Looking ahead: planning for coastal change

Using coastal change information to plan for development and infrastructure around the coast

Guidance

In partnership with the Scottish Government’s Dynamic Coast project

DynamicCoast.com
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We welcome constructive feedback on our guidance. If you have any suggestions on how to improve this guidance, have any queries about it, or know of any good case studies, please email planningrenewables@nature.scot

May 2019
Looking ahead: planning for coastal change

Introduction

Key points

– This guidance aims to help those involved in planning for development and infrastructure at the coast.

– The increasing effects of climate change, including the consequences of sea level rise, will continue to change our coastline and put existing and planned built development and infrastructure at risk.

– It is in everyone’s interest to plan ahead for sustainable development by minimising risks to business, nature and communities at the coast.

– Natural assets, including areas recognised nationally and internationally important for wildlife, protect £13 billion worth of buildings and infrastructure, compared with £5 billion protected by engineered defences.

– Understanding coastal processes and coastal change supports the making of informed decisions that are future-proofed against the effects of climate change.

The importance of planning for coastal change

A wide range of plans and policies in Scotland acknowledge the increasing risk associated with the effects of climate change. They also highlight the need to take account of the effects of coastal change in planning decisions. For example: Scottish Planning Policy (SPP)\(^1\) recognises the importance of coastal areas to Scotland’s heritage and economy, while requiring that new development in areas at risk is avoided; and Delivering for today, investing for tomorrow: the government’s programme for Scotland 2018–19\(^2\) highlights the Scottish Government’s commitment to be a world-leader in climate change mitigation to ensure our communities, economy and natural environment are resilient to the changing climate. Effective spatial planning for coastal change is integral to these commitments.

Low lying areas of Scotland’s coastline are attractive for built development, as their topography is suited to development and transport links, and they have scenic and recreational value. They are particularly attractive to infrastructure related to the marine sector, for example for ports and harbours, marine transport hubs, offshore energy and aquaculture shore-side facilities, etc.


However, climate change matters, not just because sea levels or flood extents are changing, but also because our society and infrastructure is based on the assumption that they would not. This guidance aims to inform consideration of the emerging conflict between permanent development and an increasingly changing coast.

When built development is affected or threatened by coastal change, a case is often made to protect it by installing man-made sea defences. This can have significant consequences for the coast. For example, man-made defences can damage habitats important for wildlife by removing the vegetated transition from shore to land - removing the natural qualities that make the coast attractive to people. Sea defences also change natural coastal processes, having displacing effects and making erosion worse elsewhere and increasing the risk of flooding. These consequences have long-term cost implications, requiring ongoing spending on inspections and the maintenance of defences. This places a long-term financial and resource burden on the responsible authority.

The unintended consequences of man-made defences largely come from the misconception that development at the coast must be ‘fixed’ and therefore has to be ‘protected’. However, the planning system can enable and support development that is adaptive to coastal change by ensuring that the right development is located in the right place. This is consistent with the Scottish Government’s Climate Change Adaptation Programme, which highlights the value of partnership working “with spatial planners to embed adaptation at the heart of regional and local planning processes”3.

Planning at the coast is not just about delivering built development and infrastructure such as roads and houses – there is a need to safeguard nature. Natural coastal features and the processes that support them are assets that provide public services for free, for example sand dunes provide natural defences against erosion, flooding and sea level rise. The assessment carried out as part of the Dynamic Coast project found that above-water natural defences such as beaches, dunes and saltmarshes protect at least £13 billion worth of buildings and infrastructure, compared with £5 billion protected by engineered defences4. When taking below-water natural features such as kelp beds and sandbanks that dissipate wave energy into account, the figure will be even higher.

Natural coastal features, supported by coastal processes, already protect a huge amount of built development and infrastructure.


If we are to cope with the increasing effects of climate change, we need to help nature to help us by safeguarding these important assets. Although some of these natural assets and processes are already degraded due to human pressures and interventions, many have the potential for recovery.

The importance of natural assets is recognised by the Scottish Government in its Programme for Government 2018/19\(^5\), which refers to them as being “as valuable as broadband, roads and bridges”. Spatial planning has a role to play in protecting and enhancing natural assets, which are described in the Programme for Government as being “essential to Scotland’s economy, culture, way of life and the wellbeing of future generations”. Understanding coastal processes and coastal change is therefore vital if we are to make informed decisions that reduce the risks from increasing effects of climate change in the short, medium and long term.

To provide information on coastal change that can be used to inform strategic planning decisions, a national coastal change assessment was commissioned by the Scottish Government in 2015. The outputs of that assessment, and further ongoing research, are presented on the Dynamic Coast website: http://www.dynamiccoast.com/

Purpose of this guidance – who and what it’s for
This guidance aims to help those involved in development and infrastructure planning at the coast to work towards sustainable development that takes account of current and future coastal change.

Onshore/terrestrial spatial planners are a key audience for this guidance. However given that coastal change is also important for other disciplines and areas of work within and outside public authorities, the guidance should also assist a broader audience. For example: members of the public submitting or commenting on planning applications; statutory consultees and other organisations such as Marine Scotland, Scottish Natural Heritage (SNH), the Scottish Environment Protection Agency (SEPA) and Historic Environment Scotland (HES); marine spatial planners, harbour/port authorities, developers and others considering elements of marine development that cross the intertidal area; local authority transport officers considering infrastructure such as roads; economic development officers considering how to support local businesses; as well as elected members considering planning applications and setting strategic visions for local authority areas.

