Historic England

Coastal Risk and Priority Places

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Coastal Risk and Priority Places

The development of an interactive map resource

LUC

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SUMMARY
This project centred on the creation of an interactive map resource that displays heritage assets sensitive to coastal change. In order to achieve this, the project reviewed currently available data and research to develop indices of coastal vulnerability and heritage sensitivity. The combination of these two indices provides one possible method of identifying areas where heritage assets are most at risk from coastal processes – coastal heritage 'priority places'. The focus of this study has been heritage assets captured in the National Heritage List for England (NHLE).

Historic England has made a considerable investment in ensuring that the significance of heritage assets within the coastal zone is recognised through the Rapid Coastal Zone Assessment Survey (RCZAS) programme. This study will add value to this work by providing further detail about the vulnerability of these assets to coastal processes, enabling Historic England to:

- Identify where the risk of damage to, and loss of, coastal heritage assets is most pressing;
- Better understand the drivers of change and the rates at which they are operating; and
- Provide a framework for prioritisation.

The project's key outputs are GIS data and an interactive webmap with supporting documentation and a project report. The project outputs are intended to have a wide audience, ranging from internal staff and researchers at Historic England to partner organisations and ultimately members of the public.

Execution of this research project presented a number of challenges in terms of data access, data structure and scoring heritage sensitivity. The evaluation of datasets concluded that no perfect dataset exists for such an assessment, but that this is an area of continual development and it is anticipated that better datasets will emerge in the near future. The focus has therefore been on developing a method that can accommodate better datasets in the future as they become available.

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INTRODUCTION

Background

Recent years have seen growing awareness of the challenges that climate change will bring to many coastal areas, with rising sea levels increasing the risk of coastal flooding and changing patterns of erosion and deposition. Shoreline Management Plans (SMPs) provide the vehicle for managing flood and erosion risk over the short, medium and long term. SMPs aim to define a sustainable management approach that balances interests along the shoreline, looking ahead over the short term (up to 2025), the medium term (2026 – 2055) and the long term (up to 2105), referred to as Epochs 1, 2 and 3 respectively.

A key focus of SMPs is the definition of management response, distinguishing between sections of coast where the priority is:

- to hold the line;
- managed realignment;
- no active intervention; and
- to advance the line.

The coastal zone contains a legacy of heritage assets including a complex array of fragile and irreplaceable archaeological remains, shipwrecks, historic buildings and entire landscapes, both terrestrial and submerged.

The Rapid Coastal Zone Assessment Survey (RCZAS) programme has sought to bring Historic Environment Records up to date so that the impact of Shoreline Management Plans upon the historic environment can be better considered. As the range of data and mapping to support this research improves, it is possible to provide more spatially specific responses to the potential impacts of climate change. This project builds on research programmes undertaken under the auspices of Historic England (HE) and its predecessors, most notably the English Heritage Coastal Estate Risk Assessment (Hunt 2011) which focussed on 80 historic properties in England under English Heritage's guardianship that lie within 200m of the 'Coastal Zone'. However, there is currently no comprehensive mapped overview of heritage assets on the National Heritage List for England (NHLE) at risk from coastal processes.

This project aims to rectify this by creating a mapped database of NHLE heritage assets at risk from coastal processes to enable Historic England to identify where damage to and loss of designated coastal heritage assets is most pressing. This is designed to help Historic England better understand the drivers of change and the rates at which they are operating, and provide a framework for prioritisation of resources.

The Historic England Strategic Research and Partnerships Team are developing a nationwide risk map for heritage, and this work is the first step towards this, providing a strategic overview of designated coastal heritage assets at risk of

environmental change. This work has tested what the challenges might be in terms of accessing data to broaden the scope of the assessment to cover more of the historic environment, and a key output includes the lessons learnt and the framing of questions for future work.

As stated in the Historic England Climate Change Adaptation Report (Fluck 2016), 'Our climate is changing and organisations need to adapt to these changes, to become more resilient to the challenges and to make the most of the opportunities'. This work aims to improve our understanding of the risks to heritage assets posed by climate change and other coastal processes. The Climate Change Adaptation Report, submitted to Defra, makes the following relevant commitments:

- Supporting resilience in the Historic Environment.
- Embedding climate change adaptation and environmental risk management within projects and practices.
- Developing an approach for dealing with inevitable change, including loss.

This project will support Heritage at Risk work, helping to assess and prioritise commissioned projects. It will facilitate liaison and collaboration with other organisations and researchers working on coastal heritage.

In 2017 Historic England, jointly with the English Heritage Trust, became an Independent Research Organisation of the UK Research Councils and this project will also help to demonstrate impact for research in those areas identified as high risk.

Aims

The project's overarching aim is to identify those areas where heritage assets are most at risk from coastal change by building upon previous coastal risk mapping by Historic England (as English Heritage) looking at the National Collection i.e. English Heritage's coastal heritage estate (Hunt 2011) to devise a methodology that will identify where heritage is most at risk from coastal processes.

The subsidiary aims are as follows:

- To devise a methodology for categorising coastal vulnerability, heritage vulnerability and overall heritage at risk of coastal processes;
- To provide an interactive map of heritage assets vulnerable to coastal processes that is accessible to users both within and outside of Historic England; and
- To make recommendations for any further development, enhancement or use of the data set.

Given the need to develop a novel methodology for this study, the project also reflects upon lessons learnt during the process, identifying limitations and recommended next steps. The output is one possible methodology for

identifying areas where designated heritage assets are most at risk from coastal change. The overall scope and budget available for this study meant that the work has been useful in identifying areas where further research will be necessary to fully understand the risks to the wider historic environment. As such, the work makes an important contribution to the debate around understanding which aspects of the historic environment are most at risk from coastal change.

The resultant data will be made available to a range of stakeholders and the wider public via a publicly accessible online map.

Spatial scope

Whilst the project is intended to cover the full extent of England's coast with a suitable inland extent, data availability issues early in the study meant that data was initially explored in four test areas to see what data is accessible:

- Somerset Levels;
- Suffolk Coast;
- Humberside; and
- Solway Coast.

These areas were selected based on the following:

- Having a high density of (designated) heritage assets;
- Having a relatively large inland extent of flooding due to coastal and tidal events;
- Having a mix of Shoreline Management Plan policy approaches; and
- Having a variety of backshore profiles/erosion susceptibility (BGS data).

It was useful to review data available for these test areas to aid in the development of the method. However, as the study progressed, it was possible to access more of the National Heritage List for England database (NHLE) allowing a national assessment to be undertaken. Whilst accessing the entire NHLE presented a significant amount of data upon which to develop and test the method, it should be noted that further datasets such as the Historic Environment Record (HER) contain a significantly larger volume of heritage data, including many of equivalent significance to designated assets, but not yet designated.

This study has not sought to examine vulnerability and sensitivity of protected wrecks which lie offshore.

Temporal scope

The temporal scope aligns with the short (0-20 years or 2005-2025), medium (20-50 years or 2026-2055) and long (50-100 years or 2056-2105) term definitions used in Shoreline Management Plans and the National Coastal Erosion Risk Map (NCERM), in turn reflecting the time horizons set out in the UKCP09 climate scenarios. It is recognised that data to support the evaluation

of the medium and long term timescales is cruder than that of the evaluation of the current time period.

METHOD

This section provides a summary of the methodology developed and applied in this study. A fuller description is provided in **Appendix 1**.

Review of previous and related studies

The project builds on research programmes undertaken under the auspices of HE and its predecessors, most notably the English Heritage Coastal Estate Risk Assessment (Hunt 2011). It also built on the Historic Environment Scotland study *Screening for Natural Hazards to Inform a Climate Change Risk Assessment of the Properties in Care of HES*. Both of these studies informed the method development, but both were based on a smaller set of heritage assets, whereas this new study intended to look at all assets in the NHLE with a view to extending coverage to undesignated assets. These studies were not considered to be an appropriate model, focusing as they do on assets in state care with the objective of influencing management and investment decisions of HE and HES respectively. It should also be noted that the HES study looked at a range of climate change-driven effects, of which coastal processes were but one dimension.

Defining the coastal zone

It was initially proposed that the study area should be based on a definition of 'coastal' developed previously by Natural England (NE) (Natural England 2007)[1]. This appears to have been developed with respect to coastal recreation, rather than being specifically relevant to areas at risk of coastal erosion or coastal flooding. It was agreed that a broader spatial definition would be more appropriate, based on existing areas at risk of flooding and / or likely to experience coastal erosion with a margin to reflect the likely effects of climate change.

The study area used has been defined by the inland extent of coastal erosion, flooding and sea level rise under the longer term epoch. When including coastal flooding, coastal processes can have an impact quite far inland. This makes it challenging to contextualise the impacts in the immediate 'coastal zone'. Additional analysis has therefore been undertaken to understand the impacts within a more narrowly defined zone within 1km of the High Water Mark (HWM).

Assessing coastal vulnerability

Through discussions with stakeholders and a review of existing research, a number of datasets were identified that could be of use for this research. Each of these was investigated and details are captured in **Table 47**. Some of the assumptions about availability of national datasets were, however, optimistic, and it was not possible to obtain all the datasets identified as being potentially

[1] Natural England (2007) *Improving coastal access: our advice to Government*

useful. It was recognised that data relating to medium and long term timescales are less detailed than that relating to the current time period.

The data review concluded that perfect datasets to underpin the assessment of coastal vulnerability do not currently exist. There are a number of useful datasets (most notably from the Environment Agency and BGS), but each has limitations. The focus therefore was on developing a method that is capable of accommodating better datasets as they become available in the future.

The following datasets were used in this study:

- Environment Agency National Coastal Erosion Risk Mapping (NCERM);
- Environment Agency Flood Zone 2 and 3 data as well as data showing areas that benefit from flood defences; and
- In order to further our understanding of the potential impacts of **sea level rise** on England's heritage assets for each of the three epochs, a GIS layer approximating all areas that are less than a given height above current mean sea level (three heights based on the H++ scenario for each epoch) was generated using Ordnance Survey's Terrain 50 dataset.

National Coastal Erosion Risk Mapping
Using the retreat distances contained within the NCERM data, projected erosion zones were created for each of the epochs under the No Active Intervention scenario, representing the short, medium and longer terms. Since the NCERM data does not consider complex cliffs (as their past recession cannot be used to infer their future rates of erosion) a fourth GIS layer was created to ensure that the heritage assets behind these complex cliffs are taken into account.

Flood Map for Planning (Rivers and Sea)
Data for Flood Zones 2 and 3 includes flooding from both rivers (fluvial) and the sea. Where the data allowed, information on fluvial flooding was removed to allow a focus on coastal flooding. Some areas that had a combination of fluvial and tidal flooding events remained. This is recognised as a limitation of the data and its analysis. Areas benefitting from existing flood defences were included in the assessment. Whilst these areas are likely to have a much lower flood risk as a result of these defences, it should be noted that defences could still fail or not be maintained in the future.

Sea level rise projections
The assessment drew on the Environment Agency's definition of climate change allowances for flood risk assessments which are defined by epoch and region, together with the agency's H++ allowances for the country as a whole.

Using Ordnance Survey Terrain50 topography data, raster analysis was used to add the following heights to the current mean sea level for the whole of England:

- Short term 0.21m (H++ scenario 1990-2025)
- Medium term 0.572m (H++ scenario 1990-2055)
- Long term 2.225m (H++ scenario 1990-2115)

This is largely a theoretical exercise to test the method as the vertical accuracy of Terrain50 data is not appropriate for modelling this level of detail. Lidar data is available to increase the resolution of the modelling, but it is only available in individual tiles and the stitching together of a national layer was seen as beyond the scope of this study.

Scoring coastal vulnerability

In order to establish the level of risk to each of the heritage assets, a scoring system was devised to differentiate between the levels of risk relating to each of the above layers (mapped as risk zones representing different risk types). A three point scale was considered appropriate for this strategic assessment.

This initial spatial assessment considered only whether any part of a given heritage asset is within the risk zones – rather than the proportion within the risk zones. Where possible, this was undertaken for the short, medium and long term scenarios. For coastal erosion two versions were assessed for the long term – with and without complex cliffs. For coastal flooding, future flooding scenarios have not been evaluated.

Assessing heritage sensitivity

The heritage asset data used in the study was drawn from HE's National Heritage List for England database. This combines the various designated asset datasets maintained by HE, and includes asset typology and main material types not present in the publicly-available data.

The NHLE records (in a database) and maps (in GIS) the following assets:

- World Heritage Sites
- Registered Battlefields
- Registered Parks and Gardens
- Scheduled Monuments
- Listed Buildings
- Protected Wrecks
- Heritage at Risk

Additional datasets used to assess heritage sensitivity included:

- HE/FISH Thesaurus of Monument Types

- HE/FISH Thesaurus of Material Types

Data and scope limitations

It was anticipated that data on non-designated heritage assets, drawn from Historic Environment Records (HERs) and the Rapid Coastal Zone Assessment programme would be employed in the analysis. This was considered imperative to ensure that the totality of the known historic environment and its vulnerability to the effects of climate change on coastal processes and flooding was considered. Extensive engagement with Historic England staff revealed that no central repository of RCZA data or reporting is held by the organisation, removing this potential strand of data delivery. Initial engagement with regard to sourcing HER data was also made, originally with the intention of conducting this more extensive analysis in a series of pilot areas. The challenges encountered in developing the methodology, obtaining, cleaning and applying the NHLE data – with subsequent refinements following HE engagement and feedback – squeezed the time and budget available for this strand of work. At HE's request, this workstream was then deprioritised to ensure that a working, robust and repeatable method could be consistently applied at the national level, using designated asset data.

It is recognised that the NHLE spatial datasets are not ideal in terms of feature class consistency. While Scheduled Monuments, Registered Parks and Gardens, and Registered Battlefields are recorded as polygons, Listed Buildings – by far the most numerous class of designated asset – are recorded as points.

It is readily acknowledged that the designated asset data applied in the study do not represent the totality of the historic environment, nor are they necessarily a particularly representative sample of England's suite of heritage assets. (While it is widely acknowledged that there are substantial geographical, temporal and typological biases in the corpus of designated assets, it is unfortunately beyond the scope of this project to attempt to address them.)

Similarly, the datasets discussed above do not deal effectively with the historic dimension of England's landscapes – broadly referred to as 'historic character'. While this is captured through the process of Historic Landscape Characterisation (HLC), attempting to use this data in this context was judged to be extremely challenging on a technical level and, on balance, potentially insufficiently instructive with regard to meaningful risk to the historic environment. While the National Historic Landscape Characterisation (NHLC) was completed shortly before commencement of this project, the adoption of a grid-based approach in the production of the final data severely limits its usefulness in a context where spatial precision is, if not paramount, at least very important. Applying the polygon data developed for individual local/regional HLCs to more detailed locally-focused studies would be readily possible, albeit necessitating substantial effort to clean, analyse and apply the data.

Assessing vulnerability

The vulnerability of heritage assets to coastal processes is derived principally from the substrate on which the asset stands (i.e. how resilient it is to the effects of erosion), its elevation above current and projected sea level and, to a lesser extent, its physical character and the materials from which it is constructed. In terms of erosion, this has little influence since even the most robustly-constructed asset will be lost if it is undermined by wave action. For this reason, the evaluation of heritage sensitivity to coastal erosion is a function of its coastal vulnerability only. For coastal flooding and sea level rise, consideration of physical character and materials type was considered important and this section sets out the approach to developing sensitivity ratings for coastal flooding and sea level rise.

Scoring heritage sensitivity

Monument Type Broad Term sensitivity rating

Using the typological information drawn from the HE/FISH Thesaurus of Monument Types, vulnerability to coastal flooding was assigned to each 'Broad Type'. This was done at the 'Broad Type' level to ensure a measure of proportionality appropriate to a national study. This was necessarily strategic, given the potential for a range of types to occur as upstanding, occupied and maintained buildings or as archaeological assets. This underlines the importance of regarding the outputs of this study as providing a starting point for further investigation for those sites where significant risks are identified.

A high, medium and low scale of vulnerability was used for the assessment with scores of 3, 2 and 1 respectively applied to database records.

Although a draft sensitivity rating was applied to all Broad Monument Types in the thesaurus, following review of the outputs, it was agreed that monument type sensitivity ratings would be excluded from the emerging algorithm. For the purposes of this study, it was judged to be too complex to develop an approach that would be widely accepted.

Materials Type sensitivity rating

For Listed Buildings, and a small proportion (11%) of Scheduled Monuments, information on the main construction materials of the asset is provided. This enabled further judgement on the likely vulnerability of assets to the effects of inundation. This allowed scores to be either moderated or amplified depending on the likely susceptibility of key materials to wetting (e.g. engineering brick or concrete structures being more resilient than, for instance, cob walls or earthworks). A high, medium and low scale of vulnerability was used for this assessment with scores of 3, 2 and 1 respectively. Information on the main construction materials was not available for other NHLE assets, so assumptions were applied in the absence of detailed information. The main materials sensitivity ratings are included in **Appendix 2**.

Developing a heritage vulnerability index

The assessment of heritage vulnerability considers:

- **Importance** (i.e. heritage significance) of a receptor – in this case a heritage asset. Although the significance of a heritage asset has no intrinsic bearing on its physical vulnerability to coastal processes, this information will be very important in raising awareness of the issues and influencing management responses (e.g. where to invest limited funds). Heritage significance acts as a multiplier – moderated or further amplified by the physical vulnerability of the asset to coastal processes;
- **Sensitivity to change** of the receptor (i.e. heritage vulnerability – combination of coastal vulnerability and inherent asset sensitivity). Separate scores were developed for sensitivity to change for the different coastal risks (coastal flooding, coastal erosion and sea level rise); and
- **Magnitude of predicted change** (proportion of asset affected – in this case by erosion / inundation). While recognising that actual impacts can only be determined at the level of individual historic assets, the approach was designed to measure the proportion of each asset's total footprint that was affected by coastal processes. This is a crude measure of the scale/magnitude of effect, however it does help to highlight where assets are potentially at risk of total or very substantial loss. It should be noted that the spatial extent (footprint) of listed buildings is not recorded accurately (each Listed Building is recorded as a single point), so it was assumed that impacts would result in complete loss. For larger area-based designation data, it should be noted that not all areas within the designated area will make an equal contribution to the overall significance of the asset. The assessment took account of the reduced risk of flooding where defences are in place. Sea level rise mapping was subject to limitations on accuracy noted above.

These properties (importance, sensitivity to change and magnitude of predicted change) are then combined to understand the level of effect likely to be experienced by each asset for each risk type (erosion, coastal flooding and sea level rise). Those assets on the Heritage at Risk Register, and therefore already at risk for other reasons, were weighted in the analysis.

Importance (Heritage significance)	**x**	**Sensitivity to change** (Heritage asset sensitivity X coastal vulnerability)	**x**	**Magnitude of change** (Proportion of asset affected)	**=**	**Level of effect** (Accumulated score)
						x Heritage at Risk multiplier

The resultant range of scores possible is set out in **Table 1** with examples of how the highest scores can be reached. It was agreed early on that there should be no attempt to conflate the risk scores for each risk type to arrive at an overall risk score (for all risk types for each asset. For this reason, the GIS attribution for each asset holds information on the scores for each risk type separately.

The importance of being able to 'unpick' each of these properties/factors was seen as critical, and the GIS data has been set up to allow this to be done.

Table 1: Range of possible scores for overall level of effect by risk type

Coastal Risk	Importance scores	Sensitivity to change scores	Magnitude of change scores	Level of effect scores	Heritage at Risk Multiplier
Coastal Flooding					
Score range	2 or 3	0 to 9	1-4	0 to 108	2
Max possible score	3 (e.g. Grade I Listed Building)	9 (e.g. Material Type sensitivity high, located in Flood Zone 3)	4 (e.g. entire area is within Flood Zone 3)	108	216 (Asset is on Heritage at Risk Register)
Coastal Erosion					
Score range	2 or 3	0 or 3	1-4	36	2
Max possible score	3 (e.g. Grade I Listed Building)	3 (e.g. Located in area vulnerable to erosion)[2]	4 (e.g. entire area is within Flood Zone 3)	36	72 (Asset is on Heritage at Risk Register)
Sea Level Rise					
Score range	2 or 3	0 to 9	1-4	0-108	2
Max possible score	3 (e.g. Grade I Listed Building)	9 (e.g. Material Type sensitivity high, located in inundation zone)	4 (e.g. entire area is within inundation zone)	108	216 (Asset is on Heritage at Risk Register)

The following section applies this method to the NHLE data and presents the results.

[2] Material Type sensitivity is not a contributing factor for coastal erosion.

ANALYSIS AND FINDINGS

This chapter sets out the results of applying the approach described in previous chapters. It follows the following format:

- Establishing the number and types of heritage assets considered in this assessment and their significance. This includes an assessment of the number of assets on the Heritage at Risk Register.
- Coastal vulnerability – establishing the number and types of assets within:
    - areas susceptible to coastal erosion (at each epoch)
    - areas susceptible to coastal flooding (current)
    - areas susceptible to sea level rise (at each epoch)

  This section also explores the potential magnitude of change - the extent to which vulnerable assets are likely to be inundated or lost to erosion.
- Heritage sensitivity – establishing the proportions of assets scoring High, Medium and Low for Material Type sensitivity.
- Sensitivity to change – the results of combining coastal vulnerability with heritage sensitivity.
- Exploring the overall level of effect on assets as a result of:
    - coastal erosion (at each epoch)
    - coastal flooding (current)
    - sea level rise (at each epoch)
- An exploration of the results by region (using the former government regions).
- Exploring the results using case studies.

Heritage assets considered in this assessment and their heritage significance

Table 2 shows the number of heritage assets held in the NHLE spatial datasets by grade where relevant. Protected wrecks have not been included in this assessment.

