen, the limestone cliff begins to get undercut by marine action (*Figure 9*, step 2). This continuing undercutting eventually results in a failure along a vertical shear plane (*Figure 9*, step 3) causing a local rock fall. If a large vertical failure occurs, it is anticipated that the overlying glacial till will weather back to its natural angle of repose, a 1:1 slope angle is assumed for this (*Figure 9*, step 4).

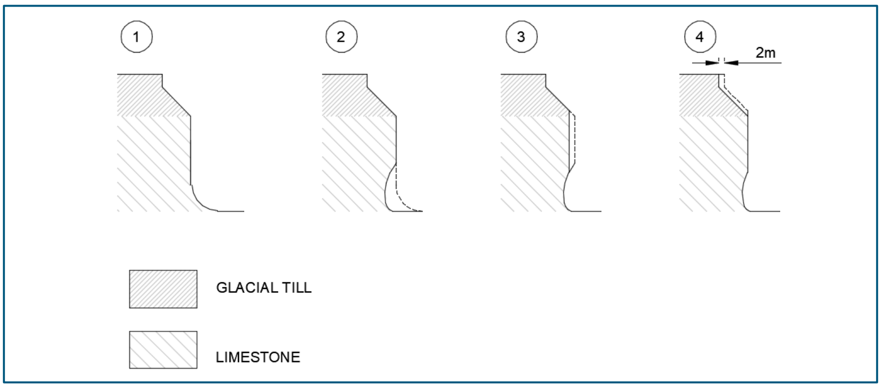


Figure 9 – Schematic diagram showing the cliff failure mechanism of Area C and F.

It is believed the failure mechanism for Area D, shown in *Figure 10*, is similar to that of Area C and F discussed above. However, it is thought the combination of the weathered rock strata and smaller cliff heights result in limited cave depth in this location

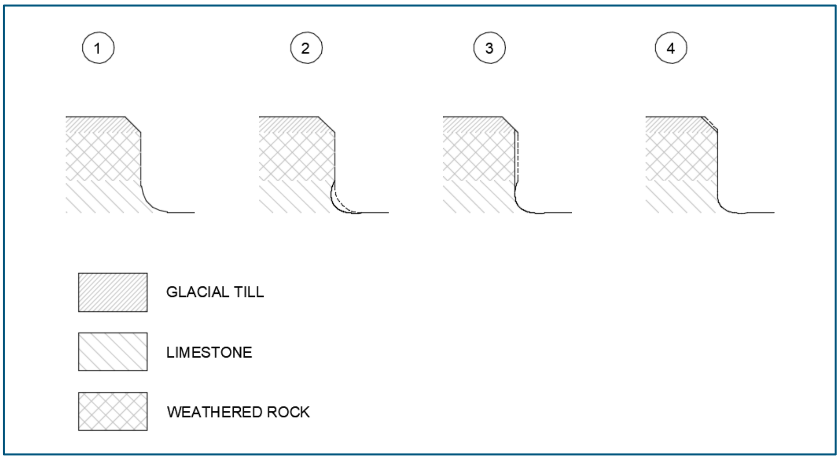


Figure 10 – Schematic diagram showing the cliff failure mechanism of Area D.

6 Erosion Rates

The succession of individual episodic failure events can be averaged as an annual erosion that can be used as a useful metric of net medium and long-term change. However, it is noteworthy that the erosion process is not necessarily continuous at this rate each and every year; rather there can be several years of zero activity followed by one single event that cuts the cliff top back.

The Shoreline Management Plan 2 (SMP2) predicts a baseline annual erosion rate of 0.1m/year from Whitburn Bay through to Souter Point. In order to corroborate this erosion rate, aerial mapping, obtained from the Cell 1 Regional Coastal Monitoring Programme, was used to trace the comparison between the cliff line in 2010 and 2020. This exercise showed that, over the 10 year period, the rates of erosion were more varied across the frontage. Over the 10 year period, the dunes protecting the cliffs within Area A appear to have experienced a negligible change; as have the cliffs themselves. The softer, glacial till cliffs north of Whitburn Bents car parks within Area B experienced approximately 0.3 to 0.4 m/year recession. The harder cliffs north of the Academy within Area C were more in line with the SMP2 rates, experiencing approximately 0.1 to 0.2 m/year. As the cliffs reduce in height towards Souter point, the rate of recession is line with the 0.1m/year predicted in the SMP2.