The guidance provides readers with context on why coastal change is important (Section 1), a basic understanding of coastal processes (Section 2), and advice on how to interpret the coastal change information available via the Dynamic Coast website, http://www.dynamiccoast.com/ (Sections 3 and 4).

This will help enable informed decisions to be made on development proposals and infrastructure needs, which take predicted changes in the coastline and the effects these may have into account. By taking account of coastal change, development should be guided to appropriate locations so that it will be sustainable in the longer term.
Section 1 – Why plan for coastal change?

Increasing effects of climate change

The rise in greenhouse gas emissions since the Industrial Revolution has contributed to climate change. This directly affects Scotland’s landscape, with the evidence of change illustrated by:

– The 20 warmest years in the UK record have been since 1995, with the warmest 5 years being recorded this decade.
– Precipitation in north and west Scotland increased by around 60% between 1961 to 2006.
– Sea level recorded at the Aberdeen tide gauge increased by 8cm between 1900 and 1990, and is likely to have risen by a similar amount by 2030.

The science around climate change is improving and the latest (2018) UK climate projections for sea level rise are higher than those in the 2009 projections. This means that Aberdeen, Edinburgh and Inverness will very likely see a sea level rise of nearly 1 metre between now and 2100. This will substantially increase the likelihood of coastal flooding in low-lying areas. For example, in Leith, a 0.3 metre increase in mean sea level would change the 1% annual flood probability to 16%. With this probability, residents and businesses would be likely to be flooded once in any 6 year period. This change is likely to have a significant effect on our coastal assets, infrastructure and habitats.

While Scottish green-house gas emissions are falling in line with our international commitments, UK emissions are falling at a reducing rate. Internationally global emissions continue to rise in line with the high emissions scenario (known as RCP8.5). Given this context and despite the continued effort to reduce domestic emissions, key sections of the Scottish public sector consider it prudent to plan for a high emissions future. Guidance exploring the consequence for Scotland is expected to be published by Adaptation Scotland, ClimateXChange, Historic Environment Scotland, Scottish Environment Protection Agency and Scottish Natural Heritage.

The extent and rate of coastal erosion have already increased above historic levels and they are expected to broaden and quicken further in coming decades.

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7 http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87933&filetype=pdf (see Table 2.11)
8 UK Climate Projections, 2018, https://www.metoffice.gov.uk/research/collaboration/ukcp
Erosion-enhanced flooding is also likely to increase. The removal of sediment from the shoreline (due to defences or dredging) will exacerbate the issue of coastal erosion. As significant proportions of our coastal infrastructure and buildings are located on our erodible coast, there is an urgency to plan to safeguard our natural and man-made defences, and where these are likely to fail or be unsustainable, we must plan to adapt.
Coastal change: policy and legislative context

Flooding and erosion are among the biggest risks caused by climate change that Scotland faces\(^\text{10}\). Tackling the effects of climate change and ensuring that people and development are not put at risk from future changes is a key requirement of UK and Scottish legislation and government policies. For example:

- International agreements and Scottish policies for achieving sustainable development make explicit reference to climate change, erosion, flooding and the consequential wide-ranging adaptation that must be factored into planning decisions (Paris Agreement\(^\text{11}\), Scottish Climate Change Adaptation Programme\(^\text{12}\), National Planning Framework\(^\text{13}\), SPP\(^\text{14}\)).

- Local authorities have a duty to embed climate change adaptations into land use strategies, Strategic and Local Development Plans and development masterplans\(^\text{15}\).

Development plans should recognise that climate change will potentially have a significant impact on coastal areas, and that a precautionary approach\(^\text{16}\) to flood risk should be taken. Development should be located away from floodplains, particularly the functional floodplain.

Policies and decisions should support climate change mitigation and adaptation\(^\text{17}\). Where appropriate, development plans should identify areas at risk, and where managed realignment would be beneficial.

New development requiring new defences will not be supported. Exceptions are only permitted with a clear justification for development in areas at risk\(^\text{18}\).

To achieve sustainable development, the planning system seeks to prevent development in areas that have a significant probability of being affected by flooding or that would increase the probability of flooding elsewhere\(^\text{19}\).

\(^{10}\) ASC, 2016, *UK climate change risk assessment 2017 evidence report: summary for Scotland*:

\(^{11}\) The Paris Agreement, https://www.mofa.go.jp/files/000197313.pdf (Articles 6.2, 6.8 and 7.1)


The Dynamic Coast project, alongside SEPA’s flood hazard maps, supports the vulnerability assessments and adaptation planning obligations within Shoreline Management Plans, LDPs, Strategic Development Plans, SPP, Flood Risk Management Plans and National and Regional Marine Plans. National Marine Planning policies also include the need to consider areas for adaptation.\(^{20}\)

Coastal change: spatial planning context
The policies and principles found in the National Planning Framework\(^ {21}\) and SPP\(^ {22}\) set out how the Scottish Government expect Planning Authorities to address national issues, such as coastal change, in Strategic Development Plans and their regional-scale LDPs.

Plans written to comply with SPP also have to take account of the requirements of the National Marine Plan\(^ {23}\), as the terrestrial and marine spatial planning systems overlap on the shore.\(^ {24}\) Marine developments and activities require shore-side facilities and access, so the interaction across marine and terrestrial planning processes is especially important for marine development.

A selection of the key points from these plans relevant to coastal change are shown in Table 1. They highlight why it is important for planners and decision makers in particular to understand coastal change and its implications, both now and in the long term, in relation to spatial planning and decision making.

Development that considers coastal change can help achieve a resilient, adaptable coast where natural assets are valued and where businesses, communities, nature and people thrive.