Table 2: Total number of heritage assets in the NHLE (as at November 2018)

Asset type	Total number	*Grade I*	*Grade II**	*Grade II*	*Number on Heritage at Risk Register*
World Heritage Sites	19	n/a	n/a	n/a	0
Registered Battlefields	47	n/a	n/a	n/a	4
Registered Parks and Gardens	1,668	*145*	*455*	*1068*	*99*
Scheduled Monuments	19,855	n/a	n/a	n/a	2,486
Listed Buildings	378,484	*9,321*	*22,001*	*347,162*	*2,067*

As noted in earlier sections, whilst the impacts of coastal processes can be felt quite far inland when coastal flooding is considered, in order to contextualise the results of this assessment, the results are additionally expressed as numbers and proportions of affected assets within 1 km of the High Water Mark. This is an arbitrary zone used to understand the impacts on assets that are closer to the coastline. **Table 3** shows the number of NHLE assets within this zone.

Table 3: Total number of heritage assets in the NHLE (as at November 2018) within 1km of the High Water Mark

Asset type	Total number within 1km of HWM (% of total on NHLE)	*Grade I* within 1km of HWM	*Grade II** within 1km of HWM	*Grade II* within 1km of HWM	*Number on Heritage at Risk Register* within 1km of HWM
World Heritage Sites	9 (47%)	n/a	n/a	n/a	0
Registered Battlefields	5 (11%)	n/a	n/a	n/a	1
Registered Parks and Gardens	204 (12%)	*17*	*49*	*138*	*12*
Scheduled Monuments	1,734 (9%)	n/a	n/a	n/a	266
Listed Buildings	45,516 (12%)	*1,300*	*2,999*	*41,217*	*313*

Coastal vulnerability

Assets vulnerable to coastal erosion
As noted in earlier sections, NCERM predicts the recession likely to occur from a baseline, located at the point at which recession will commence, for example, at the top edge of a cliff, the back of dunes, or a similar location. Frontages are divided into:

- Erodible
- Floodable
- Complex cliffs

Frontages that are categorised as Floodable have been classified as having a predominant risk of flooding (more so than erosion) so have no associated erosion profiles. Details of geologically complex areas, known as "complex cliffs" are not included within the dataset due to the inherent uncertainties associated with predicting the timing and extent of erosion at these locations. This means that in some of the most complex areas, erosion rates have been modelled by using a notional 1km projected erosion zone for the long term coastal erosion scenario.

The analysis that follows tries to take a 'catchall' approach by identifying any assets that interact with the NCERM baseline in any way. In some cases, this may mean that an asset 'straddles' the NCERM baseline, but the predominant risk is in fact flooding.

Taking all of the NHLE assets, it is possible to explore the relationship with the NCERM profiles in more detail. This gives a high level indication of the number of assets that are within areas that have been identified as at risk in terms of coastal erosion or have some level of interaction with the NCERM baseline.

Of the 19 World Heritage Sites (Core Areas), five sites interact with the NCERM erosion profiles:

- Frontiers of the Roman Empire (Hadrian's Wall)
- Dorset and East Devon Coast
- Liverpool - Maritime Mercantile City
- Cornwall and West Devon Mining Landscape
- The English Lake District

The majority of these sites have less than 5% within the erosion zones. The notable exception is Dorset and East Devon Coast, of which 96% lies seaward of the NCERM baseline. This site is designated for its geological and palaeontological importance rather than cultural heritage.

Of the 47 Registered Battlefields, only one site interacts with the NCERM erosion profiles, being partially situated seaward of the NCERM baseline (percentage of site in brackets):

- Battle of Maldon 991 (28%)

It should be noted that the NCERM baseline for this particular section of coast indicates that the coastline is floodable rather than erodible.

Table 4 and **5** set out the findings of this high level analysis for Parks and Gardens.

Table 4: Interaction of Parks and Gardens with coastal erosion profiles by grade and epoch

Erosion profile zone	Breakdown by grade		% of all Parks and Gardens	% of Parks and Gardens within 1km of HWM
Short term NAI 5th percentile	I	4	2.8%	23.5%
	II*	14	3.1%	28.6%
	II	33	3.1%	23.9%
	Total	**51**	**3.1%**	**25.0%**
Medium term NAI 5th percentile	I	4	2.8%	23.5%
	II*	15	3.3%	30.6%
	II	36	3.4%	26.1%
	Total	**55**	**3.3%**	**27.0%**
Long term NAI 5th percentile	I	5	3.4%	29.4%
	II*	15	3.3%	30.6%
	II	40	3.7%	29.0%
	Total	**60**	**3.6%**	**29.4%**
Long term NAI 5th percentile incl. complex cliffs	I	5	3.4%	29.4%
	II*	15	3.3%	30.6%
	II	42	3.9%	30.4%
	Total	**62**	**3.7%**	**30.4%**

Table 5: Interaction of Parks and Gardens with coastal erosion profiles by proportion of loss

Erosion profile zone	Proportion of loss category		Proportion of Parks and Gardens at risk (coastal erosion) in each loss category
Short term NAI 5th percentile	>0-25%	46	90.2%
	25.1 – 50%	2	3.9%
	50.1 – 75%	2	3.9%
	75.1 – 100%	1	2.0%
Medium term NAI 5th percentile	>0-25%	47	85.5%
	25.1 – 50%	3	5.5%
	50.1 – 75%	3	5.5%
	75.1 – 100%	2	3.6%
Long term NAI 5th percentile	>0-25%	49	81.7%
	25.1 – 50%	3	5.0%
	50.1 – 75%	2	3.3%
	75.1 – 100%	6	10.0%
Long term NAI 5th percentile incl. complex cliffs	>0-25%	*45*	72.6%
	25.1 – 50%	*3*	4.8%
	50.1 – 75%	*3*	4.8%
	75.1 – 100%	*11*	17.7%

Table 6 sets out the findings of this high level analysis for Scheduled Monuments.

Table 6: Interaction of Scheduled Monuments with coastal erosion profiles

Erosion profile zone	Number of affected assets	Breakdown of total by proportion of loss category	
Entirely seaward of the NCERM baseline	90	100%	90
Short term NAI 5th percentile	345	>0-25%	159
		25.1 – 50%	33
		50.1 – 75%	26
		75.1 – 100%	127
Medium term NAI 5th percentile	374	>0-25%	152
		25.1 – 50%	34
		50.1 – 75%	31
		75.1 – 100%	157
Long term NAI 5th percentile	411	>0-25%	148
		25.1 – 50%	47
		50.1 – 75%	32
		75.1 – 100%	184
Long term NAI 5th percentile incl. complex cliffs	463	>0-25%	*141*
		25.1 – 50%	*42*
		50.1 – 75%	*32*
		75.1 – 100%	*248*

Table 7 sets out the findings of this high level analysis for Scheduled Monuments within 1km of the HWM.

Table 7: Interaction of Scheduled Monuments with coastal erosion profiles within 1km of HWM

Erosion profile zone	Number of affected assets within 1km of HWM	Breakdown of total by proportion of loss category	
Entirely seaward of the NCERM baseline	90	100%	90
Short term NAI 5th percentile	343	>0-25%	158
		25.1 – 50%	33
		50.1 – 75%	26
		75.1 – 100%	126
Medium term NAI 5th percentile	372	>0-25%	151
		25.1 – 50%	34
		50.1 – 75%	31
		75.1 – 100%	156
Long term NAI 5th percentile	409	>0-25%	147
		25.1 – 50%	47
		50.1 – 75%	32
		75.1 – 100%	183
Long term NAI 5th percentile incl. complex cliffs	457	>0-25%	*139*
		25.1 – 50%	*42*
		50.1 – 75%	*32*
		75.1 – 100%	*244*

Table 8 sets out the findings of this high level analysis for Listed Buildings. This table also identifies where Listed Buildings lie entirely seaward of the NCERM baseline, implying that they may already be 'in the sea', and potentially reasonably well suited to it e.g. piers, fish traps, harbour walls etc. These are included in the figures for each subsequent epoch.

Table 8: Interaction of Listed Buildings with coastal erosion profiles

Erosion profile zone	Breakdown by grade		Number within 1km of the HWM	% of Listed Buildings within 1km of HWM affected
Seaward of the NCERM baseline	I	19	19	1.5%
	II*	33	33	1.1%
	II	418	418	1.0%
	Total	**470**	**470**	**1.0%**
Short term NAI 5th percentile	I	18	18	1.4%
	II*	35	35	1.2%
	II	476	473	1.1%
	Total	**529**	**526**	**1.2%**
Medium term NAI 5th percentile	I	23	23	1.8%
	II*	57	57	1.9%
	II	1,117	1,113	2.7%
	Total	**1,197**	**1,193**	**2.6%**
Long term NAI 5th percentile	I	40	40	3.1%
	II*	109	109	3.6%
	II	2,079	2,075	5.0%
	Total	**2,228**	**2,224**	**4.9%**
Long term NAI 5th percentile incl. complex cliffs	I	*60*	*60*	4.6%
	II*	*208*	*205*	6.8%
	II	*3,968*	*3,902*	9.5%
	Total	***4,236***	***4,167***	**9.2%**

Assets vulnerable to coastal flooding

Taking all of the NHLE assets, it is possible to explore the relationship with the flood risk layers in more detail. This gives a high level indication of the number of assets that are within areas that have been identified as at risk in terms of coastal flooding. **Table 9** sets out the number of assets that have some level of interaction with each of the flood layers. As can be seen from the table, a large proportion of assets that lie within Flood Zones 2 or 3 are currently within areas benefiting from coastal defences. Information on the anticipated lifespan and maintenance of these defences has not been interrogated for this study, but will influence the timespan over which these assets can be considered to be at lower risk than assets which are not 'defended'.

Table 9: Flood Zone analysis

Asset type	Number of assets within or partially within Flood Zone 3 (with purely fluvial flooding removed)	Number of assets within or partially within Flood Zone 2 (with purely fluvial flooding removed)	Number of assets within or partially within Flood Zone 2 or 3 but partially or wholly within a defended area
World Heritage Sites	9	9	8
Registered Battlefields	4	4	2
Registered Parks and Gardens	110	118	55
Scheduled Monuments	545	656	243
Listed Buildings	*9,984*	*9,966*	*4,795*

Assets vulnerable to sea level rise

Taking all of the NHLE assets, it is possible to explore the relationship with sea level rise projections in more detail. This gives a high level indication of the number of assets that are within areas that have been identified as at risk in terms of their height above sea level. This assessment does not take into account existing or planned defences.

Eight World Heritage Sites have been identified as potentially being vulnerable to sea level rise (under the H++ scenario) in the short term:

- The English Lake District (<1%)
- Cornwall and West Devon Mining Landscape (<2%)
- Liverpool - Maritime Mercantile City (<5%)
- Royal Botanic Gardens, Kew (<2%)
- Dorset and East Devon Coast (38.5%)
- Maritime Greenwich (<1%)
- Palace of Westminster, Westminster Abbey and St. Margaret's Church (6.8%)
- Tower of London (3.6%)

The same eight are vulnerable in the medium and longer term, with very small increases in the affected areas. Many of these sites are large in extent and some are made up of multiple disconnected areas, some of which are not coastal (e.g. Cornwall and West Devon Mining Landscape).

Table 10 and **11** set out the findings of this high level analysis for Parks and Gardens.

Table 10: Interaction of Parks and Gardens with sea level rise predictions by grade and epoch

Sea level rise projection (H++ scenario)	Breakdown by grade		Number of affected Parks and Gardens within 1km of HWM	% of Parks and Gardens within 1km of HWM affected
Short term	I	3	3	17.6%
	II*	21	21	42.9%
	II	29	28	20.3%
	Total	**53**	**52**	**25.5%**
Medium term	I	3	3	17.6%
	II*	21	21	42.9%
	II	32	30	21.7%
	Total	**56**	**54**	**26.5%**
Long term	I	5	5	29.4%
	II*	22	22	44.9%
	II	46	42	30.4%
	Total	**73**	**69**	**33.8%**

Table 11: Interaction of Parks and Gardens with sea level rise predictions by area of loss

Sea level rise projection (H++ scenario)	Proportion of loss category		Number of affected Parks and Gardens within 1km of HWM	% of assets Parks and Gardens within 1km of HWM
Short term	>0-25%	53	52	25.5%
	25.1 – 50%	0	0	0.0%
	50.1 – 75%	0	0	0.0%
	75.1 – 100%	0	0	0.0%
Medium term	>0-25%	56	54	26.5%
	25.1 – 50%	0	0	0.0%
	50.1 – 75%	0	0	0.0%
	75.1 – 100%	0	0	0.0%
Long term	>0-25%	64	62	30.4%
	25.1 – 50%	3	2	1.0%
	50.1 – 75%	1	1	0.5%
	75.1 – 100%	5	4	2.0%

Table 12 sets out the findings of this high level analysis for Scheduled Monuments.

Table 12: Interaction of Scheduled Monuments with sea level rise predictions

Sea level rise projection (H++ scenario)	Number of affected assets	Proportion of loss category	
Short term	310	>0-25%	183
		25.1 – 50%	41
		50.1 – 75%	22
		75.1 – 100%	64
Medium	329	>0-25%	187
		25.1 – 50%	46
		50.1 – 75%	26
		75.1 – 100%	70
Long term	598	>0-25%	262
		25.1 – 50%	81
		50.1 – 75%	54
		75.1 – 100%	201

Table 13 sets out the findings of this high level analysis for Scheduled Monuments situated within 1km of the HWM.

Table 13: Interaction of Scheduled Monuments within 1km of HWM with sea level rise predictions

Sea level rise projection (H++ scenario)	Number of affected assets within 1km of the HWM (% of Scheduled Monuments within 1km of HWM)	Proportion of loss category	
Short term	292 (16.8%)	>0-25%	170
		25.1 – 50%	40
		50.1 – 75%	21
		75.1 – 100%	61
Medium	303 (17.5%)	>0-25%	170
		25.1 – 50%	43
		50.1 – 75%	25
		75.1 – 100%	65
Long term	433 (25%)	>0-25%	197
		25.1 – 50%	61
		50.1 – 75%	35
		75.1 – 100%	140

Table 14 sets out the findings of this high level analysis for Listed Buildings.

Table 14: Interaction of Listed Buildings with sea level rise predictions

Sea level rise projection (H++ scenario)	Breakdown by grade		Number within 1km of the HWM	% of Listed Buildings within 1km of HWM affected
Short term	I	53	53	4.1%
	II*	120	119	4.0%
	II	1,226	1,188	2.9%
	Total	**1,399**	**1,360**	**3.0%**
Medium term	I	53	53	4.1%
	II*	122	121	4.0%
	II	1,251	1,205	2.9%
	Total	**1,426**	**1,379**	**3.0%**
Long term	I	89	73	5.6%
	II*	215	198	6.6%
	II	2,440	2,002	4.9%
	Total	**2,744**	**2,273**	**5.0%**

Heritage sensitivity

This section sets out the results of applying the Material Type sensitivity scores to all of the records extracted from the NHLE (for the area within 60km of the coastline[3]). It does not consider their spatial relationship with coastal risks at this stage. **Table 15** sets out the number of high, medium and low sensitivity assets when considering Materials Type sensitivity.

Table 16 sets out the number of high, medium and low sensitivity assets within 1km of the HWM.

Table 15 Material Type sensitivity

Asset type	Low	Medium	High	Not assessed (beyond 60km selection zone)
World Heritage Sites	2	9	3	5
Registered Battlefields	n/a	n/a	35	12
Registered Parks and Gardens	0	10	1,126	532
Scheduled Monuments	378	1,230	14,877	3,370
Listed Buildings	47,652	118,469	117,671	94,692

Table 16 Material Type sensitivity for assets within 1km of the HWM

Asset type	Low	Medium	High
World Heritage Sites	0	5	3
Registered Battlefields	n/a	n/a	5
Registered Parks and Gardens	0	2	182
Scheduled Monuments	82	138	1,509
Listed Buildings	8,944	16,973	18,454

[3] Data needs to be extracted 'manually' from the NHLE database held by HE. The data was initially made available in a series of spreadsheets for the pilot areas, but was later made available for an area within 60km of the coastline. A spreadsheet per asset type was provided.

Sensitivity to change

This section sets out the results of combining the coastal vulnerability and heritage sensitivity assessments. The results are presented in terms of their cumulative scores using the algorithms at the top of each respective section.

Coastal flooding Sensitivity

Coastal Flooding Sensitivity score **(0 to 9)**	=	Heritage asset sensitivity Materials Type vulnerability rating (1, 2 or 3)	x	Coastal Flooding vulnerability risk rating (spatial analysis) (0, 1, 2 or 3)

Table 17 shows the range of scores achieved for each asset category.

Table 18 shows the range of scores for assets within 1km of the HWM.

Table 17 Range of scores for each asset category for coastal flooding assessment

Asset type	Score						No heritage asset sensitivity score
	1	2	3	4	6	9	
World Heritage Sites		4	3		1		1[4]
Registered Battlefields			2			2	-
Registered Parks and Gardens		1	38		8	55	17
Scheduled Monuments	14	19	217	8	120	269	13
Listed Buildings	934	1,631	2,773		1,654	2,055	937

Table 18 Range of scores for each asset category for coastal flooding assessment within 1km of the HWM

Asset type	Score					
	1	2	3	4	6	9
World Heritage Sites		4	3		1	
Registered Battlefields			1			1
Registered Parks and Gardens		1	30		6	52
Scheduled Monuments	4	12	139	7	85	220
Listed Buildings	660	1,271	1,947		1,391	1,798

[4] Royal Botanic Gardens, Kew shows vulnerability to coastal flooding (which includes flooding from tidal sources), but was not within the search zone for obtaining NHLE data about monument type/materials type.

Coastal erosion Sensitivity

Coastal Erosion sensitivity score **(0 to 3)**	=	Coastal erosion vulnerability risk rating (spatial analysis) (0 or 3)

Table 19 shows the number of sites scoring 3 for each asset category.
Table 20 shows the percentage of sites within 1km of the HWM scoring 3 for each asset category.

Table 19 Number of sites scoring 3 for each asset category for coastal erosion assessment

Asset type	Entirely seaward of NCERM	Short Term	Medium Term	Long Term	Long Term (incl. complex cliffs
World Heritage Sites	0	5	5	5	5
Registered Battlefields	0	1	1	1	1
Registered Parks and Gardens	0	51	55	60	62
Scheduled Monuments	90	345	374	411	463
Listed Buildings	470	529	1,197	2,228	4,236

Table 20 Percentage of sites within 1km of the HWM scoring 3 for each asset category for coastal erosion assessment

Asset type	Short Term	Medium Term	Long Term	Long Term (incl. complex cliffs
World Heritage Sites	55.6%	55.6%	55.6%	55.6%
Registered Battlefields	20.0%	20.0%	20.0%	20.0%
Registered Parks and Gardens	25.0%	27.0%	29.4%	30.4%
Scheduled Monuments	19.8%	21.5%	23.6%	26.4%
Listed Buildings	1.2%	2.6%	4.9%	9.2%

Sea level rise sensitivity

Sea level rise sensitivity score **(0 to9)**	=	Heritage asset sensitivity Materials Type vulnerability rating (1, 2 or 3)	x	Sea level rise vulnerability risk rating (spatial analysis) (0, 1, 2 or 3)

The following tables set out the findings of the assessment of sea level rise sensitivity for the short (**Table 21**), medium (**Table 22**) and long term (**Table 23**).

Table 21 Range of scores for each asset category for short term sea level rise assessment

Asset type	Score		
	3	6	9
World Heritage Sites		5	2
Registered Battlefields			1
Registered Parks and Gardens		1	52
Scheduled Monuments	2	21	287
Listed Buildings	245	643	460

Table 22 Range of scores for each asset category for medium term sea level rise assessment

Asset type	Score		
	3	6	9
World Heritage Sites		5	2
Registered Battlefields			1
Registered Parks and Gardens		1	55
Scheduled Monuments	4	21	304
Listed Buildings	259	651	465

Table 23 Range of scores for each asset category for long term sea level rise assessment

Asset type	Score		
	3	6	9
World Heritage Sites		5	2
Registered Battlefields			2
Registered Parks and Gardens		1	72
Scheduled Monuments	13	33	552
Listed Buildings	653	1,082	957

Overall level of effect

This section sets out the results of combining all of the factors considered in this study to assign each asset an overall score against each risk type. The results are presented in terms of their cumulative scores using the algorithm below. It was decided early on that this study would not attempt to conflate the different risk scores into an overall risk score for each asset; rather each asset would have separate scores for each risk type. These can be explored in detail in the GIS outputs.

Importance (Heritage significance)	**X**	**Sensitivity to change** (Heritage asset sensitivity X coastal vulnerability)	**X**	**Magnitude of change** (Proportion of asset affected)	**=**	**Level of effect** (Accumulated score)	
						X	
						Heritage at Risk multiplier	

Coastal flooding

Table 24 sets out the resultant range of scores for each asset category. These results are illustrated on **Figure 1** for Listed Buildings and **Figure 2** for all other assets.

Table 24 Range of overall scores for each asset category for coastal flooding assessment

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
2					871
3				6	55
4			1		1,380
6	4		24	16	1,556
8					24
9	3	1	10	155	114
12			5	9	26
18	1		26	94	1
24			1	2	1,240
27		1	19	89	
36		1	5	44	64
48			1	1	1,471
54		1	3	51	
72			4	33	2,050
81				23	
96					1
108			3	105	166
144				1	18
162				2	
216				16	10

The 16 assets scoring the highest in terms of coastal flooding are shown in **Table 25** below. All of these are Scheduled Monuments.