At Souter Bay (*assumed alternative naming for Jackie's Beach*), the SMP2 predicts a baseline erosion of 0.2m/year reducing in magnitude against the harder cliffs. The corroboration exercise, described above, indicates that the cliffs backing Jackie's Beach have experienced > 0.1m/year and the cliffs north of Souter Bay have experienced between 0.1m/year and 0.2m/year.

Table 1 presents the assumed erosion rates to be used in this Adaptation Strategy. The variance in erosion rates compared to the SMP2 may be that the SMP2 averages the erosion across the whole frontage or simply that erosion has increased in the years since the SMP2 was published.

Table 1 – Baseline Erosion Rates compared to SMP2

Area	SMP2 Baseline Erosion Rate	Assumed Erosion Rate for Adaptation Strategy
Area A	0.1m/year	0.1m/year (Applied to dunes)
Area B	0.1m/year	0.3m/year
Area C	0.1m/year	0.2m/year
Area D	0.1m/year	0.1m/year
Area E	0.2m/year	0.2m/year (Applied to grassed platform)
Area F	<0.2m/year	0.2m/year

7 Future Projections

In its Appendix C, the River Tyne to Flamborough Head SMP2 (produced in 2007) produced a series of maps showing the projected position of the shore for the short (2025), medium (2055) and long (2105) epochs under a No Active Intervention (NAI) scenario throughout the plan area. The future shoreline projections were based upon analysis of historic changes at discrete points along the coast (with interpolation in between), past and projected sea level rise, and application of expert assessment in the evolution of the coast.

The study area for this Whitburn Footpath Adaption Stratergy is split between Management Area 5 and Management Area 6, the future projections of which are presented in *Figure 11*. In Phase 1, These projections show that under a NAI policy, the cliff will continue to erode, reducing the width of open ground between the properties and the top of the cliffs but not affecting the assets over the 100 years of the SMP. This gradual retreat however does mean erosion will continue to impinge upon the coastal footpath.

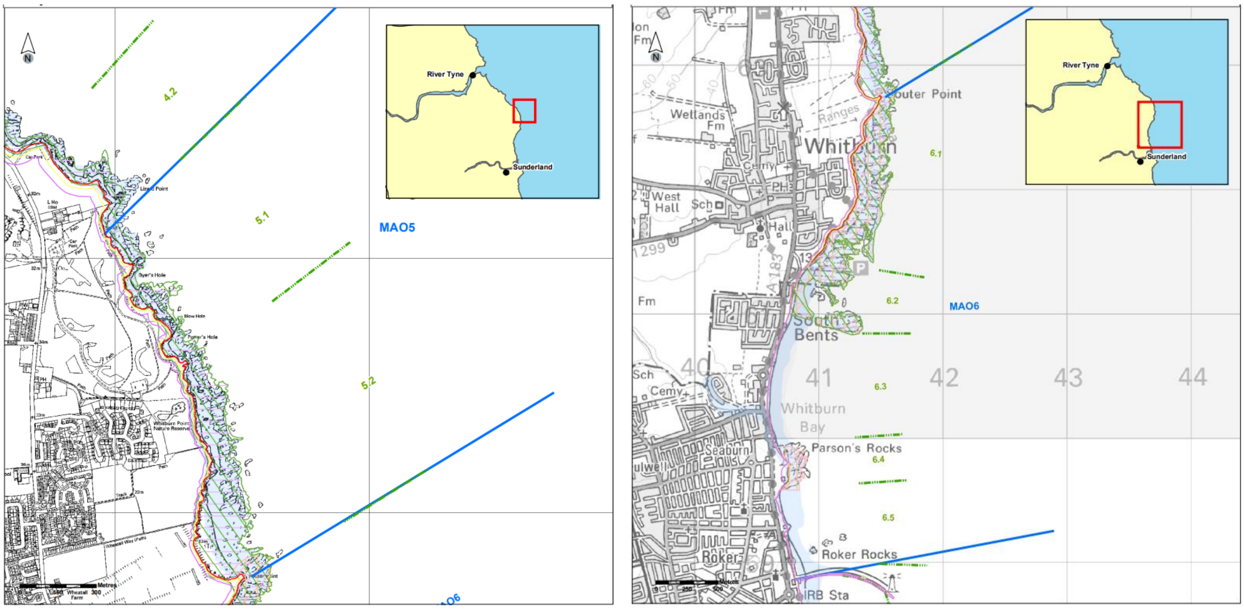


Figure 11 – Shoreline Management Plan 2 'No Active Intervention' Coastal Evolution Projections for Management Area 5 (left) and Management Area 6 (right)