### Table 1 – Extracts from national plans relevant to coastal change

<table>
<thead>
<tr>
<th>Scottish Planning Policy&lt;sup&gt;25&lt;/sup&gt;</th>
<th>Plans should identify areas of largely developed coast that are a major focus of economic or recreational activity that are likely to be suitable for further development; areas subject to significant constraints; and largely unspoiled areas of the coast that are generally unsuitable for development. (paragraph 89) Plans should recognise that rising sea levels and more extreme weather events resulting from climate change will potentially have a significant impact on coastal and island areas, and that a precautionary approach to flood risk should be taken. They should confirm that new development requiring new defences against coastal erosion or coastal flooding will not be supported except where there is a clear justification for a departure from the general policy to avoid development in areas at risk. Where appropriate, development plans should identify areas at risk and areas where a managed realignment of the coast would be beneficial. (paragraph 88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Planning Framework&lt;sup&gt;26&lt;/sup&gt;</td>
<td>The pressing challenge of climate change means that our action on the environment must continue to evolve, strengthening our longer-term resilience. A planned approach to development helps to strike the right balance between safeguarding assets which are irreplaceable, and facilitating change in a sustainable way. We must work with, not against, our environment to maintain and further strengthen its contribution to society. (paragraph 4.7) Careful planning is needed to make best use of the natural and infrastructure assets across our coastal and island areas, and to balance potentially competing uses within often sensitive environments. A strategic approach to mitigating potential impacts on this sensitive environment is likely to form an integral part of marine planning, whilst issues arising in the coastal interface should be reflected in land use plans. (paragraph 3.39)</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>National Marine Plan²⁷</th>
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<tbody>
<tr>
<td><strong>Objective:</strong> The use of the marine environment is benefiting society as a whole, contributing to resilient and cohesive communities that can adapt to coastal erosion and flood risk, as well as contributing to physical and mental wellbeing. (High Level Marine Objective 6)</td>
</tr>
<tr>
<td>Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding. (General Policy 8, Coastal process and flooding)</td>
</tr>
<tr>
<td>Marine planners and decision-makers must act in the way best calculated to mitigate, and adapt to, climate change… provide effective adaptation to its predicted effects… coastal developments should be appropriately sited and designed, … giving particular consideration to vulnerability, scale and longevity of operation. (General Policy 5, Climate change)</td>
</tr>
</tbody>
</table>

Section 2 – How coastal change works: the essentials

Introducing coastal change and development

Coastal change can occur naturally in two ways, erosion or accretion:

- Erosion, particularly from storms, can directly damage both: natural features and man-made infrastructure; and/or increase the risk of flooding. It can have significant consequences for people and built development.

- Accretion, the accumulation of sediment (often derived from eroded material), can cause local issues. For example, harbour entrances can silt up. Accretion can also have benefits. For example, new land created can be valuable for nature and occasionally for development. This is illustrated by the dunes at St Andrews, which have accreted enough in the last 130 years for nine golf holes to be added.

Human interventions along the coast can change the natural patterns of both erosion and accretion. This can have unintended consequences. For example, man-made defences can speed up erosion further along the coast, harming not only adjacent land uses but also natural sea defences such as dunes or saltmarshes.

When considering proposals for new coastal development, or how to manage existing development, these natural processes and natural defences must be considered, through understanding the essentials of coastal change.

Rates of change

Coastal change is the norm on virtually all Scottish shorelines. However, the rate of change differs between different types of coast. ‘Hard’ Scottish coasts formed from bedrock tend to wear away slowly, at rates that are almost imperceptible during a human lifetime. In contrast, ‘soft’ coasts consisting of sand, gravel or mud (as shown in Figure 1) can lose or gain metres each year.

Figure 1 – Examples of soft coasts: sand dunes at Dunbar (Lothian), salt marsh on Dornoch Firth (Sutherland) and soft boulder cliff north of Dunrobin Castle (Sutherland)
The Dynamic Coast project focused on ‘soft’ coasts. When these are eroded, a low cliff may be formed in the semi-consolidated material of stable dunes, saltmarshes or older shore sediments, but the coast is still termed ‘soft’.

**Give and take: shifting shores are normal**

The shape and nature of beaches and dunes are determined by the movement of coastal sediments by waves, tidal currents and wind. A stormy period, the rise and fall of a single tide or even a single wave can both add material to a soft coast (accretion) and carry it away (erosion). These interacting forces are infinitely variable over a range of timescales: from hours to tidal cycles, from seasons to years and decades to centuries. The erosion, transport and deposition of sediments are normal, natural processes. They allow coastal landforms and habitats to adapt to changing forces over time. For example, beaches typically lose sediment during storm conditions, particularly in winter, and repair themselves through the return of that sediment in more benign conditions.

Without erosion, as part of the natural coastal give and take, Scotland would not have such a variety of coastal habitats, or experience the benefits a dynamic coast provides. These benefits include providing attractive places for people to visit, enjoy, work and live, as well as natural coastal defences providing free protection from the sea.

However, when erosion or accretion impacts on society’s assets it is then perceived as a problem. The most obvious direct effects are when erosion threatens settlements or other forms of development such as roads or houses. Indirect effects can be equally important. For example, if beach erosion breaches through a protective dune ridge, the risk of inland flooding increases. Another more subtle effect is where erosion of beach sediment, vegetated dunes or saltmarshes lessens the ability of the intertidal zone to absorb storm wave energy. This increases the risk of wave overtopping the natural defences, placing inland areas at greater risk of flooding.