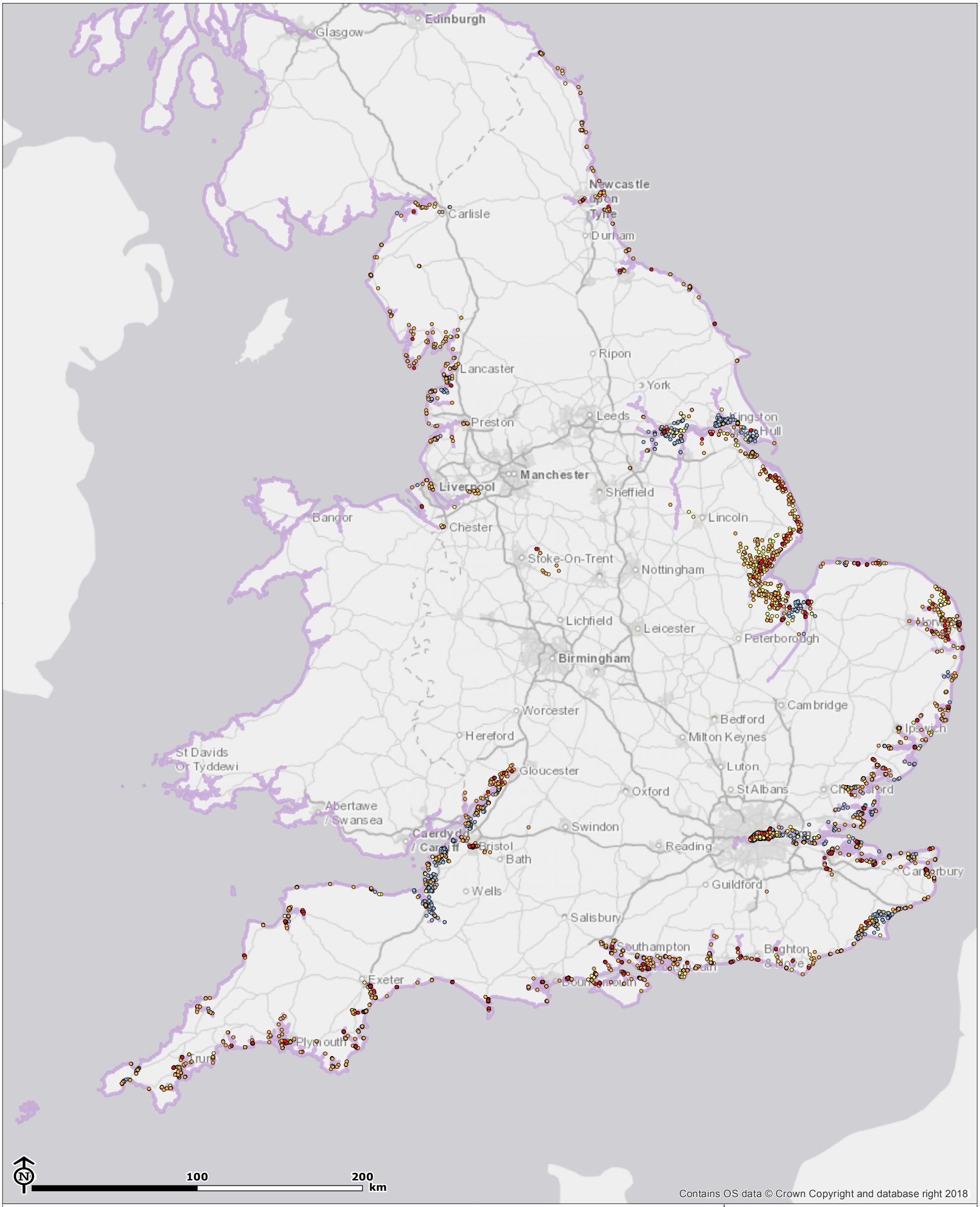
Table 25: Highest scoring assets for coastal flooding (all Scheduled Monuments)

List Entry	Name
1001852	Portsmouth Dockyard, the Docks
1001861	Hilsea Lines
1002079	Lydney Harbour
1003403	Cliffe Fort
1005898	Dunston Staithes
1005977	Settlement site E of the Cedars
1006036	Martello tower on golf course adjoining Woodbridge Haven
1006014	Martello tower SE of Buckanay Farm
1006768	Bank Quay transporter bridge
1016693	Rochford Tower
1017355	Martello tower no 64 at the Crumbles, 1.3km north east of Langney Point
1017356	Martello tower no 66, 320m north east of Langney Point
1018584	Multon Hall moated site
1019642	Fort Darnet, Darnet Ness
1019643	Hoo Fort
1020024	Heavy Anti-aircraft gunsite 220m east of West Marsh Cottage

The ten Listed Buildings scoring 216 (maximum) for coastal flooding are shown in **Table 26** below.

Table 26: Highest scoring Listed Buildings for coastal flooding

List Entry	Name	Location	Grade
1062077	CHURCH OF ALL SAINTS	Benington, Boston, Lincolnshire, PE22	I
1080970	TIDE MILL (KNOWN AS THE HOUSE MILL)	Newham, London, E3	I
1091968	CHAPEL MILLS, AMERICAN WHARF	Southampton, SO14	II*
1101724	CHURCH OF ST PETER AND ST PAUL	Westbury-on-Severn, Forest of Dean, Gloucestershire, GL14	II*
1195393	HANSE HOUSE	King's Lynn and West Norfolk, Norfolk, PE30	I
1202186	SWING BRIDGE OVER NORTH ENTRANCE LOCK	Bristol, BS8	II*
1267369	METHODIST CHAPEL	Friskney, East Lindsey, Lincolnshire, PE22	II*
1268252	MEDIAEVAL STABLES AT ABBEY FARM	Faversham, Swale, Kent, ME13	II*
1308429	CHURCH OF ST CLEMENT	Grainthorpe, East Lindsey, Lincolnshire, LN11	I
1381655	THE WEST PIER	Brighton and Hove, BN1	I



Coastal flooding overall level of effect score

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 1-9 (4,000)
- 10-36 (1,331)
- 37-81 (3,521)
- 82-216 (195)
- Areas within 1km of the HWM

Source: Environment Agency, Historic England

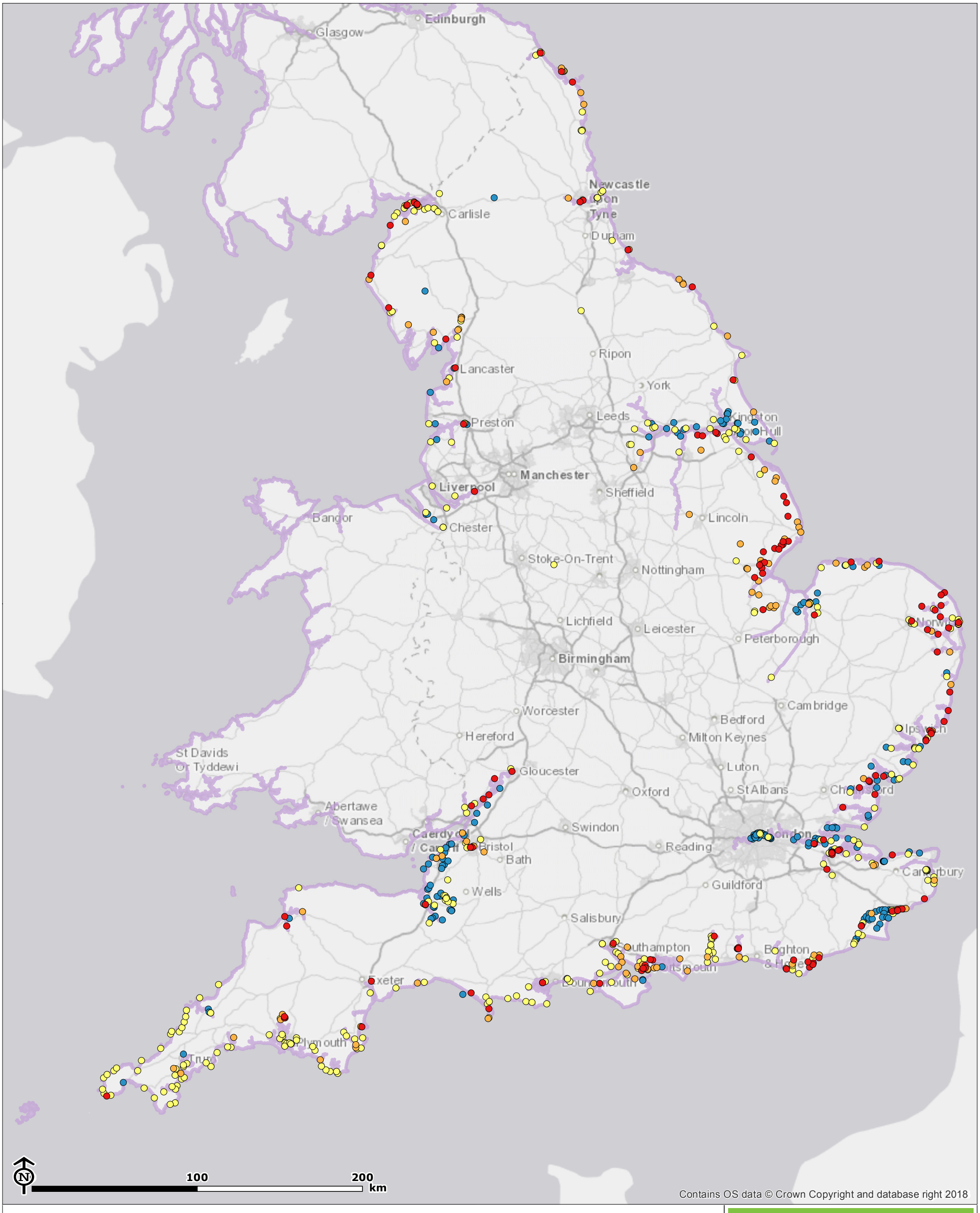
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 1: Listed Building coastal flooding overall level of effect

LUC Historic England

CB:DM EB:Manson D LUC FIG1_10193_v2_CF_LB_Overall_Scores_A3P 26/06/2019



Coastal flooding overall level of effect score

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 3 - 9 (220)
- 10 - 36 (297)
- 37 - 81 (117)
- 82 - 216 (127)
- Areas within 1km of the HWM

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 2: Other heritage assets coastal flooding overall level of effect

LUC

Historic England

CB:DM EB:Manson D LUC FIG2_10193_v3_CF_Assets_Overall_Scores_A3P 26/06/2019

Coastal erosion

The following tables set out the findings of the assessment for coastal erosion in the short (**Table 27**), medium (**Table 28**), long (**Table 29**) and long term including complex cliffs (**Table 30**). These results are illustrated on **Figures 3** and **4** for the medium term and **Figures 5** and **6** for the long term including complex cliffs.

Table 27 Range of overall scores for each asset category for coastal erosion assessment (short term)

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
6			22		
9	4		17	123	
12			8		
18		1	3	59	
24			1		476
27				21	
36	1			101	49
54				5	
72				36	4

Table 28 Range of overall scores for each asset category for coastal erosion assessment (medium term)

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
6			22		
9	4		18	120	
12			9		
18		1	4	56	
24			2		1117
27				25	
36	1			122	75
54				6	
72				45	5

Table 29 Range of overall scores for each asset category for coastal erosion assessment (long term excluding complex cliffs)

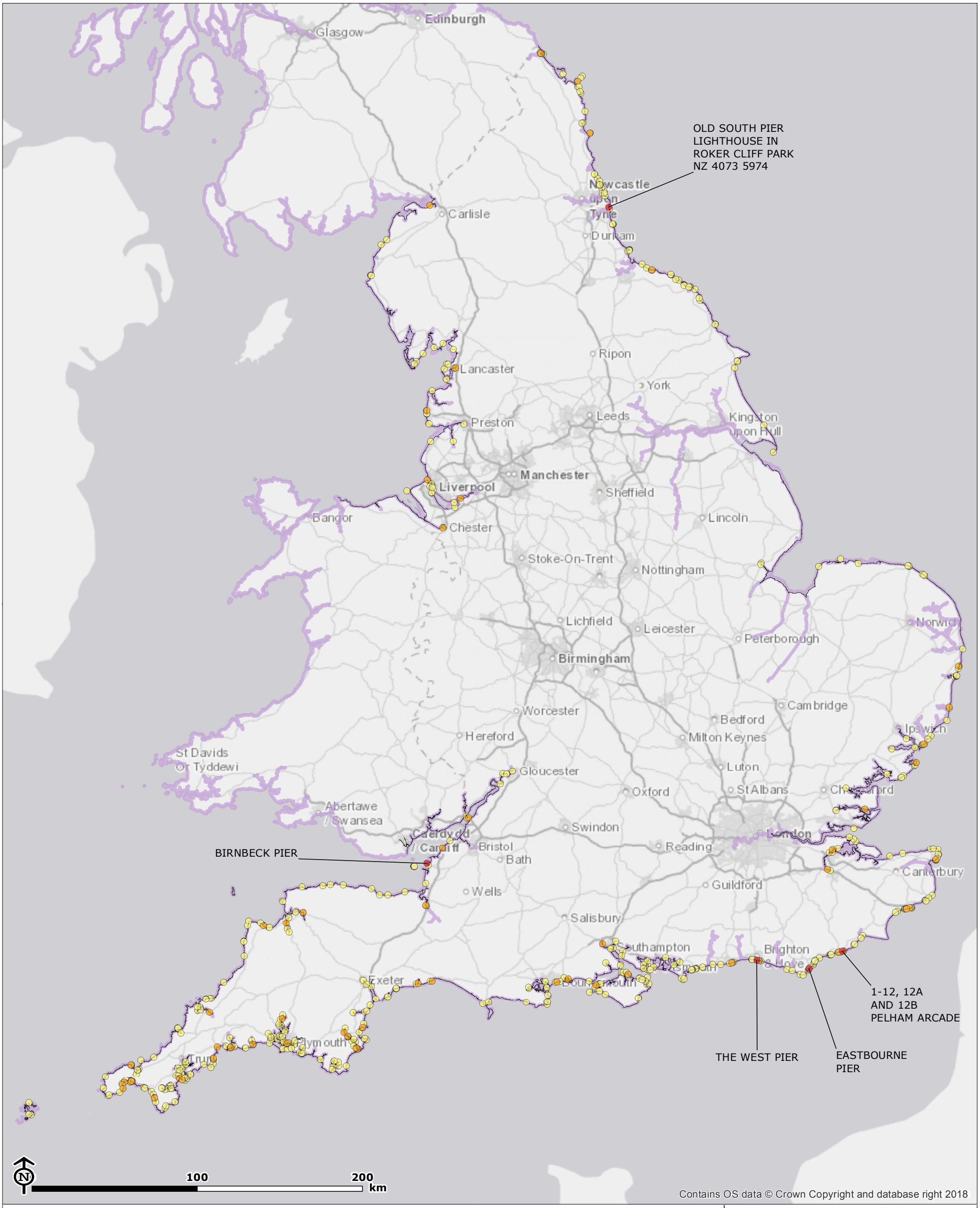
Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
6			24		
9	4		18	114	
12			8		
18		1	4	71	
24			6		2076
27				27	
36	1			144	141
48					3
54				5	
72				50	8

Table 30 Range of overall scores for each asset category for coastal assessment (long term including complex cliffs)

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
6			22		
9	4		17	109	
12			7		
18		1	4	66	
24			10		3962
27			1	26	
36	1			195	251
48			1		6
54				6	
72				61	17

In the short term, the four highest scoring Listed Buildings are Piers on the Heritage at Risk register. Three of these are already situated seaward of the NCERM baseline. Of the top scoring assets, there are a high number of piers, bridges and harbour-related structures.

All of the assets that score 72 (the highest category) in the short term are Scheduled Monuments; all of which are also on the Heritage at Risk register. Of these, a high proportion are situated seaward (or partially) seaward of the NCERM baseline.



National Coastal Erosion Risk Mapping (NCERM) baseline

Areas within 1km of the HWM

Coastal erosion overall level of effect (medium term)*

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 24 (1,117)
- 36 (75)
- 72 (labelled on map) (5)

* No Active Intervention 5th percentile scenario

Source: Environment Agency, Historic England

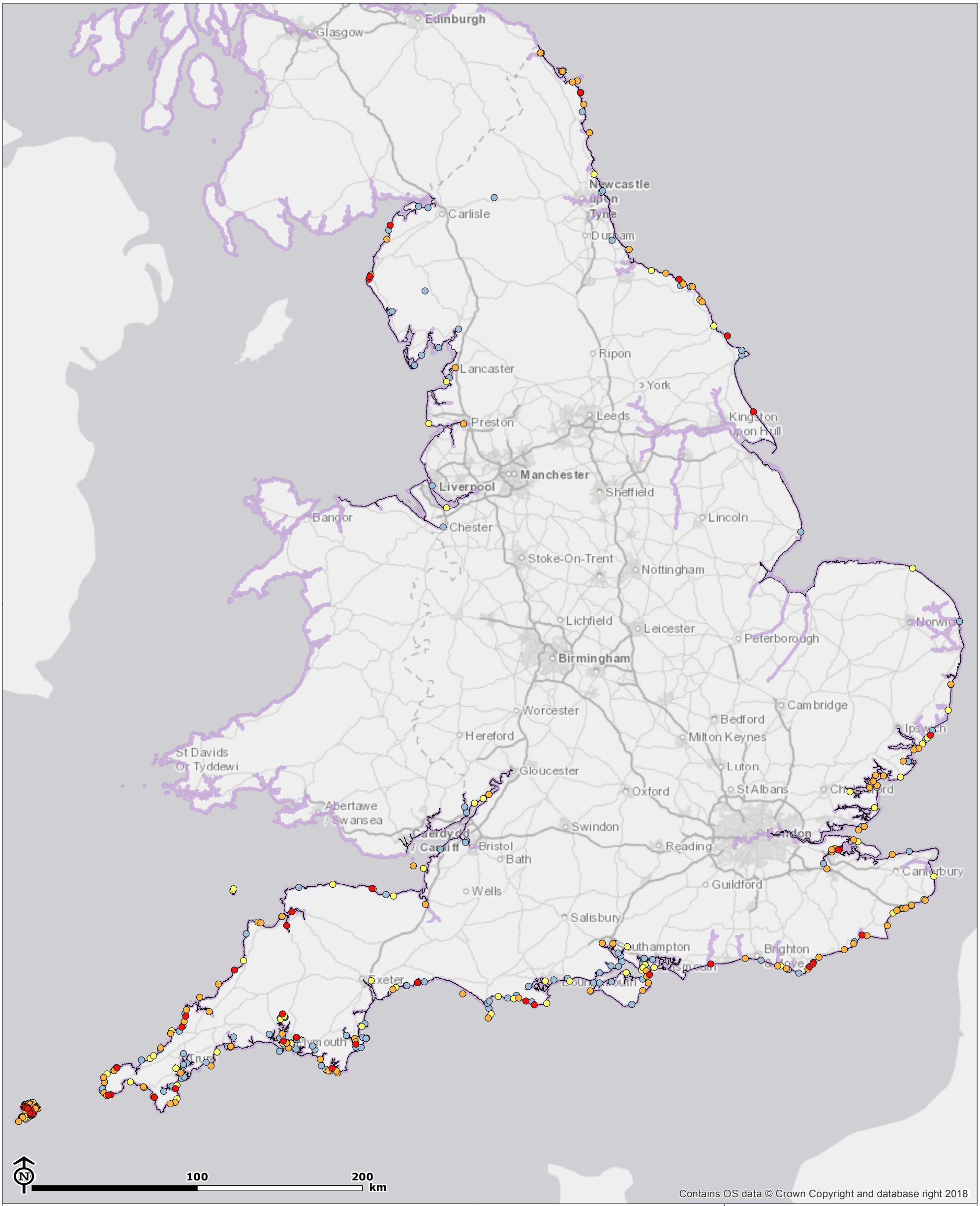
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 3: Listed Building coastal erosion overall level of effect (medium term)

LUC Historic England

CB:DM EB:Manson D LUC FIG3_10193_v1_CE_LB_MT_Total_A3P 26/06/2019



National Coastal Erosion Risk Mapping (NCERM) baseline

Areas within 1km of the HWM

Coastal erosion overall level of effect (medium term)*

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 1 - 9
- 10 - 24
- 25 - 36
- 37 - 72

* No Active Intervention 5th percentile scenario

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

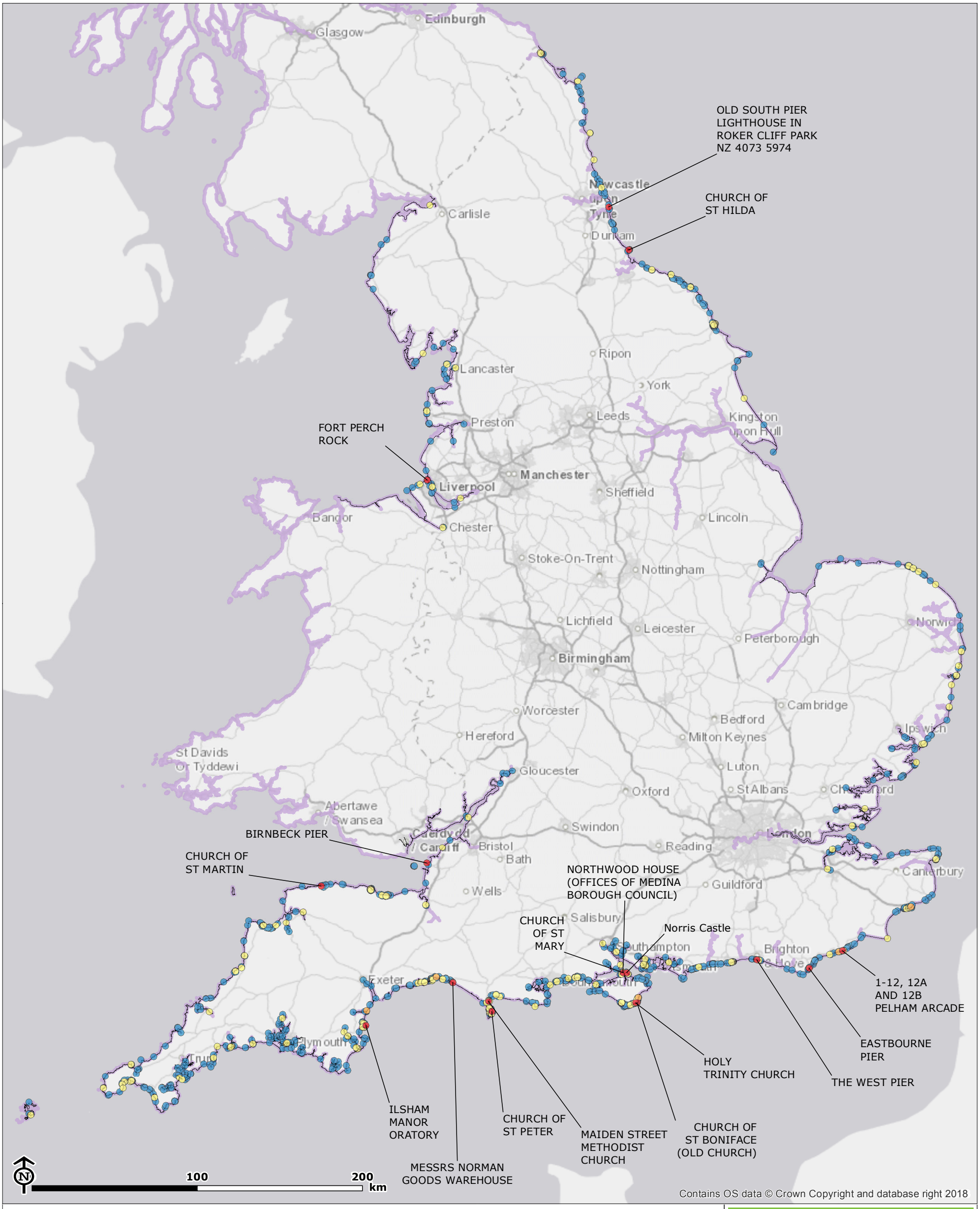
Coastal Risk and Priority Places

Figure 4: Other heritage assets coastal erosion overall level of effect (medium term)