The SMP2 projections of future shoreline position were made using the then best scientific advice on sea level rise projections, namely Defra's 2006 *Supplementary Note to Operating Authorities on Climate Change Impacts*. Since that time, not only has the 2006 guidance been superseded by the United Kingdom Climate Projections (UKCP) 2009 scientific outputs named UKCP09, but that too has been updated with newer outputs in 2018, named UKCP18. *Figure 12* shows a comparison of projected changes in sea level from a 2007 baseline (for the purposes of this study) to 2099 between the original 2006 guidance allowances and selected data from the UKCP18 User Interface for a model grid cell in the North Sea adjacent to the study area. The figure shows:

- Defra 2006 guidance allowances
- UKCP18 'standard method' projections from Representative Concentration Pathway (RCP) 2.6 for the 50-percentile value – this RCP assumes that greenhouse gas emissions are stabilised to a flat line by 2050
- UKCP18 'standard method' projections from Representative Concentration Pathway (RCP) 4.5 for the 50-percentile value – this RCP is approximately equivalent to the 'Low' emissions in UKCP09
- UKCP18 'standard method' projections from Representative Concentration Pathway (RCP) 8.5 for the 50-percentile and 95-percentile values – this RCP is approximately equivalent to the 'High' emissions in UKCP09

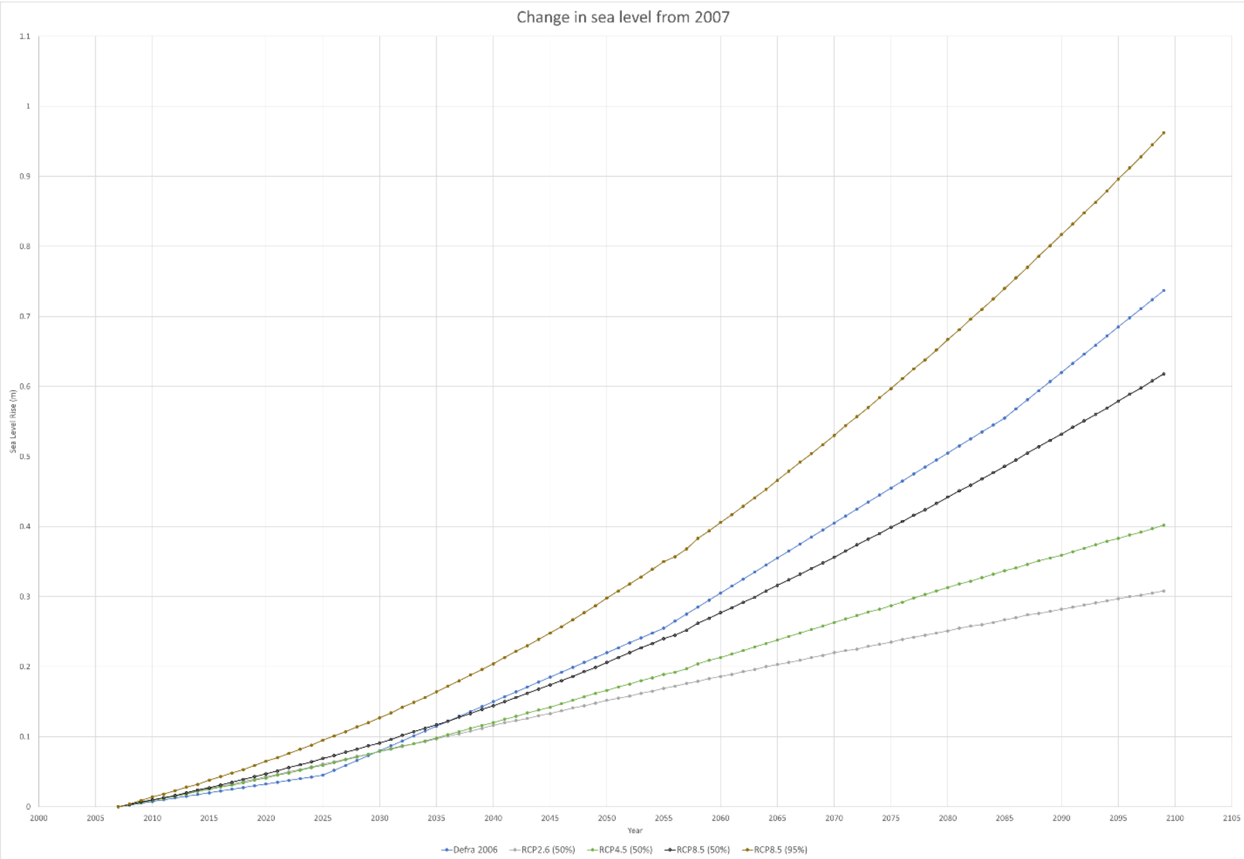


Figure 12 – Projections of change in sea level from 2007 at Whitburn

It can be seen that the Defra 2006 guidance allowances are somewhere between the 50-percentile and 95-percentile values of RCP8.5 from 2036 onwards. This shows that the use of the Defra 2006 guidance allowances in the SMP2 projections provides a robust assessment of likely future change over medium and long term epochs. However, it can also be seen that between 2007 and 2029 the Defra 2006 guidance allowances are lower than all other projections presented from UKCP18. This implies that the some of the effects projected in the SMP2 over the short and medium term epochs may become manifest within a shorter timescale than originally envisaged in 2007 when the SMP2 was published. Between 2030 and 2035, the Defra 2006 guidance allowances are between the UKCP18 RCP4.5 (50-percentile) and UKCP18 RCP8.5 (50-percentile) values.

Whilst the above findings do not alter the outcome of the SMP2's recommendations, it places greater urgency on the need to consider options for realignment of the coastal footpath.