**It’s all about the sediment**

Contrary to most public expectations, the greatest amounts of erosion tend not to occur on the most exposed coasts, as these have experienced and evolved to better resist such harsh conditions. The greatest changes caused by erosion are found within areas of soft shore, where sediments and the resultant landforms are continually being repositioned and reshaped, by wind, wave and tidal processes.

Along with these coastal processes, the availability of sediment is a key determining factor in coastal changes.
Coastal scientists refer to this as sediment supply – a concept that can include a lack of sediment. The ongoing and often unseen changes in sediment supply are no less important to coastal change than the more obvious effects of storms. Many built developments along Scotland’s coast are located on landforms composed of coastal sediments delivered as a result of abundant sediment supplies in the past. Figure 2 shows an example of this – the Beach Boulevard area of Aberdeen.

Figure 2 – The Beach Boulevard area of Aberdeen and associated leisure developments are built on what were dune ridges. Sediment supply is long exhausted. Erosion of the beach is an ongoing problem, managed in part by numerous groynes. Decades of coastal management and defences have prevented coastal erosion causing land retreat – but will require ongoing maintenance and spend in perpetuity.

In the period following the demise of the last ice sheets, vast amounts of sediments were delivered to the coast via glacial melt water. It joined the banks of sediment directly deposited by glaciers in the nearshore and offshore zone. In Scotland, as past sea levels fell, this sediment became available to be moved onshore by waves and tides, leading to extensive beach and dune building in a period of positive sediment budgets. However, over time this sediment source has become exhausted and, over more recent decades, sea level has begun to rise, outpacing land rise, placing more and more sediment out of reach of wave activity.
With a reducing sediment supply, beach sediment budgets become negative and there is greater potential for erosion. This is because there is no longer sufficient sediment capacity on beaches to withstand wave action, or to build new dunes. **Figure 3** shows an example of this – the eroding beach at Dunbar.

**Figure 3** – The historically sandy Dunbar East Beach (left) has been losing its sand (right). Costly replacement works have been undertaken in recent years. The sand loss can be attributed to failure of sediment supply. (Left photograph from https://ourlocality.org/dunbarshoreandharbour/2015/02/east-beach-regeneration-2015/)

Erosion progressively impacts the sedimentary stores at the rear of the beach and landforms such as sand dunes begin to suffer. On a regional scale, waves and tides tend to push sand, gravel and mud into the quieter environments of bays and firths.

Sediment supply is complicated by local factors such as the paths of individual storms and their timing relative to tides, the provision of new sediment from eroding cliffs (or from worn-down shells) and the effects on wave energy of changing near-shore depth (for example due to shifting estuary channels).

**Moving boundaries**

For the purposes of terrestrial spatial planning, what matters most is the loss of developable land through erosion. The erosion can range from the overnight steepening of a beach, to the loss of tens of metres of dunes and land to the sea over decades. Even if eroded sediment contributes to natural accretion of the coast elsewhere, this will form beach, dune or saltmarsh habitat that is unlikely to be suitable for development in the immediate future.

Most coastal retreat occurs over short, irregular intervals, so change over periods of a few seasons or a few years is unlikely to provide a reliable indication of future patterns. Unfortunately, choosing the longest timescale available – ie a comparison with the first Ordnance Survey (OS) mapping from circa 150 years ago – may also cause issues.
It may allow the appreciation of longer time scale changes, but can also introduce other complications if crucial driving factors have changed over that period. For example, 150 years ago, significant sea level rise affected only those locations on the Western and Northern Isles coast, but over the past few decades it is almost certainly happening everywhere. In many settings, it is very likely that the rate and spatial extent of coastal erosion will accelerate.

In addition, the appearance of stability, when comparing the late 19th century coastline with the modern one, can mislead. There may have been many cyclic changes to shorelines and landforms over the past century made up of alternating periods of net erosion and net accretion, with each period being up to several decades long.

For spatial planning purposes, the use of past intervals that encompass the late 19th and 20th centuries, plus modern times, such as those provided via the Dynamic Coast project, should give a good indication of how the coast changed in the past and is projected to change in the future. This coastal change information should inform decision making for built development and other forms of land use, ensuring that risks are avoided or appropriately managed to avoid unintended consequences in the long term.
Section 3 – How to use coastal change information

Understanding Dynamic Coast information

The Dynamic Coast project provides a publicly available evidence base of coastal changes across Scotland via 240 site summaries (grouped by ‘coastal cell’) and public web maps. The mapped data is available to download into dedicated mapping systems, making it possible for local authorities and others to use the data in their own computer mapping systems.

Coastal changes within Dynamic Coast are established and anticipated using the historical datasets described in Table 2. The datasets (shown as an extract in Figure 4) depict the changing position of three tide lines over the last 130 years, and where the recent change is significant (greater than 10m, ie more than would be expected to result from mapping errors or differences in mapping techniques/accuracy over time) the change is projected forward. The maps cannot predict changes elsewhere on the shore (ie lower beach profile changes) or changes between the survey dates.