LUC

Historic England

CB:DM EB:Manson D LUC FIG4_10193_v2_CE_Assets_MT_Total_A3P 26/06/2019



National Coastal Erosion Risk Mapping (NCERM) baseline

Areas within 1km of the HWM

Coastal erosion overall level of effect (long term + complex cliffs)*

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 24 (3,962)
- 36 (251)
- 48 (6)
- 72 (17)

* No Active Intervention 5th percentile scenario

Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

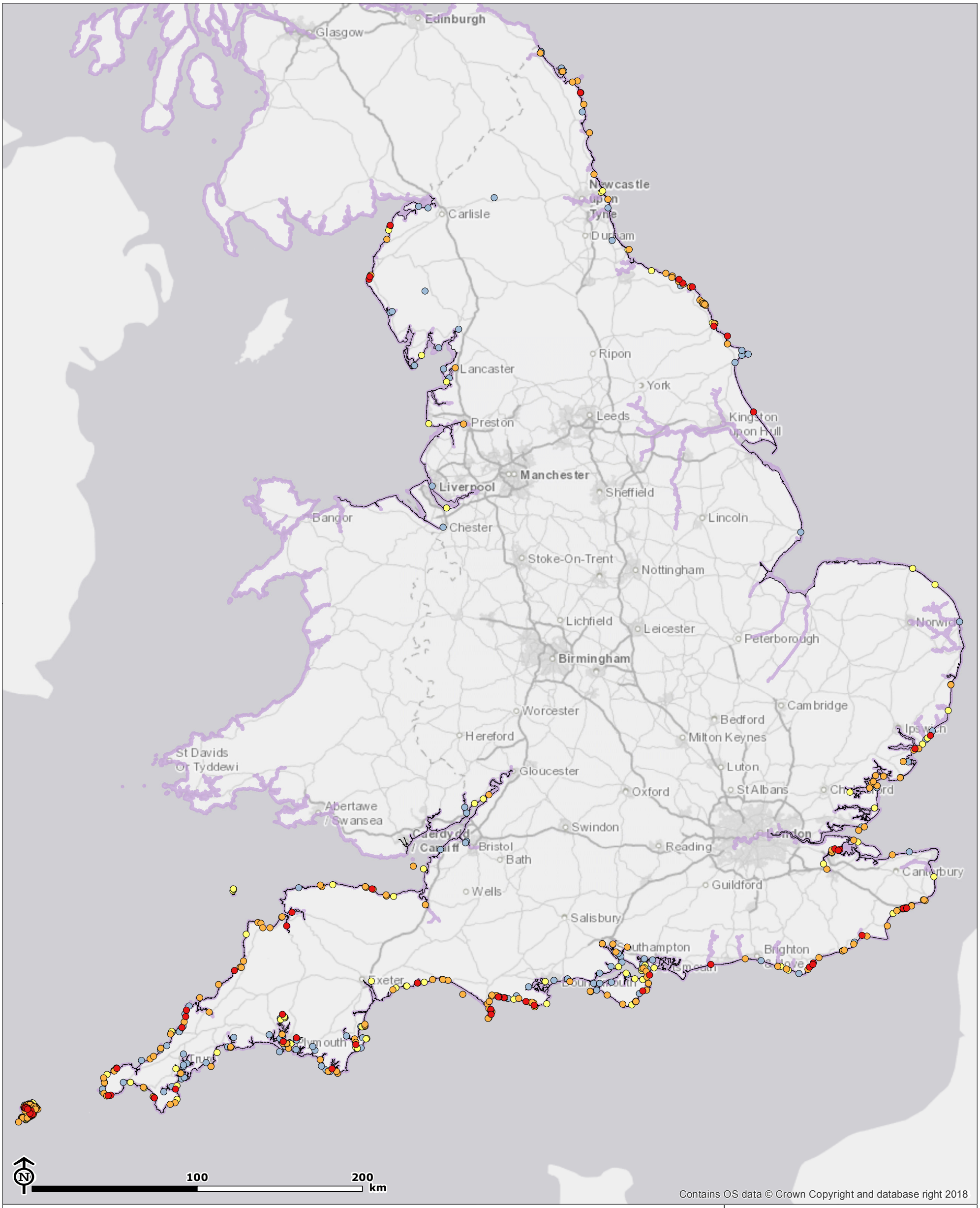
Coastal Risk and Priority Places

Figure 5: Listed Buildings coastal erosion overall level of effect (long term plus complex cliffs)

LUC

Historic England

CB:DM EB:Manson D LUC FIG5_10193_v2_CE_LB_LTCC_Total_A3P 26/06/2019



National Coastal Erosion Risk Mapping (NCERM) baseline

Areas within 1km of the HWM

Coastal erosion overall level of effect (long term plus complex cliffs)*

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 1 - 9 (152)
- 10 - 24 (88)
- 25 - 36 (223)
- 37 - 72 (68)

* No Active Intervention 5th percentile scenario

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 6: Other heritage assets coastal erosion overall level of effect (long term plus complex cliffs)

LUC

Historic England

CB:DM EB:Manson D LUC FIG6_10193_v2_CE_Assets_LTCC_Total_A3P 26/06/2019

Sea level rise

The following tables set out the findings of the sea level rise assessment for the short (**Table 31**), medium (**Table 32**) and long term (**Table 33**). The results are shown spatially for the medium term in **Figure 7** and **Figure 8**.

Table 31 Short term sea level rise assets at risk

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
9				1	
18	5		27	7	
24					222
27	1		22	128	
36			3	5	23
48					553
54	1	1	1	77	
72				5	501
81				17	
108				56	42
144				3	2
162				3	
216				8	5

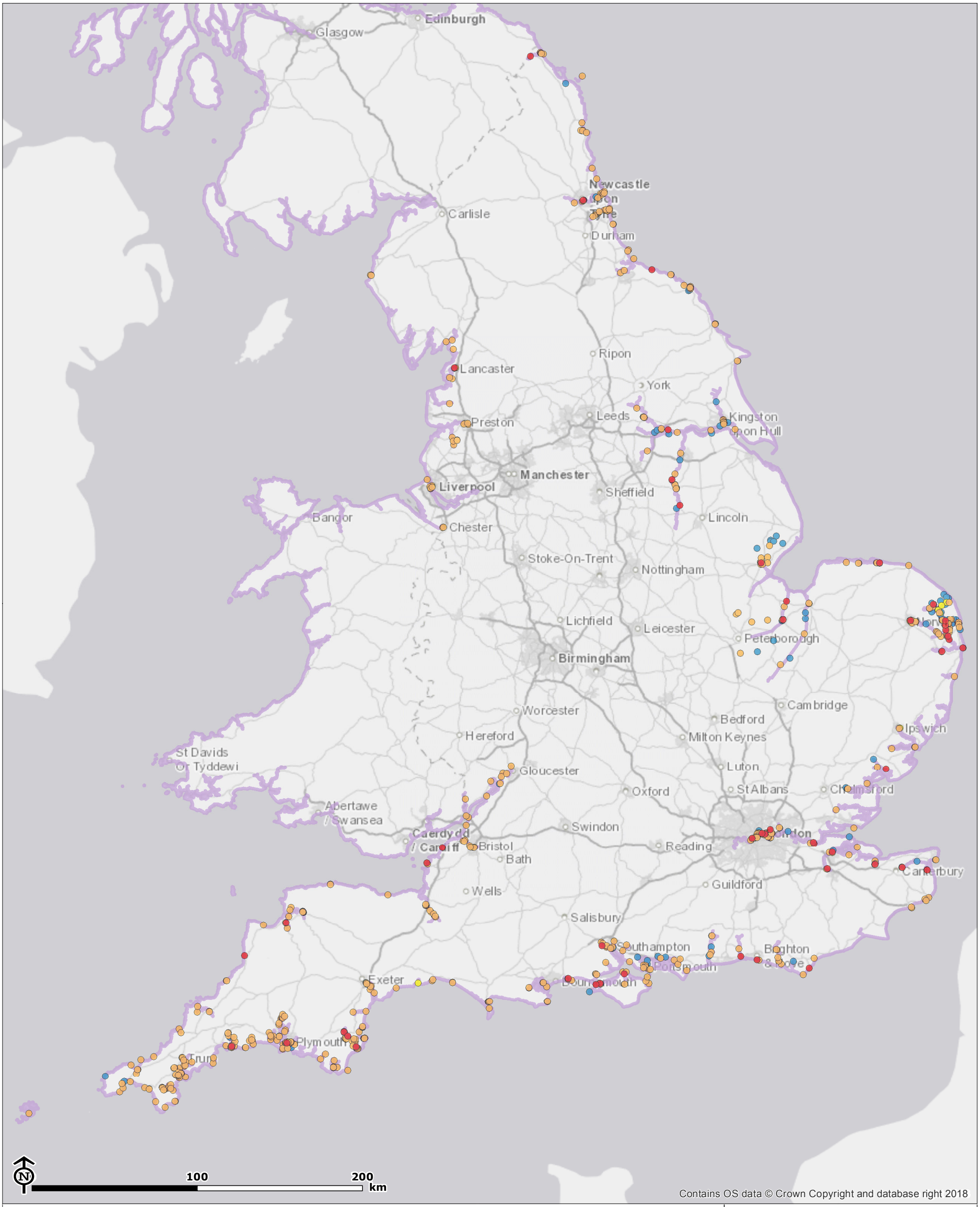
Table 32 Medium term sea level rise assets at risk

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
9				3	
18	5		30	7	
24					235
27	1		22	131	
36			3	5	24
48					561
54	1	1	1	77	
72				5	505
81				19	
108				66	43
144				3	2
162				5	
216				8	5

Table 33 Long term sea level rise assets at risk

Scores	World Heritage Sites	Battlefields	Parks and Gardens	Scheduled Monuments	Listed Buildings
9				5	
18	5		35	11	
24					600
27	1	1	24	195	
36			5	9	50
48					942
54	1	1	3	116	
72			6	12	997
81				43	
108				146	89
144				5	6
162				7	
216				49	8

Figure 9 shows the top scoring heritage assets for each coastal risk in the short term.



Areas within 1km of the HWM (1)

Sea level rise overall level of effect (medium term)

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 24 (235)
- 36 (24)
- 37-81 (1,066)
- 82-216 (50)

Source: Environment Agency, Historic England

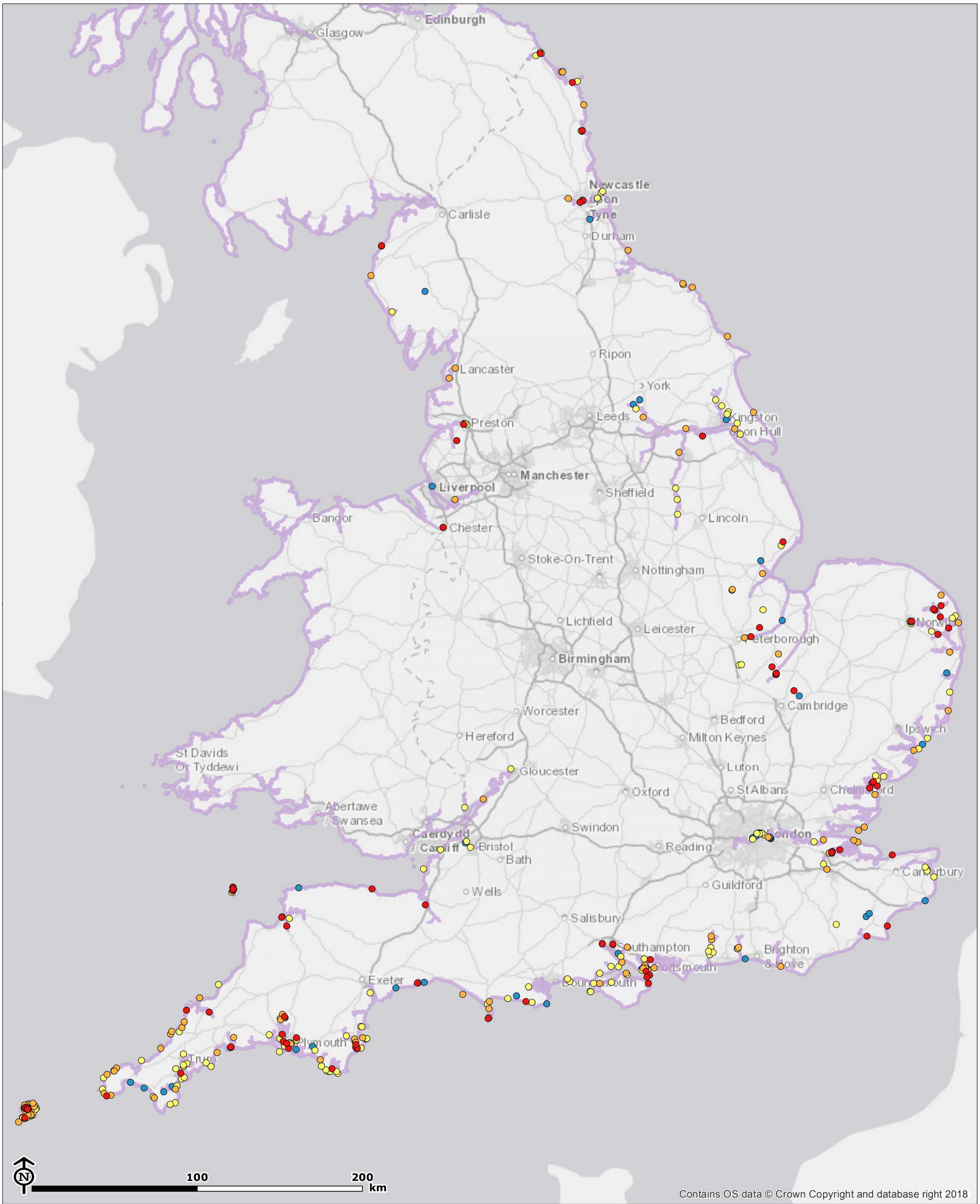
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 7: Listed Building sea level rise overall level of effect

LUC Historic England

CB:DM EB:Manson D LUC FIG7_10193_v1_SLR_LB_Total_A3P 26/06/2019



Areas within 1km of the HWM

Sea level rise overall level of effect (medium term)

(Importance x sensitivity to change x magnitude of change x HAR multiplier)

- 9 - 24 (45)
- 25 - 36 (162)
- 37 - 81 (104)
- 82 - 216 (82)

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

Source: Environment Agency, Historic England

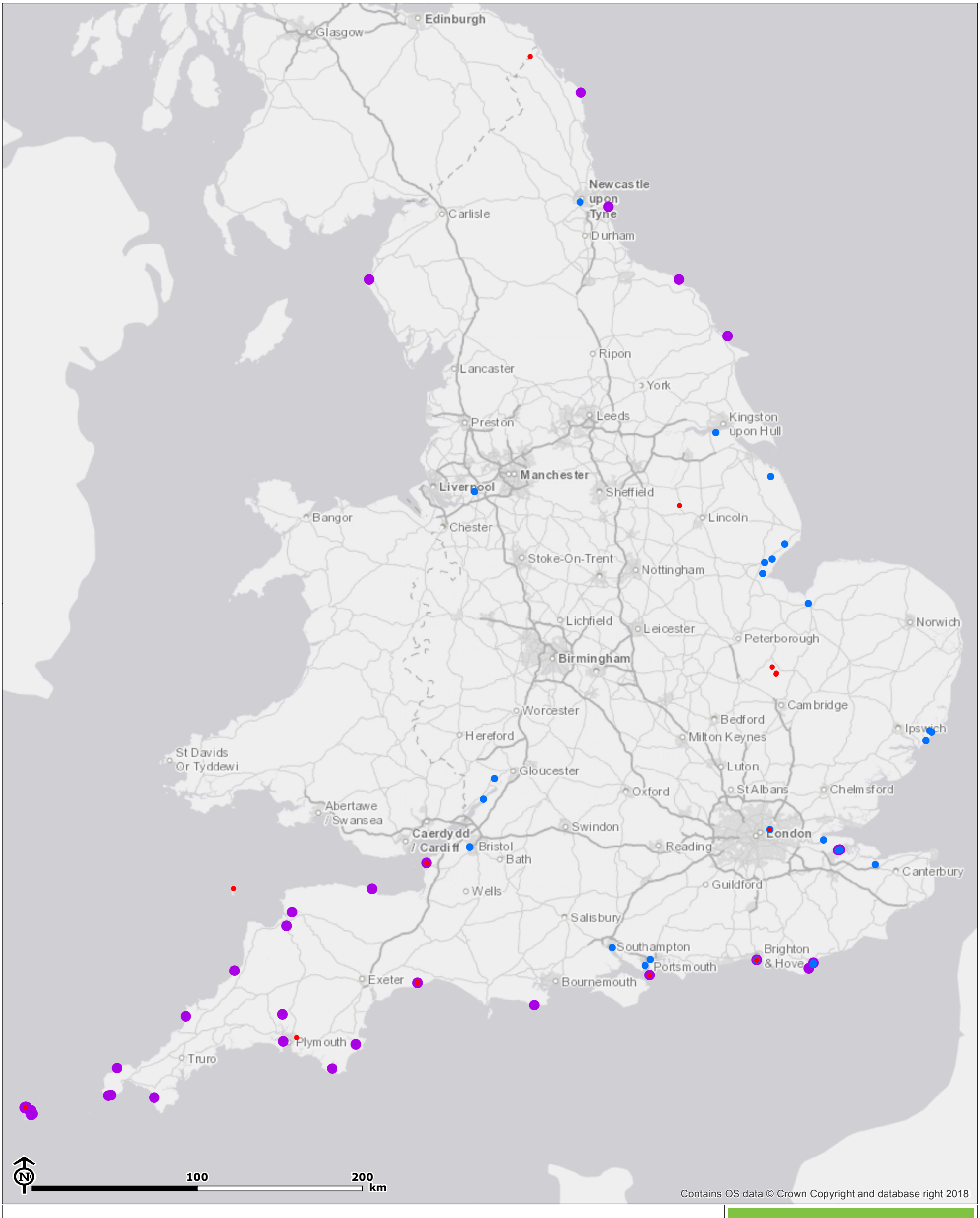
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 8: Other heritage assets sea level rise overall level of effect

LUC Historic England

CB:DM EB:Manson D LUC FIG8_10193_v2_SLR_Asset_MT_Total_A3P 26/06/2019



- NHLE assets scoring 72 for coastal erosion (short term) (4)
- NHLE assets scoring 216 for coastal flooding (10)
- NHLE assets scoring 216 for sea level rise (short term) (5)

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 9: Highest scoring heritage assets for coastal risk in the short term

LUC

Historic England

CB:DM EB:Manson D LUC FIG9_10193_v2_LB_Top_Scores_A3P 19/06/2019

Exploring the results by region

This section provides a snapshot of the results by region to identify sections of the coastline that have high numbers of assets at risk in the short term. The regions used in this assessment equate to the former Government Office Regions as shown in **Figure 10**. This information can be queried in the database, so only a handful of the results are presented in this report. Sea level rise figures have not been presented.

Figure 10: Regions used for analysis

Coastal flooding

Table 34 shows the range of coastal flooding scores for Listed Buildings by region. Whilst there are a high number of Listed Buildings at risk in London, these scores are generally lower as many of these assets will be protected by the Thames Barrier. Overall, the South West has the most Listed Buildings at risk of coastal flooding. This may be due to the type of assets found in this region and the length of the coastline.

Table 35 presents the same information for the area within 1km of the HWM, showing the total number within each score band and the percentage of all Listed Buildings within 1km of the HWM.