The shape of the curves on *Figure 12* reflects the scientific uncertainties regarding predicted Sea Level Rise (SLR). Within the next 15-20 years, the SLR curves remain bounded relatively closely together, highlighting a higher level of confidence in the projections over shorter timescales, In contrast, after circa 2040, the lines start to significantly fan out, reflecting the greater uncertainty within the scientific community regarding longer term projections of SLR. This is to be noted when considering the predicted erosion rates below.

7.1 Effects on Erosion Rate

In order to project the likely, increase in erosion rate associated with the increase in sea level of future epochs, a Scale Factor has been calculated based on the equation below.

The Environment Agency published updates in July 2020 to two guidance documents used to determine appropriate allowances for projected climate change. In accordance with this latest available guidance, the UKCP18 outputs used for the analysis is the RCP8.5 (95 percentile)

$$Scale\ Factor = \frac{Future\ Rate\ of\ Sea\ Level\ Rise}{Past\ Rate\ of\ Sea\ Level\ Rise}$$

Table 2 presents the predicted increase in erosion when this Scale Factor is applied to the baseline erosion rates;

Table 2 – Predicted increased erosion rates

	Baseline Erosion Rate (m/year)	Erosion by 2050 (m/year)	Erosion by 2100 (m/year)
Area A	0.10	0.16	0.28
Area B	0.30	0.48	0.84
Area C	0.20	0.32	0.56
Area D	0.10	0.16	0.28
Area E	0.10	0.16	0.28
Area F	0.20	0.32	0.56

8 Receptors

8.1 Coastal Footpath

Within the study area, the England Coast Path runs in close proximity to the cliff top from Whitburn Bent car parks to Whitburn Nature Reserve with its form and width varying across the frontage.

For the first 850m from Whitburn Bents car park, the England Coast Path coincides with the National Cycle Network Route 1. As a result, this section of path is 3m wide and is formalised with compacted gravel. As the National Cycle Network Route 1 returns into Rackly Way, the England Coast Path continues along the cliff top and becomes unformalised. It is apparent that there a number of parallel ‘desire lines’ (informal pathways through the cliff top grassland) within or adjacent to the footpath itself causing the width of footpath to sprawl. Sections of the path seem to have once been formalised with a similar construction to near the car park, with areas of stone concealed below layers of mud.

A timber fence line runs adjacent to the footpath from the rifle range onwards demarking the landownership from the fields behind.

Through discussion with the council, it is understood that a 3m wide footpath is to be constructed along the whole study area. The footpath will include a 1m verge either side. From the rifle range northwards, a timber fence will be reinstated adjacent to the footpath. The proposed arrangement is shown in *Figure 13*. It is recommended that the old footpath construction is removed, and the informal desire paths are scuffed and reseeded.