Figure 4 – Mapping extract from Dynamic Coast showing the different information described in Table 2

28 http://www.dynamiccoast.com/
29 http://www.dynamiccoast.com/outputs
30 http://www.dynamiccoast.com/webmap.html
31 http://www.dynamiccoast.com/outputs.html
<table>
<thead>
<tr>
<th>Name</th>
<th>How feature appears on Dynamic Coast mapping</th>
<th>What it shows</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890s high tide line</td>
<td>A black dotted line</td>
<td>The ‘High Water Mark of Spring Tides’ from the 1890s, second edition, surveyed between 1880 and 1950. Accurate to 10m wide on the ground. [In Dynamic Coast, click on the line to see the survey date.]</td>
</tr>
<tr>
<td>1970s high tide line</td>
<td>An orange dotted line</td>
<td>The ‘Mean High Water Springs’ from the 1970s OS edition, surveyed between 1959 and 1995. Accurate to 10m wide on the ground. [In Dynamic Coast, click on the line to see the survey date.]</td>
</tr>
<tr>
<td>Modern high tide line</td>
<td>A purple dotted line</td>
<td>The ‘Mean High Water Springs’ from the 2014 OS MasterMap, updated in places. Accurate to 2m - 10m wide on the ground. [In Dynamic Coast, click on the line to see the source of the line and the survey date.]</td>
</tr>
<tr>
<td>1890-1970s change</td>
<td>Traffic-light colour-coded line quantifying historic retreat/advance between 1890s and 1970s</td>
<td>Landward retreat shown in red, little change in orange, seaward advance in green. [In Dynamic Coast, click on the line to see the total change (m) and the annual rate of change (m/year).]</td>
</tr>
<tr>
<td>1970-modern change</td>
<td>Traffic-light colour-coded line quantifying recent retreat/advance between 1970s and modern shoreline</td>
<td>Landward retreat shown in red, little change in orange, seaward advance in green. [In Dynamic Coast, click on the line to see the total change (m) and the annual rate of change (m/year).]</td>
</tr>
<tr>
<td>Future Look</td>
<td>Anticipated change by 2050 with erosion in red</td>
<td>Anticipated erosion areas derived from the 1970s-modern change projected forward to</td>
</tr>
<tr>
<td>2050</td>
<td>areas and accretion shown as green lines</td>
<td>2050. This ‘erosion’ polygon is expected to be eroded by 2050 and is joined by a 10m buffer ‘erosion influence’ (where assets may be damaged) and a 50m buffer for ‘erosion vicinity’ (to capture adjacent assets). Anticipated accretion shown as green lines. Insignificant change (&lt;10m) is not projected forward. <em>These do not account for any future acceleration and widening of erosion expected because of climate change. As such, these are likely to underestimate future change.</em></td>
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<tr>
<td><strong>Future Look 2100</strong></td>
<td>Anticipated change by 2100 with erosion in red areas and accretion shown as green lines</td>
<td>Anticipated erosion areas derived from the 1970-modern change projected forward to 2100. This ‘erosion’ polygon is expected to be eroded by 2050 and is joined by a 10m buffer ‘erosion influence’ (where assets may be damaged) and a 50m buffer for ‘erosion vicinity’ (to capture adjacent assets). Anticipated accretion shown as green lines. Insignificant change (&lt;10m) is not projected forward. <em>These do not account for any future acceleration and widening of erosion expected because of climate change. As such, these are likely to underestimate future change.</em></td>
</tr>
</tbody>
</table>


How to interpret a changing coastline

To understand the implications of the information presented by the Dynamic Coast project, users also need to interpret what they see. Table 3 presents a number of different situations, showing coastal change over time and how to interpret the anticipated change presented by ‘Future Look’. This should enable decisions to be informed by whether or not a location is appropriate for future development and/or whether or not action is required now to move important infrastructure outside areas of future erosion (a ‘spend now to save later’ approach).

When interpreting ‘Future Look’ information, it is important to understand that the Dynamic Coast project compared historic and recent changes and found that there has been an increase in the extent of erosion of Scottish coasts since the 1970s. Moreover, erosion rates have doubled, while the extent of accretion has reduced.

However, at present, ‘Future Look’ is based on linear projections of recent change, so does not account for potential accelerations in erosion rates that are likely to be caused by the effects of climate change (ie increased sea level, and storm severity and frequency). As a result, it should be remembered that actual future change may be greater than mapped.

For example, in situation 3 of Table 3, it may appear from the existing ‘Future Look’ information that development to the north would not be affected by erosion. However, with increasing storm severity and frequency, this assumption may not be correct. A precautionary approach (as encouraged within SPP32) is therefore advocated when considering development and infrastructure near areas of predicted change.

<table>
<thead>
<tr>
<th>Situation 1 (Accretion)</th>
<th>Situation 2 (Stability)</th>
<th>Situation 3 (Pier/groyne)</th>
<th>Situation 4 (Rotation)</th>
<th>Caveats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890s shoreline</td>
<td>1970s shoreline</td>
<td>Modern shoreline</td>
<td>Future Look</td>
<td>Future Look</td>
</tr>
<tr>
<td>Shown as a black dotted line</td>
<td>Shown as an orange dotted line</td>
<td>Shown as a pink dotted line</td>
<td>Based on Future Look</td>
<td>Northern stability, central accretion and southern erosion</td>
</tr>
<tr>
<td>Future Look: Accretion. Beach levels may rise, rather than accrete seawards</td>
<td>Future Look: Shoreline has remained stable for 130 years</td>
<td>Future Look: Erosion and flood risk are likely to affect larger areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bear in mind: Increased storm severity and frequency means erosion may replace stability</td>
<td>Bear in mind: Increased storm severity and frequency means erosion may replace stability</td>
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</tr>
<tr>
<td>Caveats: Tide lines are shown for 1890s, 1970s and modern mapping. Linear change between these points in time is assumed and changes elsewhere (i.e. vegetation edge or low water) may not be comparable</td>
<td>Anticipated erosion areas have pink buffers: Erosion Influence (a 10m buffer) may be affected in the short term; Erosion Vicinity (a 50m buffer) may be affected in the longer term</td>
<td>Future Look erosion (left) is the recent erosion rate projected forward, excluding future sea level rise, flooding or sediment supply changes</td>
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Table 3 will help users to interpret the information provided on the Dynamic Coast project website and give an understanding of how the coastline may change. However, consideration also needs to be given to existing buildings and infrastructure and whether or not they are at risk from the changing coast. For example, Figure 5 shows an eroding coastline where the buildings and roads are at risk of future change. Due to the predicted risk of erosion, consideration needs to be given as to how the trunk road and railway will be affected. Realignment is likely to be required before erosion undermines the infrastructure.