Table 34: Range of coastal flooding scores for Listed Buildings by region

Region	Score			
	1-9	10-36	37-81	82-216
East Midlands	0	393	400	34
East of England	492	310	454	42
London	1825	25	46	5
North East	8	11	95	5
North West	100	17	210	5
South East	335	313	804	42
South West	602	154	1359	53
West Midlands	0	2	10	2
Yorkshire and Humber	638	106	143	7

Table 35: Range of coastal flooding scores for Listed Buildings within 1km of the HWM by region

Region	Total Listed Buildings within 1km of HWM	Score			
		1-9 (% of Listed Buildings within 1km of HWM)	10-36 (% of Listed Buildings within 1km of HWM)	37-81 (% of Listed Buildings within 1km of HWM)	82-216 (% of Listed Buildings within 1km of HWM)
East Midlands	498	0 (0%)	109 (21.9%)	172 (34.5%)	10 (2%)
East of England	5,849	369 (6.3%)	273 (4.7%)	384 (6.6%)	38 (0.6%)
London	4,907	1499 (30.5%)	16 (0.3%)	45 (0.9%)	5 (0.1%)
North East	2,180	8 (0.4%)	11 (0.5%)	95 (4.4%)	5 (0.2%)
North West	3,386	47 (1.4%)	15 (0.4%)	184 (5.4%)	5 (0.1%)
South East	10,865	232 (2.1%)	295 (2.7%)	756 (7%)	39 (0.4%)
South West	15,591	406 (2.6%)	149 (1%)	1,300 (8.3%)	53 (0.3%)
West Midlands	0	(0%)	(0%)	(0%)	(0%)
Yorkshire and Humber	2,236	386 (17.3%)	59 (2.6%)	97 (4.3%)	5 (0.2%)

Table 36 shows the range of coastal flooding scores for assets by region. The South East and South West regions have higher numbers of assets at risk than other regions.

Table 37 presents the same information for the area within 1km of the HWM, showing the total number within each score band and the percentage of all assets within 1km of the HWM.

Table 36: Range of coastal flooding scores for assets by region

Region	Score			
	1-9	10-36	37-81	82-216
East Midlands	0	4	21	17
East of England	44	32	13	30
London	43	4	0	0
North East	0	16	6	7
North West	11	33	15	12
South East	56	77	34	36
South West	44	115	20	19
West Midlands	0	1	0	0
Yorkshire and Humber	22	23	8	7

Table 37: Range of coastal flooding scores for assets within 1km of the HWM by region

Region	Total assets (P&G, SM, WHS, Battlefields) within 1km of HWM	Score			
		1-9 (% of assets within 1km of HWM)	10-36 (% of assets within 1km of HWM)	37-81 (% of assets within 1km of HWM)	82-216 (% of assets within 1km of HWM)
East Midlands	14	0 (0%)	0 (0%)	3 (21.4%)	2 (14.3%)
East of England	195	29 (14.9%)	29 (14.9%)	12 (6.2%)	24 (12.3%)
London	134	41 (30.6%)	4 (3%)	0 (0%)	0 (0%)
North East	93	0 (0%)	16 (17.2%)	6 (6.5%)	7 (7.5%)
North West	143	8 (5.6%)	24 (16.8%)	11 (7.7%)	11 (7.7%)
South East	385	25 (6.5%)	69 (17.9%)	30 (7.8%)	32 (8.3%)
South West	897	20 (2.2%)	102 (11.4%)	18 (2%)	19 (2.1%)
West Midlands	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Yorkshire and Humber	91	10 (11%)	12 (13.2%)	6 (6.6%)	5 (5.5%)

Coastal erosion

Table 38 shows the number of Listed Buildings in each Region that are vulnerable to coastal erosion in the short term and their overall scores.

Table 39 shows the number of Listed Buildings in each Region that are vulnerable to coastal erosion in the short term and their overall scores.

As can be seen in both tables, the South West has a particularly high number of Listed Buildings and other assets at risk of coastal erosion compared to others. This may be due to the type of assets typically found in this region and the length of the coastline.

Table 38: Range of short term coastal erosion scores for Listed Buildings by region

Region	Score		
	24	36	72
East Midlands	2		
East of England	19	1	
North East	36	7	1
North West	43	5	
South East	93	8	2
South West	263	28	1
Yorkshire and the Humber	20		

Table 39: Range of short term coastal erosion scores for assets by region

Region	Scores								
	6	9	12	18	24	27	36	54	72
East Midlands	1								
East of England	2	5	1	4	1	1	10		
North East	3	5	1	2			7		1
North West		13	1	3		1	3		1
South East	5	32		14		4	19		4
South West	11	86	4	38		15	73	5	28
Yorkshire and Humber		3	1	2		1	3		2

Case studies

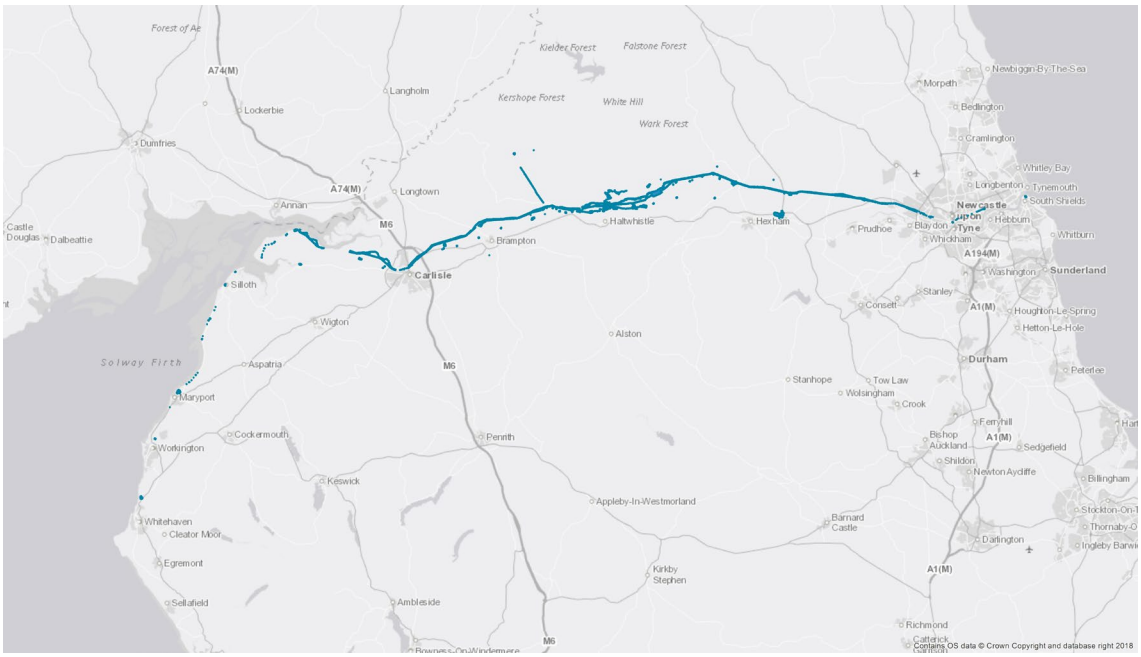
It is useful to explore some specific examples to evaluate how effectively the algorithm has identified those assets most at risk from coastal change.

Case Study 1: Hadrian's Wall

Hadrian's Wall is a useful case study in that it is both Scheduled Monument and a World Heritage Site. As a World Heritage Site (core area), it is made up of a single GIS polygon in the NHLE as shown in **Figure 11**. As a Scheduled Monument, it comprises approximately 80 sub-sections. There does not appear to be a code that demonstrates that each section is a sub-part of a larger entity, so the identification of sub-sections is based on name only.

As a single GIS polygon, in this study, the World Heritage Site has been assigned one score for the whole site against each of the risks, despite most of the site being away from the coast. With the Scheduled Monument being divided into sections, the assessment was able to selectively score those sub-sections that are impacted in some way.

Figure 11: Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site (Listing ID 1000098[5])



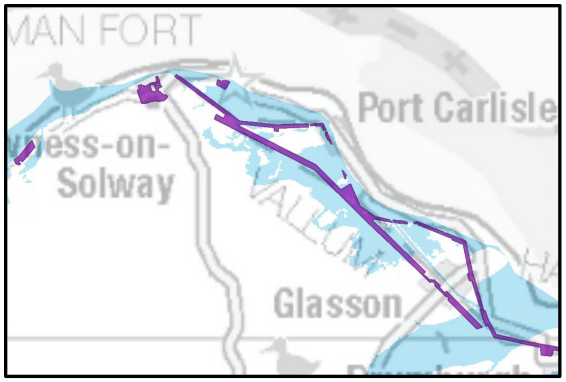
Contains OS data © Crown Copyright and database right 2018

Figure 12 shows extracts of a portion of the WHS near Port Carlisle and the various coastal risks examined in this study.

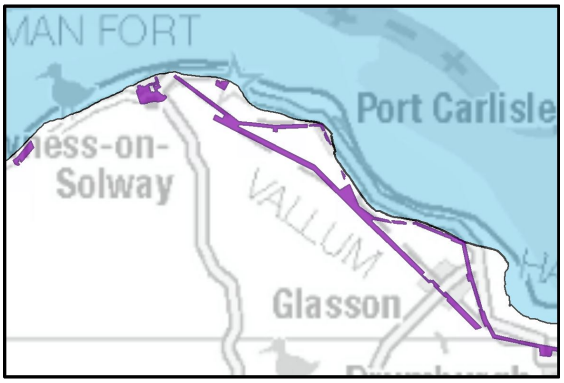
Table 40 shows the assessment scores for each risk type.

[5] https://historicengland.org.uk/listing/the-list/list-entry/1000098

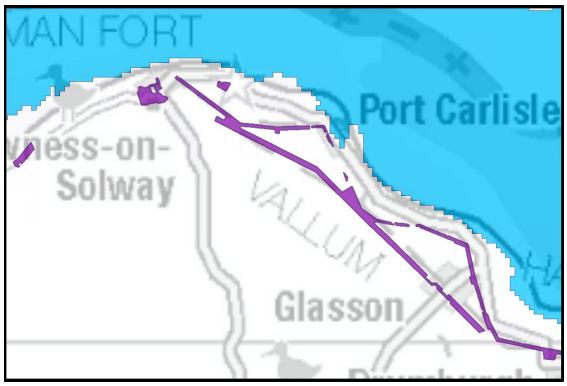
Figure 12: Hadrian's Wall near Port Carlisle and coastal risk layers



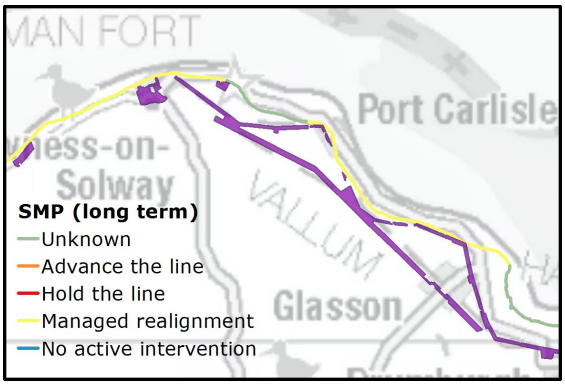
Coastal flooding



Coastal erosion (long term)



Long term sea level rise



Shoreline Management Plan

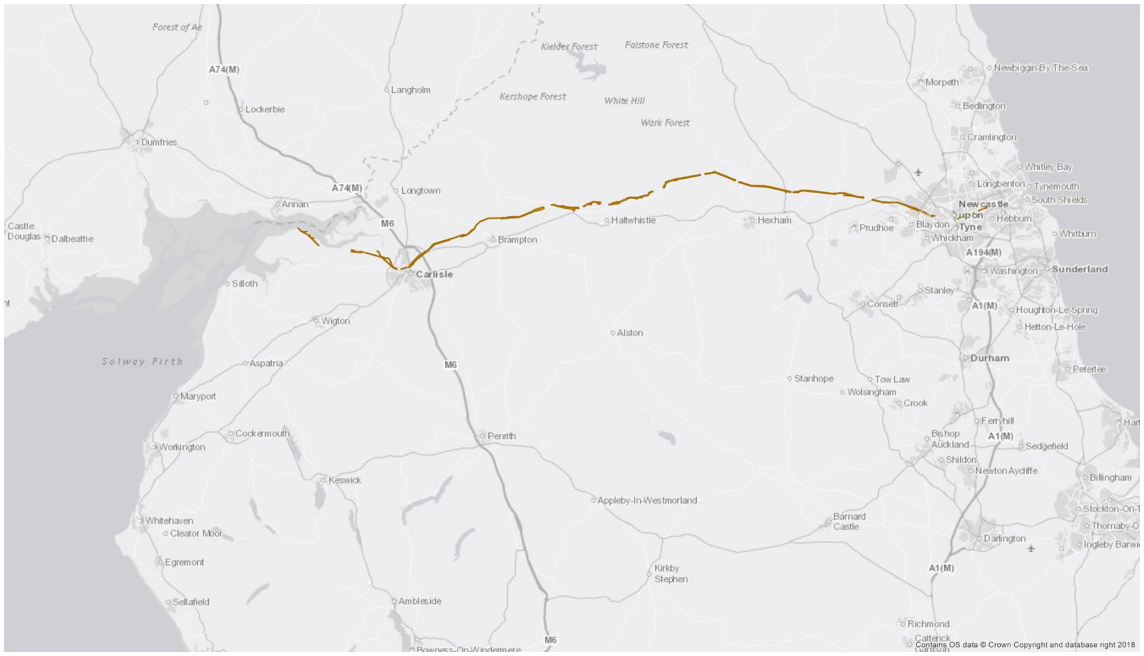
Table 40: Assessment details for Hadrian's Wall WHS

Risk type	Importance	Heritage Assets Sensitivity	Coastal vulnerability	Magnitude of change	HAR multiplier	Overall level of effect
Details	WHS, automatically scored high	Materials type automatically scored high	Small areas affected by coastal flooding and coastal erosion.	<1% of total area within coastal erosion zones. <2% within undefended flood zone	Not on the HAR	
Coastal flooding	3	3	1	1	1	9 (out of 216)
Coastal erosion ST, MT, LT and LT plus complex cliffs	3	n/a	3	1	1	9 (out of 72)
Sea level rise ST, MT, LT	3	3	0	0	1	0 (out of 216

The table above shows that although this site is at risk from coastal flooding and coastal erosion, the level of risk is relatively low as a result of the areas affected being a very small proportion of the site. The algorithm appears to have worked well in this instance, ensuring that the WHS is highlighted as at risk, but also showing that the risk level is relatively low based on the extent of the affected areas as a proportion of the whole asset. Due to the level of detail in the source data, it is not possible to determine the level of contribution the affected portions make to the overall significance / Outstanding Universal Value of the asset. Nevertheless, highlighting specific sections of the asset in this manner, exposing the level of risk, would enable far more proportionate detailed study to address this question.

The extent of the Hadrian's Wall Scheduled Monument(s) is shown in **Figure 13**. As mentioned above, this is comprised of approximately 80 sub-sections.

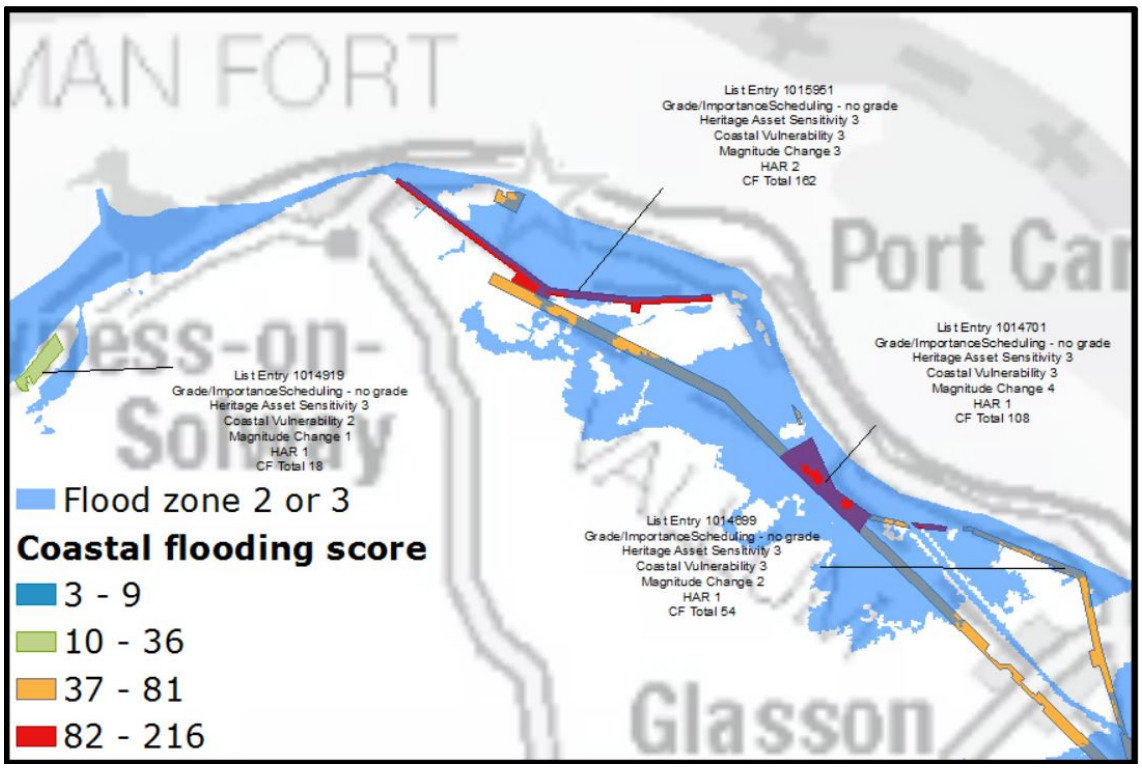
Figure 13: Hadrian's Wall Scheduled Monument (comprised of approximately 80 sub-sections)



Contains OS data © Crown Copyright and database right 2018

Some subsections are on the Heritage at Risk register and, as a result of smaller areas being assessed against the amount of inundation or erosion, some magnitude of change scores are as high as 4 (75-100% inundation). This results in 11 sections having a score of 27 or more for coastal flooding, with one section scoring 162 as shown in **Figure 14**.

Figure 14: Sections of Hadrian's Wall and coastal flooding scores

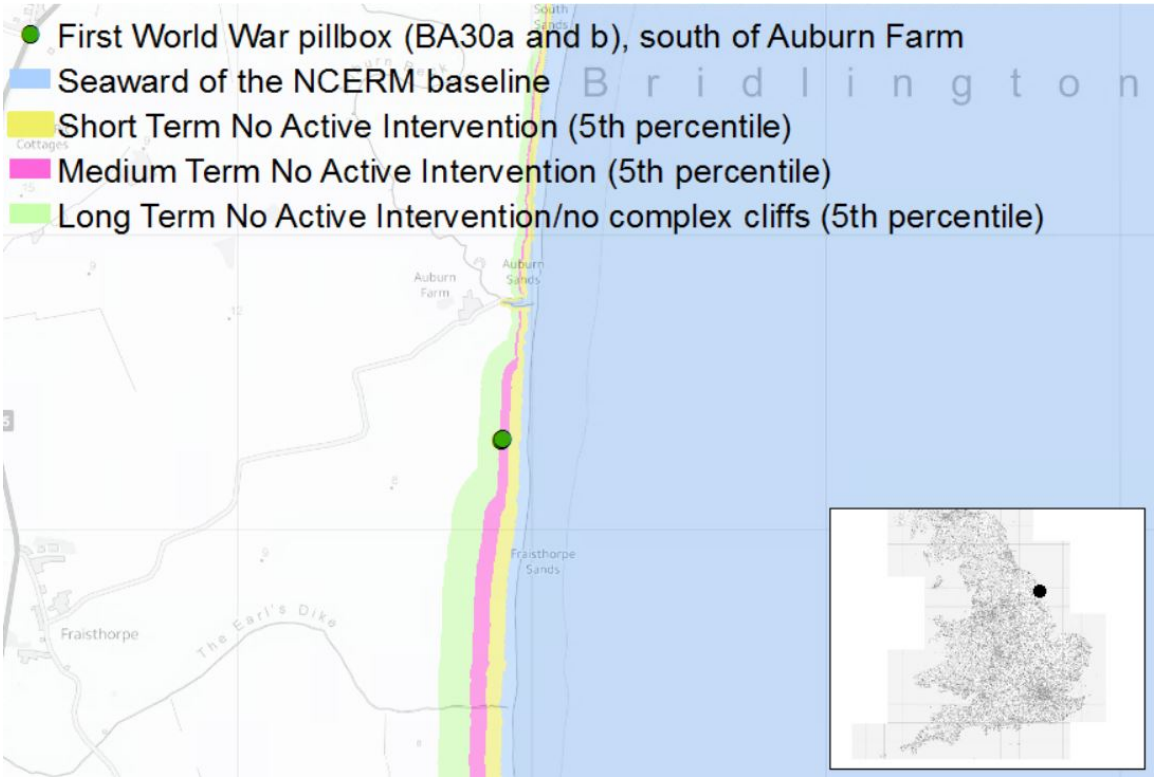


The assessment is considered to have worked well in differentiating the different levels of risk for each section.

Case Study 2: 2 x First World War pillbox (BA30a and b), south of Auburn Farm, Barmston, East Riding of Yorkshire, YO15

These two Grade II Listed First World War Pillboxes fall within the medium and long term coastal erosion risk zones. Their location is shown in **Figure 15.** The SMP policy for this section of coast for the short, medium and long term is No Active Intervention. In the longer term, the NCERM data suggests that the coastline might move up to 140m inland from the existing baseline.

Figure 15: First World War pillbox (BA30a and b), south of Auburn Farm, Barmston, East Riding of Yorkshire, YO15 (Listing ID 1445110[6] and 1445112[7])



[6] https://historicengland.org.uk/listing/the-list/list-entry/1445110
[7] https://historicengland.org.uk/listing/the-list/list-entry/1445112

Table 41 shows the assessment scores for coastal erosion at the different epochs. This study did not identify a coastal flooding or sea level rise risk for these assets.

Table 41: Assessment for First World War pillbox (BA30a and b), south of Auburn Farm, Barmston, East Riding of Yorkshire, YO15

Risk type	Importance	Heritage Assets Sensitivity	Coastal vulnerability	Magnitude of change	HAR multiplier	Overall level of effect
Details	Grade II	Reinforced concrete	Wholly within the medium and long term coastal erosion zones	Listed Building point, so assume 100% loss	Not on the HAR	
Coastal flooding	2	1	0	0	1	0
Coastal erosion ST	2	n/a	0	0	1	0
Coastal erosion MT, LT, LTCC	2	n/a	3	4	1	24 (out of 72)
Sea level rise ST, MT, LT	2	1	0	0	1	0

As the primary risk in this location is coastal erosion, the main material (reinforced concrete) is not considered in the algorithm. The overall coastal erosion score is 24.