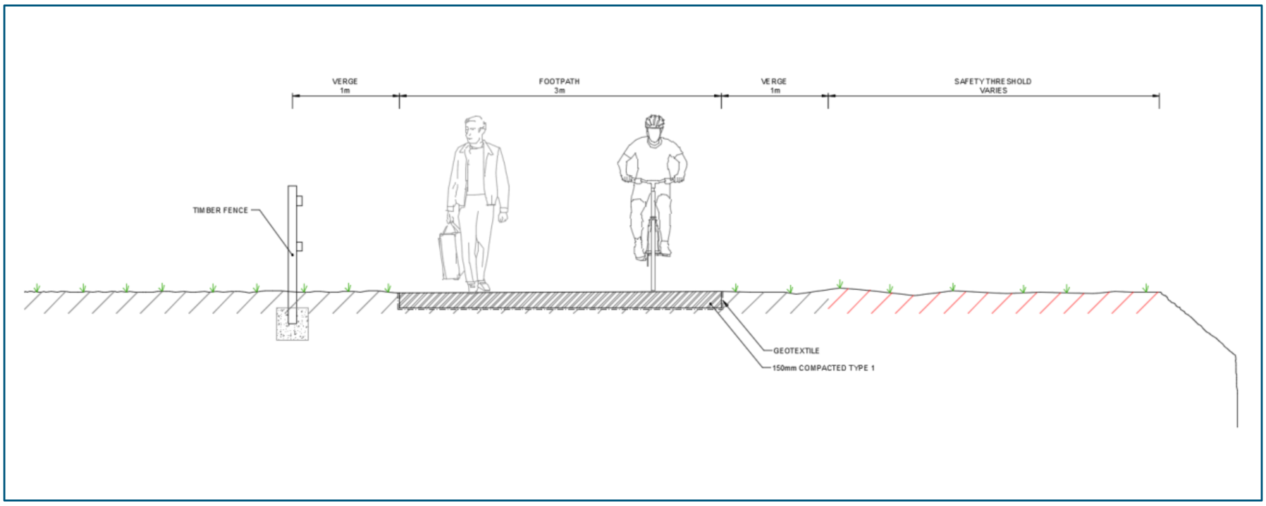


Figure 13 – Typical footpath realignment layout

Note: As the previous construction of the England Coast Path varied from the National Cycle Network Route, it was clear for cyclist that the official cycle route returned away from the cliff top before the rifle range.

Now, as the paths will be the same construction, it is thought that this will be less clear. It is therefore recommended that the council check that the NCN Route is clearly signposted to avoid cyclist inadvertently cycling on the England Coast Path (as cycling is not legally allowed on public footpaths).

8.2 Land Ownership

Within the study area, there are a number of owners along the coastal footpath. As shown in *Figure 14* the grassed buffer zone in Phase 1 is believed to be owned by South Tyneside Council (TBC). In Phase 2, the former rifle range is owned by a local farmer (Wheatall Farm), the field north of the ranges is owned by the Church Commissioners and the land further north of the range is owned and managed by the National Trust.

Figure 14 – Land Ownership along study area

Royal HaskoningDHV

Summary

Cliff Profiles

- The cliff profile along the study area varies in form which is likely to impact the maximum failure distance and erosions rates. As a result, the study area has been divided into **six areas** (Areas A to F).

Erosion Rates

- By analysing aerial datasets, the current annual average rate of retreat at Whitburn varies between **0.1m/year** and **0.3m/year**.
- Considering future sea rise, annual average erosion rates are predicted to increase.
- The above values represent **annual average** erosion rates and this is a useful metric of net medium and long-term change. However, the erosion process is not necessarily continuous at this rate each and every year; rather there can be several years of zero activity followed by one single event that cuts the cliff top back.
- Previous cliff collapses in the area substantiate that between approximately **2-3m** depth of cliff can be lost in a single failure event depending on location.

Failure Mechanisms

- Area A and E – Currently not at risk of failure whilst the dunes / grassed platform are offering protection respectively.
- Area B – Progressive landslips in the glacial till caused by continuous erosion of the toe.
- Area C and F– Medium / Large - Cliff Collapses associated with caves/undercutting, occur without warning

Receptor

- Coastal Path – England Coast Path follows the cliff top line and is vulnerable to caving, undercutting and slumping.

9 Proposed Safety Thresholds

A safety threshold has been defined as the distance from the cliff top that, when reached through erosion, prompts management action.