**Figure 5** – Extract from Dynamic Coast showing the changing coastline and areas of predicted erosion, the road and rail infrastructure at risk.

A collaborative approach between industry, planners and communities is encouraged when considering spatial planning for future development needs. This will help to ensure that the functionality of important infrastructure is retained whilst taking into account the reality of ongoing coastal change. Early engagement with SNH is encouraged in line with our planning service statement\(^{33}\) commitment to helping developers and communities achieve the right development in the right place. It is also beneficial to include other relevant agencies and organisations, such as SEPA\(^{34}\) and Historic Environment Scotland\(^{35}\), in such engagement.

\(^{33}\) SNH, 2018, [https://www.nature.scot/planning-service-statement](https://www.nature.scot/planning-service-statement)
Working together will help Planning Authorities (and other parties involved in the planning process) understand coastal change and natural heritage issues, while they can help SNH gain a better understanding of social and economic issues. Working together should therefore enable development and infrastructure to be located in places that are resilient to the effects of coastal change.

How to include coastal change in your work

This guidance aims to help those involved in planning for development and infrastructure at the coast to take account of the increasing effects of climate change and sea level rise. Failing to take account of this will put existing and planned built development and infrastructure at risk, as well as natural assets that are providing coastal defences for free. Taking a longer term view than has traditionally been practiced should enable sustainable development that minimises risks to business, nature and communities at the coast.

The below summarises the main points that should be considered by those working and making decisions on development planning, development management and related disciplines such as flooding and transport around the coast:

**Everyone:**

- Make use of available coastal change data and information, such as from the Dynamic Coast project, to identify areas at risk.

- Look at specific locations (eg settlements) but also the surrounding area. Consider whether coastal change along the coast could have an effect, eg through erosion allowing flooding to come round the back of development.

- Take a long term view. Climate change and sea level rise will exacerbate coastal change over a long time period, so ensure decisions made today are future proofed as far as possible. Look to the future and consider the implications for people, development, nature, resources and budgets.

- Where necessary, take action now. The cost of managing climate change will be less if met now, than if meeting it in the future.

**In addition, for development planning:**

- Include a specific coastal policy section in the Local Development Plan that reflects the requirements of SPP, and takes account of the NMP (and where present, Regional Marine Plans).

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*With reference to SNH’s balancing duties, as set out in Section 3 of the Natural Heritage (Scotland) Act 1991 and Section 1(2) of the Deer (Scotland) Act 1996 (as amended).*
The policy should seek to manage expectations around coastal defences and development opportunities along the coast, whilst also safeguarding areas important to people (eg beaches used for recreation, coastal trails, etc), nature (eg areas important for habitats and the wildlife they support) and the economy (eg harbours and ports, locations important to tourism, productive agricultural land, etc).

- Identify natural defences that are protecting built development, important infrastructure and land uses (eg productive agricultural land, coastal trails, etc). Where appropriate, safeguard these from inappropriate development or interventions through policy protection.
Section 4 – Putting an understanding of coastal change into practice: case study examples

Sun, sea and shifting sand:
Planning for adaptive land use

**Case study key points**
- A risk of future erosion doesn’t have to rule out new development at the coast – and new development at the coast doesn’t have to lead to future defences.
- Some forms of development are moveable and adaptable to coastal change.
- It is in everyone’s interest to have sustainable development plans that forecast and avoid future risks.
- Smart spatial planning can raise the profile of coastal change while enabling development that can adapt to it.

The following example considers how adaptive development planning policy can inform consideration of proposed planning applications for recreational development at the coast (such as those shown in Figure 6).

**Figure 6** – Examples of the type of beach front development that would benefit from the approach outlined in this case study: a Berwickshire caravan park, Coldingham beach huts.

A pre-application enquiry was received for the erection of new beach huts on a small parcel of land along an undeveloped sandy coast. Each small, un-serviced hut would be for the personal use of the owner or tenant, providing a form of shelter and private space that allows them to enjoy the beach location and connect with nature throughout the year.
The location, where footpaths from an inland car park connect to the beach, is suitable in terms of accessibility. The development would also contribute to the local economy through increasing visitor spend.

However, the Dynamic Coast project mapping shows that dunes immediately adjacent to the area proposed for the beach huts have experienced erosional retreat in recent decades, and erosion is likely in the future.

The cost of installing and maintaining coastal defences would be in excess of the modest economic benefit the huts would provide. In addition, SPP\textsuperscript{37} does not support development that relies on new coastal defences, and stipulates that development avoids areas of coastal erosion. Consequently, the risk of coastal erosion in the area means that the beach huts proposal could be considered in conflict with planning policy, and the applicant would be advised not to proceed.