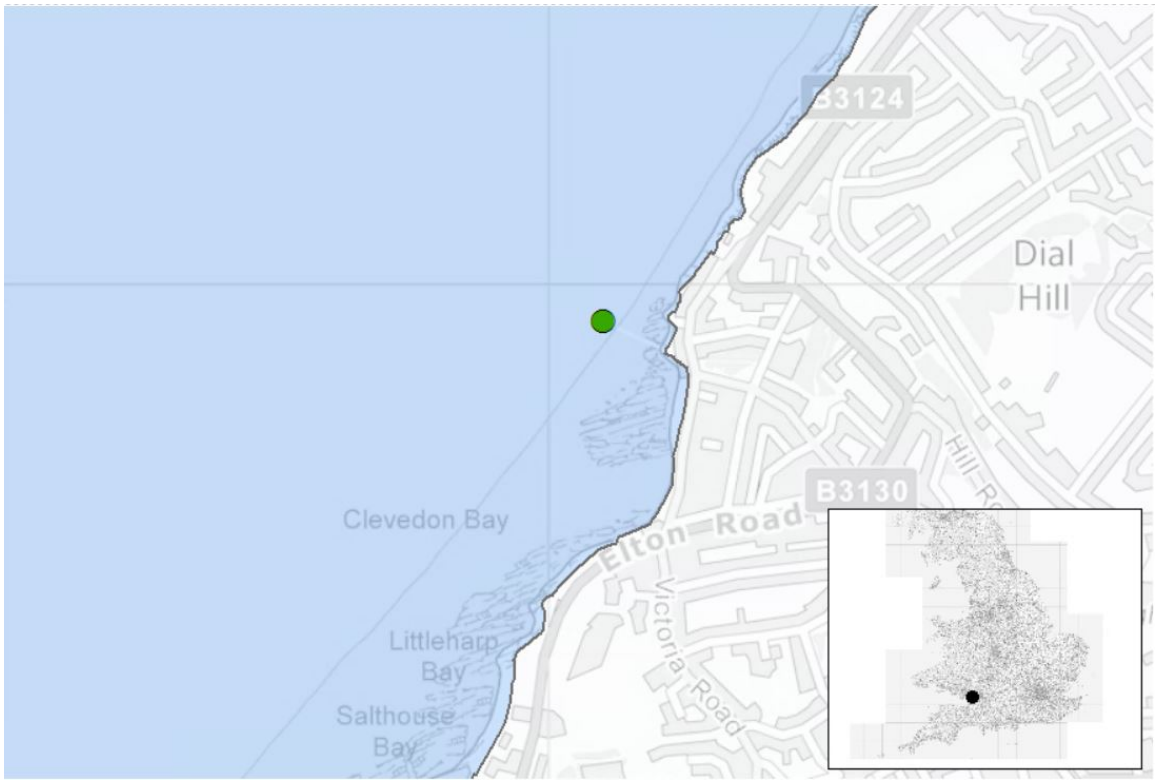
Case Study 3: The Pier, including the tollhouse, Clevedon, North Somerset

The Pier is an example of a Grade I Listed Building that is situated seaward of the NCERM baseline. The pier has achieved a high score for coastal erosion (all epochs), and a high score for sea level rise (all epochs). It has not been scored for coastal flooding. The pier is not on the Heritage at Risk register, but if it had been, it would have received the maximum scores for coastal erosion and sea level rise.

Although the stretch of coastline is categorised in the NCERM as erodible, there is a natural defence in place and the SMP policy is to Hold the Line in the short, medium and longer term. Under the coastal erosion No Active Intervention scenario, the coastline is expected to start eroding in the medium to long term.

The location of the pier is shown in **Figure 16. Table 42** shows the assessment scores for coastal erosion and sea level rise at the different epochs. This study did not identify a coastal flooding risk for this pier. The Environment Agency flood zone layers are onshore only.

Figure 16: The Pier, including the tollhouse, Clevedon, North Somerset (Listing ID 1129687[8])



[8] https://historicengland.org.uk/listing/the-list/list-entry/1129687

Table 42: Assessment for The Pier, including the tollhouse, Clevedon, North Somerset

Risk type	Importance	Heritage Assets Sensitivity	Coastal vulnerability	Magnitude of change	HAR multiplier	Overall level of effect
Details	Grade I	Main materials: Cast iron, glass, iron stone, wood	Located offshore (seaward of the NCERM)	Listed Building point, so assume 100% loss	Not on HAR	
Coastal flooding	3	3	0	0	1	0
Coastal erosion ST, MT, LT	3	n/a	3	4	1	36 (out of 72)
Sea level rise ST, MT, LT	3	3	3	4	1	108 (out of 216)

In this case, the algorithm does not contain suitable data to consider the type of asset – a pier - that is by its very nature situated in the sea. (Issues such as this were the cause of the attempt to assign sensitivity to change at a Thesaurus type-level – to enable design and function to be taken into account.) The level of risk for sea level rise and coastal erosion are high as a consequence, which may well be inappropriate. This example suggests that assets wholly within the area seaward of the NCERM baseline may need different treatment in the algorithm.

PRESENTING THE FINDINGS IN AN ONLINE MAP

GIS outputs

A key output of this study is the GIS data that has been generated. The data has been provided in an ESRI geodatabase to Historic England with an mxd file with all of the relevant layers included.

There are two key GIS layers – one for the assets that can be mapped as polygons (areas) and one for Listed Buildings which are mapped as points. **Appendix 2** describes the attributes in each table.

The geodatabase contains the following layers:

- **NCERM_2018**: The NCERM profile line. This line feature also includes Shoreline Management Plan policies for each frontage as an attribute.
- **Beyond NCERM**: A polygon layer showing those areas that are seaward of the NCERM baseline.
- **LUC_NCERM_2018_STNAI5_COMPLETE:** A polygon layer showing those areas that are either seaward of the NCERM baseline or within the short term no active intervention 5th percentile coastal erosion zone.
- **LUC_NCERM_2018_MTNAI5_COMPLETE:** A polygon layer showing those areas that are either seaward of the NCERM baseline or within the medium term no active intervention 5th percentile coastal erosion zone.
- **LUC_NCERM_2018_LTNAI5_No_CC_COMPLETE:** A polygon layer showing those areas that are either seaward of the NCERM baseline or within the long term no active intervention 5th percentile coastal erosion zone.
- **LUC_NCERM_2018_LTNAI5CC_COMPLETE:** A polygon layer showing those areas that are either seaward of the NCERM baseline or within the long term (plus complex cliffs) no active intervention 5th percentile coastal erosion zone.
- **EA_FZ2_FZ3_AOB:** Coastal flood risk dataset showing areas with Flood Zone 2, Flood zone 3 and Areas benefiting from flood defences.
- **EA_AOB_201810:** Environment Agency Areas Benefitting from Flood Defences layer.
- **OST50_ST_SLR_poly:** Short term sea level rise scenario based on Ordnance Survey Terrain 50 data.
- **OST50_MT_SLR_poly:** Medium term sea level rise scenario based on Ordnance Survey Terrain 50 data.
- **OST50_LT_SLR_poly:** Long term sea level rise scenario based on Ordnance Survey Terrain 50 data.
- **HE_LB_merged_2019:** All Historic England Listed Buildings. For detailed information on attributes, see **Appendix 3**.

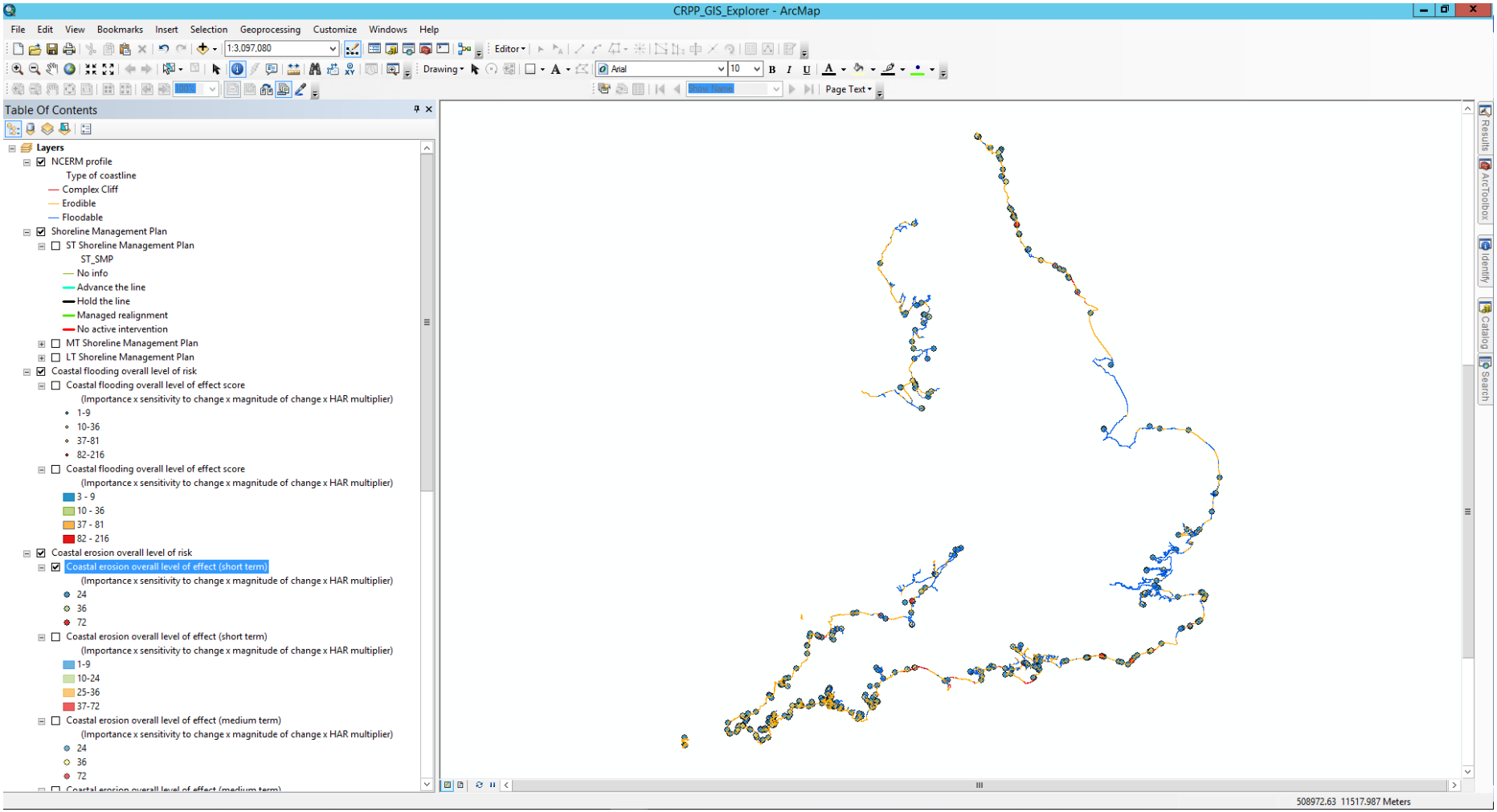
- **HE_LB_merged_2019_Some_Risk:** As above, but a subset including only those Listed Buildings with some level of coastal risk identified through this study. Produced to make handling the data easier due to the size of the full Listed Buildings file.
- **HE_Assets_merged_2019:** All Historic England Scheduled Monuments, Registered Parks and Gardens, Registered Battlefields, World Heritage Sites (core areas only) and Protected Wrecks (although these were not assessed in this study). For detailed information on attributes, see **Appendix 3**.
- **HE_Assets_merged_2019_Some_Risk:** As above, but a subset including only those assets with some level of coastal risk identified through this study. Produced to make handling the data easier due to the size of the full heritage assets file.

The mxd has been set up to enable selection and querying of a number of scenarios. A screenshot of the mxd is shown in **Figure 17**.

ArcGIS Online Map

In order to make the findings more accessible, the data has been loaded into an ArcGIS Online (AGOL) map. This allows for the inclusion of contextual layers that haven't been used in the algorithm, but provide very useful context (such as SMP policy).

Figure 17: Screenshot of the GIS project file



CONCLUSIONS AND RECOMMENDATIONS

This study has used GIS to explore the level of threat to designated assets in England as a result of coastal erosion, coastal flooding and sea level rise. A number of national datasets have been explored to develop indices of coastal vulnerability and heritage sensitivity. The combination of these two indices has provided a means of identifying areas where heritage is most at risk from coastal processes – coastal heritage 'priority places'.

The evaluation of datasets concluded that no perfect dataset exists for such an assessment, but that this is an area of continual development and it is anticipated that better datasets will emerge in the near future. The focus has therefore been on developing a method that can accommodate better datasets in the future as they become available.

Table 43 shows the high level findings of the study for coastal erosion in terms of the percentage of each asset type at some level risk in the short to long term. There are additionally 470 Listed Buildings and 90 Scheduled Monuments seaward of the NCERM.

Table 43: Headline figures Coastal Erosion

Asset type	Total number of heritage assets in NHLE	*Number (and %) within 1km of HWM*	*Number within 1km of HWM vulnerable to erosion in ST (percent of assets within 1km of HWM in brackets)*	*Number within 1km of HWM vulnerable to erosion in MT (percent of assets within 1km of HWM in brackets)*	*Number within 1km of HWM vulnerable to erosion in LT (percent of assets within 1km of HWM in brackets)*	*Number within 1km of HWM vulnerable to erosion in LT +CC (percent of assets within 1km of HWM in brackets)*
Listed Buildings	378,484	*45,516 (12%)*	*526 (1 %)*	*1,193 (3%)*	*2,224 (5%)*	*4,167 (9%)*
Registered Battlefields	47	5 (11%)	1 (20%)	1 (20%)	*1 (20%)*	*1 (20%)*
Registered Parks and Gardens	1,668	*204 (12%)*	*51 (25%)*	*55 (27%)*	*60 (29%)*	*62 (30%)*
Scheduled Monuments	19,855	1,734 (9%)	343 (20%)	372 (21%)	*409 (24%)*	*457 (26%)*
World Heritage Sites	19	9 (47%)	5 (56%)	5 (56%)	*5 (56%)*	*5 (56%)*

Table 44 shows the high level findings of the study for coastal flooding in terms of the percentage of each asset type at some level risk.

Table 44: Headline figures Coastal Flooding

Asset type	Total number of heritage assets in NHLE	*Number (and %) within 1km of HWM*	*Number (and %) within 1km of HWM at risk of coastal flooding (any flood zone)*	*Number (and %) within 1km of HWM at risk of flooding with 50+% of area undefended*
Listed Buildings	378,484	*45,516 (12%)*	*7,067 (16%)*	*4,103 (9%)*
Registered Battlefields	47	5 (11%)	2 (40%)	1 (20%)
Registered Parks and Gardens	1,668	*204 (12%)*	*89 (44%)*	*7 (3%)*
Scheduled Monuments	19,855	1,734 (9%)	467 (27%)	147 (8%)
World Heritage Sites	19	9 (47%)	8 (89%)	0 (0%)

Table 45 shows the high level findings of the study for sea level rise in terms of the percentage of each asset type at some level risk in the short to long term.

Table 45: Headline figures Sea Level Rise

Asset type	Total number of heritage assets in NHLE	*Number (and %) within 1km of HWM*	*Number within 1km of HWM vulnerable to SLR in ST (percent of assets within 1km of HWM in brackets)*	*Number within 1km of HWM vulnerable to SLR in MT (percent of assets within 1km of HWM in brackets)*	*Number within 1km of HWM vulnerable to SLR in LT (percent of assets within 1km of HWM in brackets)*
Listed Buildings	378,484	*45,516 (12%)*	*1,312 (3%)*	*1,331 (3%)*	*2,224 (5%)*
Registered Battlefields	47	5 (11%)	*1 (20%)*	*1 (20%)*	*2 (40%)*
Registered Parks and Gardens	1,668	*204 (12%)*	*52 (25%)*	*54 (26%)*	*69 (34%)*
Scheduled Monuments	19,855	1,734 (9%)	*292 (17%)*	*303 (17%)*	*433 (25%)*
World Heritage Sites	19	9 (47%)	*7 (78%)*	*7 (78%)*	*7 (78%)*

In addition to identifying the assets that lie within areas that are likely to experience some level of coastal change, the study has used information on the type of asset, the importance of the asset, the main materials of construction and any existing risk to identify the level of threat to these designated assets.

The South East and South West regions have the largest number of assets at risk and in terms of the proportion of assets affected, coastal flooding poses the greatest threat, with a large number of assets being situated in flood zones.

Project challenges

Execution of this research project presented a number of challenges; namely:

- Data access – it is difficult to access datasets accurately mapping the risks posed by coastal processes. It is also difficult to access historic environment datasets. Whilst the NHLE is held centrally, HER and RCZAS data is not managed centrally and no collated version exists;
- Data structure – In depth analysis of the NHLE highlighted that the current data structures and formats are inhibiting their use for studies such as this;

- Scoring heritage sensitivity – at this scale, considering the entire Monument Type and Materials Type thesauri has meant that scoring can be crude and can have the effect of oversimplifying complex relationships; and
- Resources – a far greater amount of time was required to source and augment datasets than originally anticipated in the project design phase, depleting the available time to explore a greater number of historic environment datasets.

Project limitations

It is important to note that this study has been entirely desk-based. No field verification of the outputs has been undertaken. A number of limitations need to be borne in mind when using the results of this assessment.

Climate scenarios

Most of the research was completed before the publication of UKCP18 data in November 2018. It therefore relied on UKCP09 data, though comparison of the two sets of projections suggests that differences are unlikely to be significant[9].

The study includes consideration of the extreme climate change projection known as the H++ scenario. Although considered unlikely to occur, the level of change modelled in this scenario is likely to be associated with very high levels of impact. This is useful in describing the 'worst case' impacts of climate change and testing the ability of adaptation plans to cope with more severe change than is currently anticipated. The H++ scenario was not updated within the UKCP18 climate projects, but is still regarded as being valid.

Modelling of sea level rise was undertaken using Ordnance Survey Terrain50 data which has a spatial resolution of 50m. The resultant sea level rise scenario layers are particularly crude and should be seen as indicative only. Whilst Lidar data is available to increase the resolution of the modelling, it is only available in individual tiles and the stitching together of a national layer was seen as beyond the scope of this study.

Historic environment data availability

As a result of difficulties in accessing HER and RCZAS data on a large scale, this study has focussed on the NHLE data that is available at a national scale. It must be recognised that the NHLE represents only a subset of recorded coastal heritage, and further work will be needed to test the method on sites that sit outside of the NHLE.

The historic environment is far wider than designated heritage assets, and within the scope of this study it has not been possible to explore the full range of

[9] https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-guidance-ukcp18-for-ukcp09-users.pdf

datasets that can be used to represent the historic environment. Additional datasets that have not been examined include:

- Historic Environment Record
- Rapid Coastal Zone Assessment Survey
- Local Historic Landscape Characterisation
- National Historic Landscape Characterisation
- National Historic Seascape Characterisation

Patterns of designation are influenced by a number of factors, and when interpreting the findings at a regional level, there may be other factors influencing the numbers such as regional variations in designation of assets in the coastal zone.

Algorithm construction

The final algorithm involves a number of elements that are potentially problematic in their construction, but for this reason, within the GIS data, the individual elements can be identified and 'unpicked'.

Coastal flooding and coastal erosion data

As a first attempt to examine heritage at risk from coastal processes at a national scale in England, this study has identified a number of difficulties with regards to the data that is available to undertake such an assessment. Details about each dataset can be found in this report, but it should be recognised that whilst it hasn't been possible to make use of such data in this study, it is highly likely that more accurate datasets exist for coastal flooding, erosion around complex cliffs and sea level rise scenarios.

Furthermore, it has not been possible to create a spatial layer that depicts coastal flooding scenarios in the future as a result of sea level rise and potential increased storminess.

Sediment transport change

In parallel with increased erosion, sediment transport and accretion patterns are also likely to change – potentially resulting in sediment inundation of intertidal heritage assets in some locations (for example, areas of accreting salt marsh in Morecambe Bay and The Wash). It has not been possible to access spatial information to support an evaluation of this factor.

Recommendations

Whilst this study has successfully developed a method to identify designated assets at greatest risk of loss or damage as a result of coastal processes, it is clear that there exist environmental datasets that may more accurately map the areas at risk than those used in this study. A number of these datasets are currently being developed or have been developed, but are only available at a cost.

Recommendation 1: Seek to work in partnership with, or arrange access to, the coastal risk datasets that are used to underpin the Committee on Climate Change UK Climate Change Risk Assessment to rerun the GIS analysis.

Recommendation 2: Work to ensure that heritage assets are factored in alongside other assets in future coastal change management assessments (for example the UK Climate Change Risk Assessment).

Recommendation 3: Continue to work with the BGS to develop the Coastal Vulnerability Datasets to ensure that they can be used in an assessment such as this study.

This study has developed an approach to stratifying the level of risk posed to designated assets. The method has been developed in such a way that it is anticipated that it can be transferred to non-designated assets on the Historic Environment Records. It has not been possible to test this within the scope of this study.

Recommendation 4: Using regional case study areas, obtain GIS data for undesignated assets from the HER and RCZAS and test the application of the method established in this study to undesignated assets. Explore the range of attribution available within HER data that might add further contextual information to our understanding of the level of risk at each site and any mitigating factors.

This study has identified that although extensive thesauri exist to categorise NHLE assets on the basis of their monument type and main materials types, the format in which these attributes are stored against asset records makes the data difficult to interrogate. Furthermore, the study has identified that the thesauri terms are not always consistently applied. The approach would benefit from a clearer understanding, consistent application and enforced referential integrity of the thesaurus hierarchy in source historic environment datasets.

Recommendation 5: Review the format of the NHLE database and application of thesauri terms within it.

Although this study trialled a method for considering the sensitivity of monument types, it was felt by internal stakeholders at HE that any approach to determining monument type sensitivity across the NHLE dataset would require significantly more work and consultation than was possible within this study. Nevertheless, it is still considered that this additional information would provide valuable information when considering the risk posed to each asset.