The safety thresholds are calculated based on the following;

$$Safety\ Threshold\ Distance = Timeline\ Factor\ Distance + Likely\ Failure\ Distance$$

Timeline Factor Distance – The cliff top erosion distance that will occur during the lead time associated with relocating the asset. In all but emergency situations, the lead time will comprise tasks from option appraisal through funding and consenting to construction. This duration (in years) is then multiplied with the predicted annual coastal erosion rate (in m / year) to yield a distance. It is expected that the timeline associated will rolling back a coastal footpath will be very short (in contrast, for example, to relocating a road, building or similar type of asset).

Likely Failure Distance – The depth of cliff loss under a likely foreseeable failure mechanism, informed from historic failures in the area (as previously described Section 4).

9.1 Timeline Factor Distance

9.1.1 Planning, Licencing and Consents

Through discussions with South Tyneside Council, it is understood that if the proposed rollback of the footpath is such that the new alignment does not overlap the existing alignment, planning permission is required. This is because it is technically creating a new highway rather than just maintaining/changing the existing one. It is estimated that the standard planning application process takes 8 weeks and therefore, the erosion experienced in this time would be negligible.

The area along the Whitburn Coast has the following designations: Site of Special Scientific Interest (Durham Coast SSSI), Special Area of Conservation (Durham Coast SAC) and Ramsar (Northumbria Coast). All of the aforementioned designations are located on the foreshore and as such the coastal footpath doesn't lie within the boundary. As a result, no permits/licences/consents are required in association with these for rolling back the footpath. There is also a Local Wildlife Site and Local Nature Reserve adjacent to the study area, but again should not affect any realignment works.

An initial assessment of Zetica risk maps suggests that the risk of potential UXO being present in the study area is low. Despite this, it is noted that a section of footpath is backed by the former Whitburn rifle range. As such it is recommended that before any footpath realignment in this area, a detailed risk assessment is carried out before any ground is broken. It is estimated that a detailed assessment would take <8 weeks and therefore the erosion experienced in this time would be negligible.

As sections of the coastal footpath are backed by land not owned by the council, it is envisaged discussions will be required with the relevant land owners to negotiate land purchase. It is estimated that land purchase discussions could take 1-3 months and therefore again, the erosion experienced in his time would be negligible.

9.1.2 Construction

The construction of the footpath once any necessary permissions, licences or consents have been obtained is simple and can be done relatively quickly, often using in-house workforce or locally appointed Contractors. Due to this, the timeline factor distance is small, tending to negligible.

9.2 Likely Failure Distance

Based on analysis of previous cliff failures along Whitburn, the likely magnitude of failure that can reasonably be expected could yield a likely loss of between 2 to 3m of cliff top depending on location.

9.3 Safety Threshold

Given the above findings, the safety threshold to be applied to the England Coast Path is;

$$Safety\ Threshold\ Distance = Timeline\ Factor\ Distance + Likely\ Failure\ Distance$$

	Timeline Factor Distance (m)	Likely Failure Distance (m)	Safety Threshold Distance (m)
Area A*	0	0	0
Area B	0	3	3
Area C	0	2	2
Area D	0	1.5	1.5
Area E*	0	0	0
Area F	0	2	2

* Whilst the cliffs are divorced from marine action, the safety threshold distance for Area A and E is 0m. However, once the dunes have been eroded it is anticipated that the cliff line will reactivate. It is thought the likely maximum failure distance, and therefore safety threshold distance, will be comparative to that of the adjacent sections.

10 Application of Safety Thresholds

10.1 Methodology

This section below details how the safety thresholds described above have been applied along Whitburn Coastal Footpath to establish the risk to coastal receptors.

1. New drone survey point cloud data has been uploaded into *AutoCAD Civils3D* and overlapped against aerial mapping and topographic survey for the cliff top footpath.

2. To establish the ***present baseline***, the most landward possible cliff line or back of cave along the bay was traced. This cliff line follows the landward edge of the bevelled glacial till.

3. It is assumed that any localised areas of significant caving, that extend beyond the clifftop, are at risk of immediate failure. As such, a further 1.5m buffer was applied around such areas of

significant caving that extend landward of the cliff top. This is to allow for a likely vertical collapse of the cliff and the subsequent anticipated progressive natural regrading in the upper glacial till layer towards a stable angle of repose, see series 4 of *Figure 4*. This task requires careful consideration to identify appropriate areas along the bay where this additional buffer should be applied. Similarly, in Areas B, C, D and F a additional 1m buffer was applied to allow for the consistent general overhang observed in these sections.