However, the solution lies in having an adaptive spatial policy for sustainable development at the coast. In this case, consent for the huts could be given on the basis that, if they were threatened by coastal erosion in the future, they would be relocated landward within the boundary of the land ownership to ensure that they were not lost. This low-cost solution would avoid the need for coastal defences and manage expectations. Planning conditions could incorporate the following adaptive measures:

- Appropriate land at a set distance away from the mean high water spring must be identified in which the huts could be located/moved to over time, without the need for new planning permission, in response to erosion.

- The developer, owners or tenants must not attempt to create coastal defences in any form, whether informally through excavation or the placement of materials, or formally through engineered or built structures.

- Replacements of old beach huts must replicate the position of the old beach huts, unless an alternative position is agreed in advance and in writing with the Planning Authority.

- To avoid the huts becoming an unwelcome eyesore and/or liability, should coastal change or other factors render huts un-useable in a way that cannot be either repaired or remedied by moving them to elsewhere within the land holding, the affected huts must be removed.

Incorporating these adaptive measures into planning conditions would enable huts to be moved within the land holding to adapt to a changing coastline, while being clear that coastal defences are not appropriate in this location.

This adaptive policy approach would enable appropriate development that contributes to the local economy and allows people to connect with nature. The negative consequences associated with sea defences would be avoided, and the natural defences that the dunes provide against flooding and erosion would be safeguarded.
Coastline change front and centre:
Addressing coastal change in development planning policy

**Case study key points**

- Using the Dynamic Coast project from the outset helps plan for future coastal change and encourage creative and flexible solutions.
- Outputs from the Dynamic Coast project provide a nationally consistent starting point for ensuring that development avoids areas at significant risk of future coastal erosion.

Planning Authorities, through their LDPs, have a duty to ensure that development in areas of future coastal erosion or flooding is avoided\(^{38}\). In some locations, the preparation of a Shoreline Management Plan and/or Strategic Flood Risk Assessment has given some indication of where erosion is likely to occur. For the majority of Scotland’s coast, there is information available to help the delivery of this duty with regard to erosion. The following example highlights how this information can be used to inform and support development planning policy:

Coastal erosion is a recognised issue for the Orkney islands, where there is much low-lying land exposed to very high storm energies. An example of this is the Neolithic site at Skara Brae (Figure 7), first revealed by coastal erosion caused by a powerful storm in 1850.

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Figure 7 – Part of the Skara Brae site, with the continually eroding coastline in the background. The site is under threat from ongoing erosion and storm damage.

Orkney’s previous LDP, published in 2014, placed a general presumption against development on land at risk from coastal erosion. However, that risk was identified through analysis of theoretical potential for erosion, rather than through observed changes at the coast. While the LDP coastal policy did allow for ‘other available information’ indicating an erosion risk, and the linked Supplementary Guidance signalled the Orkney Islands Council’s intention to review coastal vulnerabilities, overall a risk-averse and precautionary approach to development was encouraged.

In 2015-2016, during preparation of the next LDP, the emerging Dynamic Coast project team contacted Orkney Islands Council. The project was identifying past coastal change from historical maps, and offered projections of which sections of the coast would be likely to erode over coming decades. SNH, as a statutory consultee, encouraged the Council to update the coastal LDP policy to take account of Dynamic Coast project information.

Drawing on this information, the Coastal Development policy of the plan adopted in 2017 sets out positively the circumstances in which coastal development will be supported.

For example, it encourages development that requires a coastal location to focus on areas in which the coast is already developed. Under the separate heading of ‘Coastal Change’, and reflecting the SPP aim to achieve the right development in the right place, the policy states that development will not generally be supported in areas vulnerable to the adverse effects of coastal change as identified by Dynamic Coast project. Exceptions may be permitted for development that incorporates a strategy of adaptation to the anticipated change, avoiding any need for coastal intervention over the whole lifetime of the development.

By referring to Dynamic Coast project outputs, this policy benefits from the Scottish Government’s nationally consistent assessment of coastal change. The erosion projections are updated as new data on shoreline change is received, so the implementation of Orkney’s Coastal Development Policy is automatically updated. This would not be the case if erosion projections had been mapped within the LDP itself.

Importantly, one of the criteria for development in the Orkney policy is that any development avoids the disturbance or degradation of coastal landforms. This recognises the crucial role that beaches, dune systems, saltmarshes, etc, play as natural defences against coastal erosion and flooding. The policy also complements the duties assigned to SEPA under the Flood Risk Management (Scotland) Act 2009 to identify the most important of these features for safeguarding.
While safeguarding the coast, the policy does not prevent appropriate activities or development. An example of this is found at Churchill Barrier Number 4 (shown in Figure 8), linking Burray and South Ronaldsay where sand extraction has been permitted, due to the levels of accretion. While the natural dune defences protect the road from waves, the levels of accretion mean that sand blows onto the road. Managing it through carefully controlled extraction enables the dune to function as a natural defence while ensuring that the road remains passable.

Figure 8 – Vital coastal infrastructure: the Churchill barriers (Orkney) no. 2, which experiences routine wave overtopping (top picture) contrasted with no. 4, which is protected from waves by a large accumulating sand dune.
Beyond the horizons of spatial planning at the coast:
Facing the future with shoreline management planning

Case study key points

– Shoreline management planning sets a longer-term context to inform shorter term spatial planning.
– Managing the coast involves careful risk-benefit analysis for the short and longer term.
– Projections of coastal change are a key element in shoreline management planning.
– Close collaboration between local authorities, communities, developers and other stakeholders can help to provide more certainty for future development at the coast.