The value of looking at the monument type vulnerability lies in the lessons learnt from attempting to classify their vulnerability, assessing the feasibility of classifying them, and could be used to inform an assessment of the balance between numbers of designated and undesignated sites on a national scale. This could in turn help to identify the types of assets which are under-represented in the NHLE (i.e. potentially under-designated).

Having a better understanding of the type of monument may also help to differentiate between those assets that are upstanding versus buried. Many of the features identified as being at risk in this study are raised above water (bridges, piers) to such an extent that the three-dimensionality of the asset may make them more resilient to inundation, along with specific design factors intended to increase their resilience to the water environment.

When reviewing the format of the NHLE database, consider how data could be restructured so as to enable further screening by type. Applying consistent typological information to designated assets datasets would have significant wider benefits – although it is recognised that this would require substantial work and extensive consultation across HE and, potentially, more widely.

Further work to rearrange how data on period is recorded in the NHLE might open up opportunities to explore whether particular archaeological periods are disproportionately affected by climate change related risks.

Recommendation 6: Undertake further research to gain a better understanding of how coastal processes (in particular flooding) affect different assets and different materials.

Recommendation 7: Future climate change scenarios will need to be considered; including exploring the climate change impacts that were beyond the scope of this study.

Recommendation 8: Often climate change impacts will not be a gradual process. Further research is needed to understand where the 'tipping points' lie for different assets. Whilst this study has explored vulnerability of different assets, whether an asset experiences gradual or catastrophic loss relates to wider factors such as geology, location, materials etc. These are subtleties that have not been exposed through this study and further work is needed to understand this.

Recommendation 9: The NHLE is not representative of all types of site. For example, Quaternary SSSIs (such as Happisburgh Cliffs), that have associated Palaeolithic finds and assets, have not been included in this assessment. Further work is required to incorporate sites of this nature. It may be necessary to explore data held by Natural England relating to these sites. Whilst this study has focussed on heritage assets on the NHLE, the historic environment is far wider than this. It is recommended that further work is undertaken to understand the risks posed to the wider historic environment; including the

historic cultural dimension of landscapes as captured in Historic Landscape Characterisation (national and local) and the National Historic Seascape Characterisation.

APPENDIX 1

Detailed Methodology

Whilst the study methodology has been necessarily iterative, it has been undertaken in six broad stages in line with MoRPHE as set out in **Table 46**. below.

Table 46: Summary of method

Stage	Associated tasks	Location in this report
Stage 1: Set-up, familiarisation and data collection	Task 1: Project start-up Task 2: Inception Meeting Task 3: Familiarisation and data collection.	Introduction Method
Stage 2: Development of methodology for creation of heritage vulnerability index	Task 4: Review of data Task 5: Development of methodology for assessing coastal vulnerability Task 6: Development of methodology for assessing heritage sensitivity Task 7: Development of method for defining heritage vulnerability to coastal change	Assessing coastal vulnerability Assessing heritage sensitivity Assessing heritage vulnerability
Stage 3: Analysis and development of GIS layer	Task 8: Process data/run GIS analysis Task 9: Critically review GIS outputs and refine Task 10: Create GIS layer for incorporation into ArcGIS Online webmap	Analysis and findings
Stage 4: Development of online map	Task 11: Upload GIS layer with agreed symbology and contextual information to ArcGIS Online Task 12: Develop user interface Task 13: Test and refine online map	Presenting the findings in an online map
Stage 5: Prepare project products, archiving and dissemination	Task 14: Project Report compilation, drafting; submission for HE comment Task 15: Preparation of follow up questionnaire Task 16: Closure Report Task 17: Project archive preparation and submission to HE and ADS	Appendix 4
Stage 6: Follow up questionnaire (outside of project scope)	Disseminate questionnaire	

Stakeholders
A wide range of stakeholders or organisations/public bodies will have an interest in this work. These include:

- Historic England staff;
- Local Authorities;
- Protected Landscape Officers;
- Association of Local Government Archaeological Officers (ALGAO);
- Coastal Partnerships;
- Environment Agency;
- Natural England;
- Defra
- English Heritage
- Coastal land owners and managers such as the National Trust or MoD;
- Coastal and Intertidal Zone Archaeological Network (CITiZAN);
- Committee on Climate Change;
- Marine Management Organisation;
- Crown Estate;
- British Geological Society.

The project also interfaces with a number of on-going and programmes being undertaken in relation to heritage protection and climate change research:

- Historic England Heritage at Risk Programme;
- Historic England Environmental Risk research programme;
- Historic England RCZAS Programme;
- Heritage Action Zones (in coastal towns such as Weston super Mare and Ramsgate);
- Committee on Climate Change's recently tendered 'Research to assess the economics of coastal change management in England';
- integrating COAstal Sediment SysTems (iCOAST).

Review of previous and related studies

The project builds on research programmes undertaken under the auspices of HE and its predecessors, most notably the English Heritage Coastal Estate Risk Assessment (Hunt 2011). In addition, it sought to build on the Historic Environment Scotland study *Screening for Natural Hazards to Inform a Climate Change Risk Assessment of the Properties in Care of HES.*

English Heritage Coastal Estate Risk Assessment (Hunt 2011)
This study looked at the 400 historic properties in England under English Heritage's guardianship. Of these, it was established that 80 lie within 200m of the 'Coastal Zone'. This number was reduced by removing monuments within large, urban areas where major flood or erosion defence systems exist, coastal

erosion was not an issue and a 'Hold the Line' policy option is in place. This left 54 properties to form the core of the analysis.

Contextual and detailed information on each property was gathered in GIS. Environment Agency Flood Zone data was obtained, and in the absence of a national GIS layer depicting the National Coastal Erosion Risk Mapping project outputs, data from each Shoreline Management Plan 2 was requested and for the most part, obtained.

To assess risk, sites were individually, visually examined to establish the potential threat from coastal erosion or flooding.

Where sites intersected flood or erosion risk profiles, the proportion of the asset footprint in the risk zones was calculated in GIS. Percentage bands were used to determine the level of risk, and these were augmented by the assessor if further contextual knowledge of the site meant that a risk was mitigated or enhanced. A matrix was used to present the resultant level of risk.

The study highlighted a range of caveats attached to the underlying risk mapping. These related to the inherent difficulties in predicting future climate patterns, the level of certainty of the available flooding data and the erosion profiles being predictions based on current rates of change and models rather than guaranteed statements of future events.

The study concluded that all 54 sites were at some risk of flooding, coastal erosion or both. Whilst the majority of sites fell into the low risk category, 28% of sites were found to be at medium or high risk of flooding and 19% at medium or high risk of coastal erosion.

The study was able to use information on the period of each asset to estimate the relative number of assets from each period at risk.

Screening for Natural Hazards to Inform a Climate Change Risk Assessment of the Properties in Care of Historic Environment Scotland (HES 2018)
This report, which was published early on in the Historic England study, was reviewed to inform the methodology for this new study. In summary, this national project looked across a wider range of hazards than the present study, but looked at a narrower range of historic assets – only properties in care.

The project used simple GIS-based intersection analysis of assets and natural hazards to identify the likelihood of that hazard occurring at each property. This was determined by assessing (i) what the hazard was and (ii) what type of 'likelihood' score that particular dataset showed.

The impact was assessed by considering the property type, staffing and visitor access and assigning this a score. A risk score was calculated for each hazard at every property by multiplying the likelihood and impact scores together. This generated a measure of 'inherent risk' – primary vulnerability of a site to natural

hazards considered before taking account of site management or mitigation measures. 'Residual risk' was calculated taking account of mitigation and management.

The results were expressed in terms of proportion of properties in care at very high, high or acceptable levels of inherent and residual risk, overall and for each type of hazard.

Both of these studies informed the method development, but both were based on a smaller set of heritage assets, whereas this new study intended to look at all assets in the NHLE with a view to extending coverage to undesignated assets.

Assessing coastal vulnerability

Defining 'coastal'

The project originally intended to cover the full extent of England's coast with a suitable inland extent. In developing the approach, and reviewing available datasets, the spatial scope of the study needed to be revisited.

It was proposed early on that the study area should be based on the coastal zone definition adopted in the previous English Heritage Coastal Estate Risk Assessment report (Hunt 2011). This was described as 'within 200m of the 'Coastal Zone'. As part of the review of previous research looking at heritage vulnerability in the coastal zone, it was established that the definition of the coastal zone used in the Hunt research was based on a definition of 'coastal' developed previously by Natural England (NE). Upon further investigation of the NE work giving rise to the definition, this appears to have been developed with respect to coastal recreation, rather than a stronger geographical understanding of the concept or anything related to coastal erosion or coastal flooding.

While this caught most if not all areas at risk of coastal erosion, it did not represent the full extent of flooding where coastal and/or tidal flooding is a contributor. It was determined that a broader spatial definition would be more appropriate based on existing areas at risk of flooding, likely to experience coastal erosion plus a margin to reflect the likely effects of climate change.

The study area used has been defined by the inland extent of coastal erosion, flooding and sea level rise under the longer term epoch. When including coastal flooding, coastal processes have an impact quite far inland. This makes it challenging to contextualise the impacts in the immediate 'coastal zone'. Additional analysis has therefore been undertaken to understand the impacts within a more narrowly defined zone within 1km of the High Water Mark (HWM).

Data review

Through discussions with stakeholders and a review of existing research, a range of datasets were identified that could be of use for this research. Each of these was investigated and **Table 47** provides an overview of this data review. It quickly became clear that some of the assumptions about availability of national datasets were optimistic, and it would not be possible to obtain all of the datasets identified as potentially useful in the original Project Design. It was also recognised that data to support the evaluation of the medium and long term timescales are likely to be cruder than that relating to the current time period.

Table 47: Review of data to support assessment of erosion risk

Data owner	Availability for this study	Description of dataset	Limitations for this study	Consideration of climate change
National Coastal Erosion Risk Mapping (NCERM)				
Environment Agency	Whilst assumed that this data was publicly accessible at project inception, this data was only made available part way through the study. The data has been updated in September 2018. URL: https://data.gov.uk/dataset/7564fcf7-2dd2-4878-bfb9-11c5cf971cf9/national-coastal-erosion-risk-mapping-ncerm-national-2018-2021 As of December 2018, this data is now available in an interactive map here: https://environment.maps.arcgis.com/apps/webappviewer/index.html?id=9cef4a084bbb4954b970cd35b099d94c	• The NCERM shows the coastal baseline position split into 'frontages'; defined as lengths of coast with consistent characteristics based on the cliff behaviour characteristics and the defence characteristics. • For erodible frontages, information is provided about erosion projections aligned with each SMP management policy under two scenarios: 1) SMP policies are implemented as they currently stand 2) Hypothetical scenario of no active intervention (NAI) • The dataset covers three periods: 1) Short Term (0 – 20yr); 2) Medium Term (20 – 50yr); 3) Long Term (50 – 100yr). • For each scenario, and each time period, erosion extents (cumulative distance in metres) for the 5th, 50th and 95th percentile confidence levels are provided. • NCERM predicts the recession likely to occur from a baseline, located at the point at which recession will commence, for example, at the top edge of a cliff, the back of dunes, or a similar location.	• The data is provided as lines around the coast rather than extents (areas). Erosion risk areas need to be generated in GIS through use of buffers that relate to the attributes held in the table. • The data does not estimate the absolute location of the future coastline. • NCERM considers the predominant risk at the coastline although flooding and erosion processes are often linked, and data on erosion of foreshore features are, in general, not included. • When data became available for download in May 2018, it was made available in 22 separate files reflecting the SMP sections around the coast. Data needed to be stitched together in GIS to create a complete 'baseline' around the coast. • Once the erosion buffers had been created, clipping of the buffer extent behind the NCERM baseline was difficult as the line was not complete, with small gaps in the layer that needed to be closed to allow for clipping of the buffers. This was done manually in GIS. • For this study, it was considered prudent to use the NAI scenario for the GIS analysis. The 5th percentile confidence levels have been assessed (rather than the 50th or 95th percentile). • NCERM excludes the erosion of complex cliffs as their past recession cannot be used to infer their future erosion. Instead, they erode via multi-tiered landslides at unpredictable points in time.	• Climate change is predicted to lead to higher sea levels, more rainfall and a more severe wave climate. The impact of these factors on coastal erosion is not well understood. However, it is widely accepted that it will lead to an acceleration of coastal erosion due to more aggressive marine conditions. • The cliffs of the England and Wales coastline have been assessed for their sensitivity to climate change in the Futurecoast study (Halcrow 2002). The cliffs with low and medium sensitivity in the Futurecoast study are considered to be only slightly affected by climate change. These cliff types are characterised by relatively resistant rock types and simple modes of failure. For these cliff types it is considered that the erosion bands within NCERM will be sufficient to encompass the magnitude of change currently anticipated as a result of climate change. • Complex cliffs are landslides with failure at more than one level, which interact with the sea at their toe. The erosion of these areas is driven by ground instability, which itself is driven by high groundwater. The groundwater is commonly increased by high rainfall. The toe may be destabilised by coastal processes but the driving force is often the weather. These locations are highly susceptible to compounded climate change impacts (rainfall, sea level rise, coastal erosion).
BGS Coastal Vulnerability Dataset (CVD) Backshore and Foreshore				
BGS	Data was made available by the BGS for use in this study. Data is not publicly accessible, but is available under licence.	• The Coastal Vulnerability Dataset (CVD) is a GIS-based analysis for indicating multi-hazards and interdependencies within the coastal zone of Wales and England. Version 1 of the CVD does not include islands (e.g. Isle of Wight, Anglesey). • Version 1 of the CVD represents the natural geological coastline (around the mainland of Wales and England) as if no coastal defences or made ground are present. This is of particular value in areas where coastal defences are no longer maintained. Subject to availability, it is intended that future versions of the CVD will include all coastal defences and made ground. • Version 1 of the CVD consists of four data layers in GIS format that identify areas susceptible to flooding and coastal erosion for mainland Great Britain within 1km of the coast: o Backshore (Erosion susceptibility): A	• Version 1 was deliberately released early so as to harvest feedback from stakeholders on how they would like the product to develop to be of maximum use. • Foreshore and backshore lines are not coincident (50m offset), and it has therefore not been possible to create a combined fore/backshore vulnerability rating/score. • No information is provided to estimate the extent of erosion (metres inland of the line).	• Not included in Version 1, but recognised as one of the key drivers for developing the CVD mapping.

Data owner	Availability for this study	Description of dataset	Limitations for this study	Consideration of climate change
		scoring system was derived based on a range of geological and engineering properties and applied to each rock layer within the cliff stratigraphy. These scores were summed to produce an overall score of erosion susceptibility. ○ Foreshore (Holocene Buffers): the spatial extent of coastal geomorphological features (beaches, tidal flat deposits, saltmarshes or wave-cut platforms or any combination of these) that would potentially act to dissipate wave energy before it meets the cliff. These features would effectively "buffer" the cliff or backshore, potentially decreasing rates of erosion from waves and currents. ○ Cliff Top Height: a point dataset derived from the NEXTMap digital terrain model (DTM) at a 5m resolution which depicts the height of the cliff top. ○ Inundation: see below		
Shoreline Management Plans (SMP2)				
Coastal Groups/ Environment Agency	SMP2 'lines' are available for download here: https://data.gov.uk/dataset/0c492f70-8d54-42d9-ba2c-23cd2e513737/shoreline-management-plan-mapping With corresponding reports available online.	• An SMP is a large-scale assessment of the risks associated with coastal processes and helps reduce these risks to people and the developed, historic and natural environments. Coastal processes include tidal patterns, wave height, wave direction and the movement of beach and seabed materials. The SMPs provide a 'route map' for local authorities and other decision makers to move from the present situation towards meeting future needs, and identify the most sustainable approaches to managing the risks to the coast in the short term (0-20 years), medium term (20-50 years) and long term (50-100 years). • There are four main management policies for each stretch of coast, and options have been rigorously appraised and publicly consulted upon. In any location, the agreed policy can change in reality if it proves financially or technically unfeasible, or environmentally damaging, over time. The four policy options are: ○ Hold the line ○ No active intervention ○ Managed realignment ○ Advance the line	• This dataset was created for the purposes of creating a strategic overview map; as a consequence it was created at a notional scale of 1:250,000, this means that the definition of the breakpoints and the accuracy to which the SMP lengths reflect the 'coastline' is suitable for strategic level use only. • Data is presented as a line feature. Whilst the accompanying reports present mapping that shows an indicative inland encroachment extent, these areas were not available for this study.	SMP2s consider the latest studies (at the time of their preparation) with regard to climate change.
Flood Map for Planning (Rivers and Sea) – Flood Zone 2				
Environment Agency	Quarterly updates available for download via https://data.gov.uk/dataset/cf494c44-05cd-4060-a029-35937970c9c6/flood-map-for-planning-rivers-and-sea-flood-	• The Environment Agency's best estimate of the areas of land at risk of flooding, when the presence of flood defences are ignored and covers land between Zone 3 and the extent of the flooding from rivers or the sea with a 1 in 1000 (0.1%) chance of	• The information on the Flood Map for Planning (Rivers and Sea) is designed to only give an indication of flood risk to an area of land and is not sufficiently detailed to show whether an individual property is at risk of flooding. This is because the	• Whilst the data has a defined return period, increased flooding as a result of sea level rise and climate change factors is not modelled in.

Data owner	Availability for this study	Description of dataset	Limitations for this study	Consideration of climate change

	zone-2	flooding each year. This dataset also includes those areas defined in Flood Zone 3.
		• This dataset is designed to support flood risk assessments in line with Planning Practice Guidance; and raise awareness of the likelihood of flooding to encourage people living and working in areas prone to flooding to find out more and take appropriate action. The information provided is largely based on modelled data and is therefore indicative rather than specific.
			EA cannot know all the details about each property.
			• Attribution relating to the source of flooding has the following types:
			  ○ Fluvial / Tidal Models and/or
			  ○ Fluvial / Tidal / Coastal/Undefined Events
			• Flooding from purely fluvial sources is also included and needs to be removed for the purposes of this study to approximate coastal flooding extents.
			• It has not been possible to rule out Undefined Extents as being non-coastal/tidal in origin, so they remain in the coastal flooding dataset.	

Flood Map for Planning (Rivers and Sea) – Flood Zone 3				
Environment Agency	Quarterly updates available for download via https://data.gov.uk/dataset/bed63fc1-dd26-4685-b143-2941088923b3/flood-map-for-planning-rivers-and-sea-flood-zone-3	• The Environment Agency's best estimate of the areas of land at risk of flooding, when the presence of flood defences are ignored and covers land with a 1 in 100 (1%) or greater chance of flooding each year from Rivers; or with a 1 in 200 (0.5%) or greater chance of flooding each year from the Sea. • This dataset is designed to support flood risk assessments in line with Planning Practice Guidance; and raise awareness of the likelihood of flooding to encourage people living and working in areas prone to flooding to find out more and take appropriate action. The information provided is largely based on modelled data and is therefore indicative rather than specific.	• The information on the Flood Map for Planning (Rivers and Sea) is designed to only give an indication of flood risk to an area of land and is not sufficiently detailed to show whether an individual property is at risk of flooding. This is because we cannot know all the details about each property. • Attribution relating to the source of flooding has the following types: ○ Fluvial/ Tidal Models • Flooding from purely fluvial sources is also included and needs to be removed for the purposes of this study to approximate coastal flooding extents.	• Whilst the data has a defined return period, increased flooding as a result of sea level rise and climate change factors is not modelled in.
Flood Map for Planning (Rivers and Sea)- Areas Benefiting from Defences				
Environment Agency	Quarterly updates available for download via https://data.gov.uk/dataset/eaa328e7-2eea-4cbf-bd6b-c66121981ba1/flood-map-for-planning-rivers-and-sea-areas-benefiting-from-defences	• This dataset shows those areas that benefit from the presence of defences in a 1 in 100 (1%) chance of flooding each year from rivers; or 1 in 200 (0.5 %) chance of flooding each year from the sea. If the defences were not there, these areas would flood in a 1 in 100 (1%)/ 1 in 200 (0.5 %) or larger flooding incident. • The rivers and sea criteria 1 in 100 (1%)/ 1 in 200 (0.5%) chance of occurring in any year aligns with Flood Zone 3 as described in the Planning Practice Guidance. In mapping areas benefiting from defences, it assumes that flood defences and other operating structures act perfectly and give the same level of protection as when the assessment of the area was made.	• The dataset does not show all areas that benefit from all flood defences. Some defences are designed to protect against a smaller flood with a higher chance of occurring in any year, for example a flood defence which protects against a 1 in 30 chance of flooding in any year. Such a defence may be overtopped in a flood with a 1 in 100 (1%)/ 1 in 200 (0.5%) chance of occurring in any year, but the defence may still reduce the affected area or delay (rather than prevent) a flood, giving people more time to act and therefore reduce the consequences of flooding. • The dataset does not always map areas that benefit from defences that offer a lower standard of protection. Other defences are designed to withstand a larger flood with a smaller chance of occurring in any year. In this case, it will only show the area that would have been affected in a flood with a 1 in 100 (1%)/ 1 in 200 (0.5%) chance of occurring in any year, even though further areas would benefit in the event of more severe flooding for example in a 1 in 1000 (0.1%) flood.	• Not included.