4. The ***safety thresholds***, defined in Section 9, were then offset from the present baseline to define the minimum distance the receptors need to be away from the cliff line.

5. In order to prevent the need for an annual role back of the coastal footpath, the Council has suggested a life span of 20 years for the initial roll back. Therefore, the mapped present-day safety thresholds from task 4 has been be projected to future years, based upon the erosion rates presented in Section 6.1. For purposes of this report, this has been done to the years 2042 (in 20 years) and 2100. An inflated erosion rate has been applied locally to the areas of scour caused by surface water in Area D as discussed in Section 3.2

6. The alignment of the footpath was then mapped, using the widths discussed in Section 8.1, to determine the position of the roll back. The footpath is smoothed out to avoid following the scalloping coastline.

10.2 Findings – Coastal Footpath

The present-day and 2042 safety thresholds for the England Coast Path are plotted on drawings PC1950-0001 and PC1950-0002, found in *Appendix B*. The 2042 threshold has been used to inform the proposed position for the initial roll back of the coastal footpath which is understood to be ongoing at the time of writing. If for any reason this project is cancelled or suspended, the council should still prioritise the local realigning of the sections of the footpath that are currently within the safety threshold. Such sections are found locally in Area's B, C, D and F.

In Area A, the current data suggests that the majority of the dunes protecting the cliffs are unlikely to erode within the next 20 years based on a 0.1 m/year erosion rate. As a result, the footpath does not necessarily need to be rolled back at this time. The dunes to the very northern extent of Area A, adjacent to the outfall structure, are likely to be the first to erode due to the tapering out of the existing dunes. The proposed alignment of the footpath therefore does step out in this location to provide an additional buffer.

For the rest of Area A, the Council has a decision to make, either; A) Roll back the footpath at the same time as the other sections to avoid additional mobilisation costs and provide a buffer for when the coastline does reactivate in the future. B) Leave the footpath where it is in Area A for the time being and avoid disrupting the memorial benches. The Council would have to continue to monitor the dunes for erosion and react accordingly.

In Area D, at the former rifle range, the earth butt creates a pinch point for the proposed footpath. Based on the lower erosion rates observed here it is believed that the footpath can remain on the seaward side of the earth but for the 20 year roll back. This is only achievable when locally removing the landward 1m verge around the mound. Although this is not ideal, it is considered an appropriate compromise as opposed to relocating the footpath behind the mound and the additional costs / H&S issues associated with that. The footpath should be located as close to the earth butt as possible without undercutting its slopes.

In Area E, the data suggests that the grassed platform is unlikely to erode in the next 20 years. As a result, the footpath in this location does not necessarily need to be rolled back. However, as shown on drawing PC1950-0002, if the council wish to formalise the footpath in line with Section 8, additional land is required in order to accommodate the 5m corridor of footpath proposed.

11 Emergency response plan

In the event that a cliff collapse occurs which brings any section of the footpath within the defined Safety Threshold, an Emergency Response Plan (ERP) should be implemented. The ERP is shown on drawing PC1950-0003 in *Appendix B* and is described below.

The ERP is intended to prevent access to the area of cliff collapse, whilst minimising disruption to footpath users. It is for this reason that various diversions are suggested depending on the location of the collapse.

11.1.1 Recommended preparatory actions

- It is recommended that the following signs, or similar signs to the same effect, are obtained as soon as possible to ensure that the ERP can be implemented, without delay, if required.

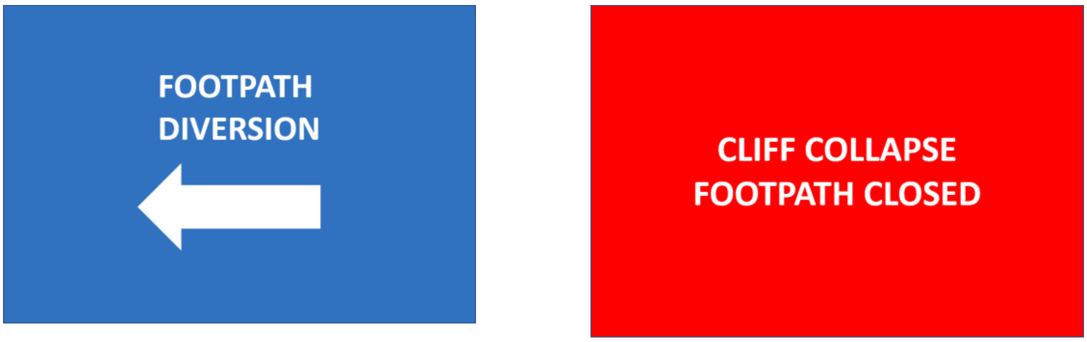


Figure 15 – Whitburn Emergency Response Plan required signage

- It is recommended that the South Tyneside Council Contact Centre is briefed on the ERP and who to contact following a call from the member of the public informing of a cliff collapse.