A Shoreline Management Plan (SMP) sets a longer-term context for short-term spatial planning. While it is a non-statutory planning requirement, it is uniquely placed to both inform and support the spatial planning process at the coast. In places, the SMP process could initiate specific proposals (e.g., maintaining coastal defences to protect vital infrastructure), while in others it could help underpin zoning of vulnerable coastal land where new built development will not be supported.

The other case studies in this guidance illustrate the need for a shift in mind-set, from assuming shorelines are fixed to accommodating likely coastal change. In practice however, there will be locations where the preferred policy will be to resist coastal change, for example in order to protect vital infrastructure from coastal erosion. Shoreline management planning can help clarify where there is a need to resist coastal change, and where it makes greater social, environmental and/or economic sense to allow natural processes to prevail.

To move from reacting to coastal erosion problems to a more positive and strategic approach to coastal planning, Angus Council published one of Scotland’s first Shoreline Management Plans (SMPs) in 2004 (extract cover and images shown in Figure 9). This work pre-dated Dynamic Coast outputs, so historical OS mapping was used to assess changing positions of both Mean High Water Springs and Mean Low Water Springs over the preceding 140 years. Expert assessment then projected the past trends and rates into the future (together with other factors such as the condition of existing built defences). This helped to assess future risks to assets from erosion and flooding.
The SMP assessed potential high-level coastal management policies, such as ‘Hold the Line’ (ie upgrade or build defences) or ‘No Active Intervention’ (ie let natural processes determine change), in terms of economic and environmental benefits and costs. This assessment took account of how each policy might address the risks identified for each stretch of coast and on adjoining coastal areas. Policy was specified for both the shorter (<15 years) and longer term (15-50 years). In some locations the short and long term policies differed because of a need for early action, for example, establishing the principle of realigning parts of Montrose Golf Course. In other places, such as Montrose Basin, the longer-term policy differed because existing management was expected to become less sustainable as sea-level rise accelerates.

Through well-planned consultation with a range of stakeholders tailored to local circumstances, SMPs aim to achieve consensus between stakeholders about timescales for actions that are considerably longer than those of development plans. In the revision of the Angus SMP, published in 2017, an additional 50-100 year time period was introduced.

Such a long timescale does introduce greater uncertainty in terms of the effects of climate change on the coast. However, on the other hand it increases certainty for developers and communities as to where built development should be located, and therefore encouraging attention to be focussed on those areas.
The data used for both versions of the Angus SMP have been superseded by the more recent Dynamic Coast project outputs. These provide the basis for both new and iterated shoreline management planning through its nationally consistent dataset that future versions of the SMP can use.

The ongoing development of Dynamic Coast project, including study of changes to intertidal extents rather than just the high-water line, will greatly inform planning for coastal change. At the same time, emerging new approaches to shoreline management planning have focused effort on areas of greatest coastal change as well as tailoring the policy timescales. These improvements mean that shoreline management planning can help coastal communities, developers, planning authorities and others with an interest in the coast to face the future with greater confidence.
Future-proofing major infrastructure against coastal change:
£billion developments address the risks

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<th>Case study key points</th>
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<td>– Projections of future coastal change can inform planning at all stages and levels of detail, from in-principle strategic considerations through to post-consent technical discharge of conditions.</td>
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<tr>
<td>– Using Dynamic Coast information can help identify solutions and enable crucial development.</td>
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The design outlines of large infrastructure developments are often well advanced long before it is known exactly how erosion risks/constraints could be overcome. This is because mitigation initially identified through the Strategic Environmental Assessment of development plans may be no more specific than stating ‘alter its location/how it is installed’. As projects progress, more detailed development proposals emerge and undergo Environmental Impact Assessment. At this stage, minimising the impacts that the environment may have on a development, such as erosion risk, becomes a matter of how much time and money might be needed to overcome such risks.

The following example shows how coastal change can be taken into consideration, from early strategic planning through to delivery and the discharge of conditions:

In 2011, SNH gave a developer pre-application advice on several power cable landfalls along the Moray Firth's southern coast, including one that would affect a Site of Special Scientific Interest (SSSI) at Spey Bay. This SSSI is nationally important for natural features that experience coastal change, with coastal retreat averaging up to 1m/year over recent decades. SNH therefore advised the developer that Spey Bay experiences coastal erosion, which could threaten the landfall installations (as demonstrated in Figure 10). With just one of the cable landfall projects costing £2.5 billion, it was imperative that the cable landfalls were ‘future-proofed’ for their lifetime.

As a result of other factors, it was not possible to avoid the cable landfalls occurring within the SSSI. During the Environmental Impact Assessment, carried out to inform the application, tunnelling the cable under the beach by Horizontal Directional Drilling (HDD) was identified as a way of bypassing the estimated ‘envelope’ of shoreline retreat to avoid damaging SSSI features. Detailing the exact locations and methods for the HDD was made a condition of the terrestrial and marine consents.
Figure 10 – Image showing the proposed infrastructure location with Dynamic Coast coastal change mapping information overlain, demonstrating the significant erosion risk.

Unfortunately, detailed investigations done post consent in 2015 showed that the length of the HDD tunnels would present engineering challenges. To find a solution, newly available Dynamic Coast projections of future erosion were used by the developer to assess local beach dynamics and erosion risk. This allowed them to identify the minimum drilling distances that would enable them to minimise the risk of future erosion exposing and damaging cable where it exited its tunnel.

Finding a solution to enable installation of the cable that did not impact the SSSI, but that was also future-proofed against predicted coastal erosion, involved collaboration between the developers, SNH and the regulators. In 2017, the future-proofed landfall was successfully installed under the beach by HDD, without disturbing the SSSI.