- It is recommended that South Tyneside Council and the National Trust carry out their own independent risk assessment to assess the current risk to the public and any future risks to ensure they are satisfied with proposed recommendations.

- It is recommended that whilst the council are undergoing current land purchasing negotiations for the 2042 roll back that the requirement for future land purchasing is also discussed in order to speed up future conversations.

11.1.2 Roles and responsibilities

It is the responsibility of South Tyneside Council to implement the ERP.

11.1.3 Recommended response actions

The emergency response actions are set out below

- Locally cordon-off cliff failure and enforce path closures.
- Implement diversions with appropriate signage.*
- Initiate project to roll back footpath.

*The proposed diversion route varies depending on the location of the cliff failure.

1. If a failure occurs within South Tyneside Council land, it is believed the footpath can locally be diverted around the failure within the grassed area.
2. If a failure occurs within the former rifle range, it is believed that a diversion onto Mill Lane via Ash Grove and Wheatall Way is required.
3. Ff a failure occurs on the footpath fronting the church commissioners' field, a diversion to Mill Lane via Marden Avenue and Wheatall Way is required.

Whilst it is recognised that in practise footpath users may find a more direct route around the failure. This is not recommended due to the potential health and safety risks associated with climbing a fence and walking in a field with cattle.

11.1.4 Contact List

Following implementation of the ERP, the following parties would need to be informed;

- The Ramblers' Association
- Byways and Bridleways Trust
- Cyclists Touring Club
- Auto Cycle Union
- Open Spaces Society
- BRAG
- The British Horse Society
- British Driving Society
- British Horse Society
- Cyclists Touring Club (CTC)
- Local Access Forum
- Tyneside Fire and Rescue
- Northumberland Police
- North East Ambulance
- Ordnance Survey

11.1.5 Monitoring

If the coastal footpath does get rolled back to a 2042 position , It is considered that the Cell 1 Regional Coastal Monitoring Programme's surveys and inspections are of a suitable type and adequate frequency to monitor and record erosion of the frontage. The future inspections should however pay particular attention to the dunes in Area A and grassed platform in Area E to identify signs of recession that could then lead to reactivation of the backing cliffs in those areas.

12 Budget Cost Estimates

Appendix C provided costs estimates for the roll back of the coastal footpath at Whitburn. The costs assume a 3m wide, whinstone or granite dust path constructed along the whole 2.25km length of the study area. The costs are based on costs set out in *Paths for all*'s Estimating price guide for path projects (2019) which have been inflated by 20% to allow for time since publication

This costing exercise predicts that the estimated costs (excluding land purchase) is **£195,427.00.**

The approximate area of permanent land take required is also provided in Appendix C. It is estimated that 4,635m² will be required from the former rifle range and 3205m² from Church Commissioners Field. As a guide, if 1m² of land cost £5.00 then this would mean an additional **£39,195.00.** It is stressed that the land purchase cost is estimated, and it is believed the council will have a better idea of current cost per m².

13 Conclusion

The following key actions are concluded from the Whitburn Coastal Footpath Adaption Strategy;

1. The council is currently in the process of rolling back the coastal footpath along the whole study area to the 2042 position suggested within this report. If for any reason this project is cancelled or suspended, the council should prioritise to locally realign those sections of the footpath that are currently within the safety threshold. Such sections are found in Areas B, C, D and F and can be seen on drawings in Appendix B.

2. Implement preparatory actions for ERP.

3. Continue ongoing inspection/monitoring/review. Going forwards, particular attention to be paid to dunes and grassed area protecting Areas A and E respectively for signs of recession.

4. Deep caves have been noted in the cliff line fronting nature reserve (just to the north of the study area considered in this report). It is recommended a similar study is carried out on these cliffs to assess risk to the coastal footpath at this location, which is very tightly pinched against the stone wall of the nature reserve.

Appendices

Appendix A – Extents of Phase 1 and Phase 2

Appendix B – Drawings

Appendix C – Budget Estimate