Data owner	Availability for this study	Description of dataset	Limitations for this study	Consideration of climate change
			•	
Risk of Flooding from Rivers and Sea				

Environment Agency	Available for download via https://data.gov.uk/dataset/bad20199-6d39-4aad-8564-26a46778fd94/risk-of-flooding-from-rivers-and-sea	• This is a national assessment of flood risk for England produced using local expertise. The dataset shows the chance of flooding from rivers and/or the sea, based on cells of 50m. Each cell is allocated one of four flood risk categories, taking into account flood defences and their condition.
		• 50m x 50m cells each allocated one of four flood risk likelihood categories:
		  ○ High: each year, there is a chance of flooding of greater than 1 in 30 (3.3%).
		  ○ Medium: each year, there is a chance of flooding of between 1 in 30 (3.3%) and 1 in 100 (1%).
		  ○ Low: each year, there is a chance of flooding of between 1 in 100 (1%) and 1 in 1000 (0.1%).
		  ○ Very Low: each year, there is a chance of flooding of less than 1 in 1000 (0.1%).
		• Each cell has a suitability rating to show at what scale it is generally appropriate to use the data to assess flood risk, and how suitable the data is for a range of different uses.
			• Similar to many other flood models it does not take individual property threshold heights into account so is not property specific.
			• Provides no indication of source of flooding (fluvial/coastal/tidal).
				• Not included.

BGS Coastal Vulnerability Dataset (CVD): Inundation				

BGS	Data was made available by the BGS for use in this study. Data is not publicly accessible, but is available under licence.	• The Coastal Vulnerability Dataset (CVD) is a GIS-based analysis for indicating multi-hazards and interdependencies within the coastal zone of Wales and England. Version 1 of the CVD does not include islands (e.g. Isle of Wight, Anglesey).
		• Version 1 of the CVD represents the natural geological coastline (around the mainland of Wales and England) as if no coastal defences or made ground are present. This is of particular value in areas where coastal defences are no longer maintained. Subject to availability, it is intended that future versions of the CVD will include all coastal defences and made ground.
		• Version 1 of the CVD consists of four data layers in GIS format that identify areas susceptible to flooding and coastal erosion for mainland Great Britain within 1km of the coast:
		  ○ Backshore (Erosion susceptibility): see above
		  ○ Foreshore (Holocene Buffers): see above.
		  ○ Cliff Top Height: see above.
		  ○ Inundation: highlights areas where coastal flooding is likely to occur during extreme storm events and the potential exacerbation of the coastal flooding from coincident groundwater flooding. It also
			• Version 1 was deliberately released early so to harvest feedback from stakeholders on how they would like the product to develop to be of maximum use.
			• Foreshore and backshore lines are not coincident (50m offset), and it has therefore not been possible to create a combined fore/backshore vulnerability rating/score.
			• Inundation data is cut to an arbitrary 1km extent inland. In some areas this is not adequate to completely assess the zone vulnerable to coastal flooding. This is something that will be addressed on further releases.
			• Whilst the BGS data is perhaps more sophisticated in some ways (incorporating geomorphology and groundwater), the spatial limitations and the lack of alignment with the EA flood risk layers has meant that it has not been possible to transfer the return period information from the EA data to the BGS data.
				• Not included in Version 1, but recognised as one of the key drivers for developing the CVD mapping.

Data owner	Availability for this study	Description of dataset	Limitations for this study	Consideration of climate change
		highlights areas susceptible to fluvial flooding which may also exacerbate coastal flooding when the two hazards coincide. Information is provided for the 1km terrestrial coastal zone.		
UK Climate Change Risk Assessment 2017 : Projections of future flood risk in the UK				
Report prepared for the Committee on Climate Change, UK by Sayers, P.B, Horritt, M.S., Penning-Rowsell, E and McKenzie, A	No GIS data could be made available. Sayers and Partners hold the data used in their Future Flood Explorer (FFE). Sayers report available here: https://www.theccc.org.uk/wp-content/uploads/2015/10/CCRA-Future-Flooding-Main-Report-Final-06Oct2015.pdf Committee on Climate Change Evidence Report available here: https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/uk-climate-change-risk-assessment-2017/	• The UK Government is required under the 2008 Climate Change Act to publish a UK-wide Climate Change Risk Assessment (CCRA) every five years. The Act stipulates that the Government must assess 'the risks for the United Kingdom from the current and predicted impacts of climate change'. • The analysis presented covers the whole of the UK (England, Wales, Scotland and Northern Ireland) and the risks associated with coastal, fluvial, surface water and groundwater flooding. • The report metrics cover future risks in five key area of society: ○ Property ○ People ○ Natural Capital ○ Agriculture ○ Infrastructure	• Data on coastal erosion and flooding risks used in the analysis was not available for review. • Although heritage assets could be considered Natural Capital, the definition of Natural Capital for the purposes of the assessment covers: ○ The area of land exposed to flooding within Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites.	• The assessment of future flood risk presented considers three climate change scenarios (a 2C and 4 C change in Global Mean Temperature by the 2080s and a H++ scenario) and, three population growth projections (low, high and no growth). • The UK FFE uses nationally recognised source, pathway and receptor data from across the UK to construct an emulation of the present day flood risk system and to explore the future change in flood risk (taking account of climate change, population growth and adaptation). The flexibility of UK FFE enables multiple futures to be explored and compared, and for the first time, the impact of adaptation, climate change and population drivers to be disaggregated.
UK Climate Projections 18 (UKCP18)				
Met Office	Available as of 26/11/2018 https://www.metoffice.gov.uk/research/collaboration/ukcp UKCP09 available here: http://ukclimateprojections.metoffice.gov.uk/	• The UKCP18 project builds upon the previous set of projections (UKCP09), which provide crucial information about how we can expect our climate to change over future decades. These tools help decision-makers assess the full range of risks from the changing climate and advise how we can adapt.	• The UK Climate Projections 2018 (UKCP18) became available too late in this study to be interrogated for use. • The resolution for the UK projections is 12km.	• UKCP18 updated observations and climate change projections out to 2100 in the UK and globally.
FloodFutures™ data layers				
Ambiental Risk	Commercial product. Costs unknown and not available for use within this study. http://www.ambientalrisk.com/wp-content/uploads/2017/07/Landmark-Ambiental-CCA-Product-Card.pdf	• A suite of GIS layers covering current and future: ○ Fluvial/Pluvial flooding ○ Tidal flooding ○ Sea level rise/sea level rise inundation areas	• Not able to be explored. This is a chargeable product.	• Currently based on UKCP09 scenarios.

Datasets used in the assessment

The data review highlighted that there do not exist perfect datasets to underpin the assessment of coastal vulnerability at present. There are a number of useful datasets (most notably from the Environment Agency and BGS), but each has limitations. Commercial datasets were not able to be explored. **The focus is therefore on developing a method that can accommodate better datasets in the future as they become available.** This is an area of continual development and it is anticipated that better datasets will emerge in the near future.

Recognising the limitations, and noting that this is the first strategic assessment of its kind for heritage assets, the following datasets were selected for use in this study:

- Environment Agency National Coastal Erosion Risk Mapping: to map the approximate inland encroachment of the sea as a result of **coastal erosion** for the three epochs.
- Environment Agency Flood Zone 2 and 3 data (including the consideration of areas currently benefiting from defences, but excluding areas that are subject to fluvial (from rivers) flooding only) to map the current approximate inland extent of **coastal and tidal flooding**.
- In order to further our understanding of the potential impacts of **sea level rise** on England's heritage assets for each of the three epochs, a GIS layer approximating all areas that are less than a given height above current mean sea level (three heights based on the H++ scenario for each epoch) has been generated using Ordnance Survey's Terrain 50 dataset and applying a simple upward shift in sea levels. This has been used to generate some high level statistics to identify the number of heritage assets included in the NHLE that lie within this 'vulnerable zone' at each epoch under the H++ worst case scenario. The resultant sea level rise scenario layers are particularly crude and should be seen as indicative only. Whilst Lidar data is available to increase the resolution of the modelling, it is only available in individual tiles and the stitching together of a national layer was seen as beyond the scope of this study.

Efforts have been made to model the impact of the H++ sea level rise scenarios on the Flood Zone 2 and 3 data to estimate **future flooding** vulnerability, but this has not been possible to produce robust spatial layers within the constraints of this study.

Preparing the GIS layers for analysis

Following selection of the datasets to underpin the analysis in this study, they needed to be processed in GIS to create usable layers for the spatial analysis.

National Coastal Erosion Risk Mapping (NCERM)

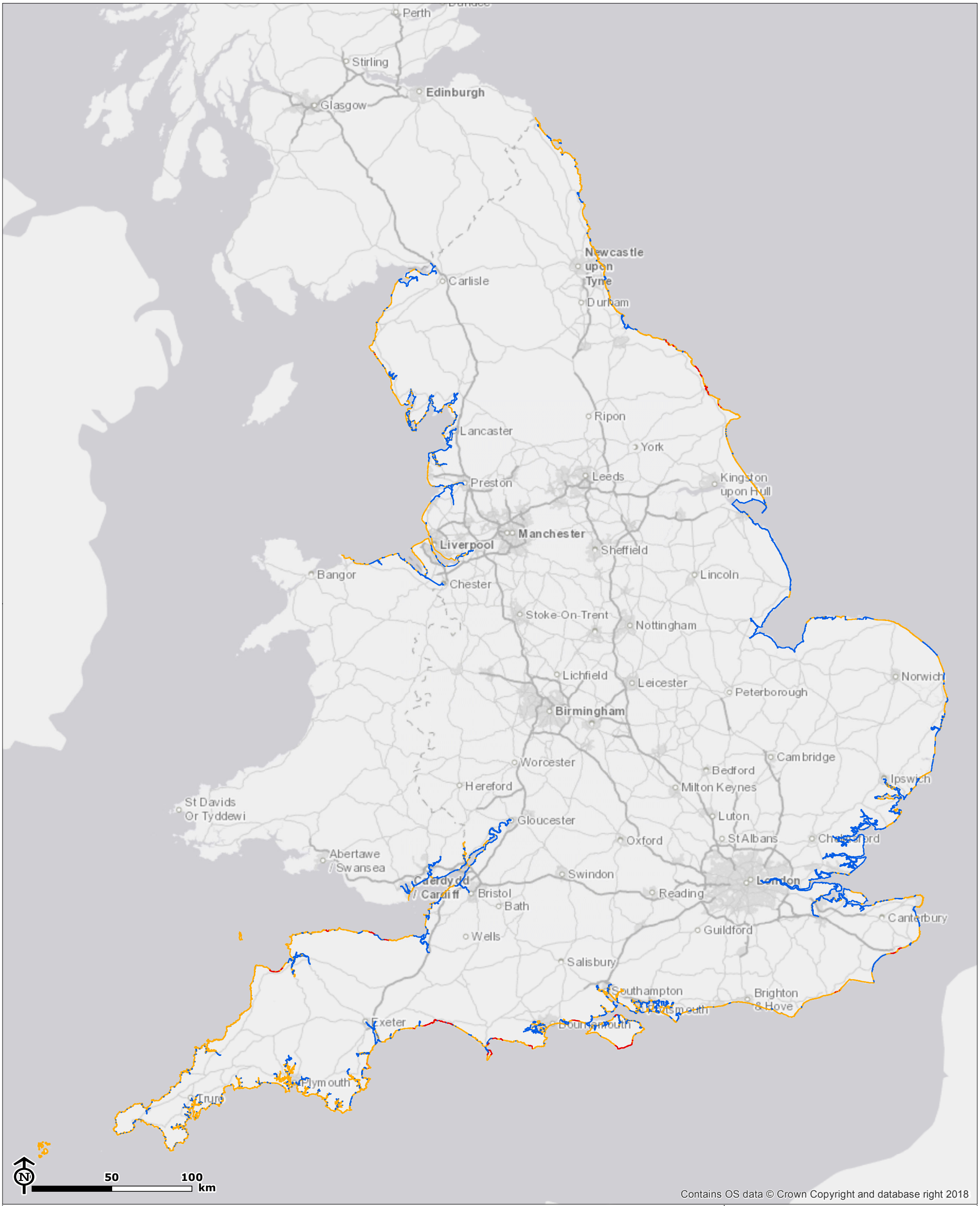
Using the Merge Tool in ESRI ArcMap, each of the 22 NCERM SMP sections were joined together to form a single NCERM line around the coast. The resultant layer is shown in **Figure 18**.

A snapshot of the attributes in the NCERM data is shown in **Table 48.**

Table 48: NCERM information of erosion rates

Field name	Notes	Example 1	Example 2
SMP_NO	Shoreline Management Plan number	17	17
SMP_NAME	SMP name	Rame Head to Hartland Point	Rame Head to Hartland Point
ST_NAI_5	No Active Intervention retreat distance in metres for the Short Term 5%-ile	1.32	0.5775
ST_NAI_50	No Active Intervention retreat distance in metres for the Short Term 50%-ile	1	0
ST_NAI_95	No Active Intervention retreat distance in metres for the Short Term 95%-ile	0.68	0
MT_NAI_5	No Active Intervention retreat distance in metres for the Medium Term 5%-ile	3.3	3.3
MT_NAI_50	No Active Intervention retreat distance in metres for the Medium Term 50%-ile	2.5	2.5
MT_NAI_95	No Active Intervention retreat distance in metres for the Medium Term 95%-ile	1.7	1.7
LT_NAI_5	No Active Intervention retreat distance in metres for the Long Term 5%-ile	6.6	6.6
LT_NAI_50	No Active Intervention retreat distance in metres for the Long Term 50%-ile	5	5
LT_NAI_95	No Active Intervention retreat distance in metres for the Long Term 95%-ile	3.4	3.4
ST_SMP_5	Short Term SMP Policy retreat distance in metres for the 5%-ile	1.32	0.5775
ST_SMP_50	Short Term SMP Policy retreat distance in metres for the 50%-ile	1	0
ST_SMP_95	Short Term SMP Policy retreat distance in metres for the 95%-ile	0.68	0
MT_SMP_5	Medium Term SMP Policy retreat distance in metres for the 5%-ile	3.3	3.3
MT_SMP_50	Medium Term SMP Policy retreat distance in metres for the 50%-ile	2.5	2.5
MT_SMP_95	Medium Term SMP Policy retreat distance in metres for the 95%-ile	1.7	1.7

Field name	Notes	Example 1	Example 2
LT_SMP_5	Long Term SMP Policy retreat distance in metres for the 5%-ile	6.6	6.6
LT_SMP_50	Long Term SMP Policy retreat distance in metres for the 50%-ile	5	5
LT_SMP_95	Long Term SMP Policy retreat distance in metres for the 95%-ile	3.4	3.4
DefType	Defence Type as utilised in the NCERM model	Natural	Seawall
ST_SMP	Short Term SMP Policy	No active intervention	No active intervention
MT_SMP	Medium Term SMP Policy	No active intervention	No active intervention
LT_SMP	Long Term SMP Policy	No active intervention	No active intervention
MidX	Easting of the midpoint of the Frontage to OSGB	222411	222366
MidY	Northing of the midpoint of the Frontage to OSGB	51591	51612
FeatType	Feature Type (either Erodible, Floodable or Complex Cliff)	Erodible	Erodible
Shape_Length or Shape_Leng	Length of the frontage (in metres)	35.21	71.09



NCERM profile

Type of coastline

- Complex Cliff
- Erodible
- Floodable

Source: Environment Agency

Map Scale @A3: 1:2,325,000

Coastal Risk and Priority Places

Figure 18: NCERM coastal profile

LUC Historic England

CB:DM EB:Manson D LUC FIG18_10193_v2_NCERM_A3P 19/06/2019

Using the retreat distances contained within the NCERM data for each frontage section, a series of projected erosion zones were created for each of the No Active Intervention epochs for the 5th percentile confidence levels. A proposed method for turning the line data into an area of erosion loss is provided alongside the NCERM data files, and this approach was followed.

The Buffer Tool was used to generate these projected erosion zones based on the erosion distances recorded for each section of the coastline. As the projected erosion zone size changes for each frontage length within an epoch, the projected erosion zone was smoothed into a single line by merging all of the zones. This resulted in three layers:

- Short Term No Active Intervention 5th percentile
- Medium Term No Active Intervention 5th percentile
- Long Term No Active Intervention 5th percentile

The NCERM data does not consider complex cliffs as their past recession cannot be used to infer their future erosion. Instead, they erode via multi-tiered landslides at unpredictable points in time. An example of such a section of coast is the southern coast of the Isle of Wight (Luccombe Village to Chale). A fourth GIS layer was created to ensure that the heritage assets behind these complex cliffs were considered in some way, even if not based on more exact erosion predictions. Based on the approach used in the recent Committee on Climate Change Report: *Managing the coast in a changing climate* (October 2018)[10], an approximate inland erosion extent has been modelled in an additional Long Term No Active Intervention Scenario. Complex cliff erosion has only been included in the longer term scenario as there is no reasonable assumption to apply as to when complex cliffs might fail.

Whilst the Committee on Climate Change report discusses the approach that has been taken to estimate the extent of complex cliff erosion in each affected section of the coast, this data has not been made available for use in this study, so a pragmatic approach was required. On this basis, the additional Long Term scenario with complex cliffs included assumes that these sections will be subject to erosion of up to 1km. All other sections will be subject to the erosion extents set out for the Long term No Active Intervention 5th percentile scenario. This is likely to be an overestimate and needs to be considered as a limitation of this study.

The GIS process generated projected erosion zones each side of the NCERM baseline and the layers needed to be clipped to remove the seaward extent of the zone. Whilst it should have been possible to use the NCERM line data to do this, there were some data integrity issues (gaps between line segments) that made

[10] https://www.theccc.org.uk/wp-content/uploads/2018/10/Managing-the-coast-in-a-changing-climate-October-2018.pdf

this difficult. Where gaps were identified, these were closed (by joining the end points). This meant that the zones could be clipped.

Furthermore, the **NCERM baseline is located at the point at which recession will commence**; for example, at the top edge of a cliff, the back of dunes, or a similar location. This line often sits above the Mean High Water Line (MHWL) and it therefore left an area of the coast between the MHWL and the NCERM baseline unattributed in GIS.

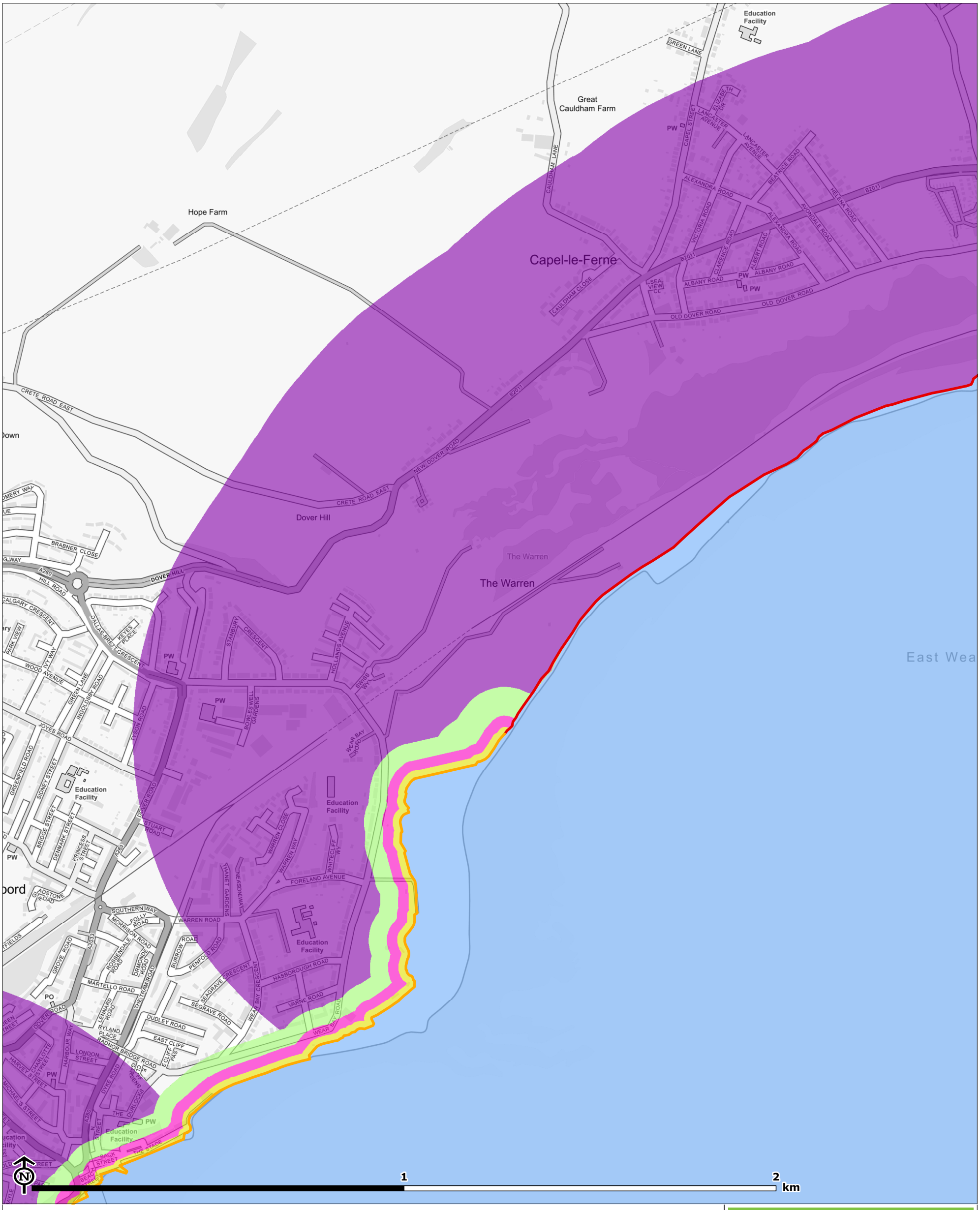
In order to allow for this area to be included in the analysis, a band seaward of the NCERM baseline was required to 'catch' any assets that may lie within this zone. This zone (seaward of the NCERM baseline) was added to each of the layers.

The resultant layers identified all areas:

- Seaward of the NCERM baseline.
- Seaward of the NCERM baseline or at risk of loss to erosion in the short term (5^{th} percentile confidence level) under the no active intervention scenario.
- Seaward of the NCERM baseline or at risk of loss to erosion in the medium term (5^{th} percentile confidence level) under the no active intervention scenario.
- Seaward of the NCERM baseline or at risk of loss to erosion in the long term (5^{th} percentile confidence level) under the no active intervention scenario.
- Seaward of the NCERM baseline or at risk of loss to erosion in the long term (5^{th} percentile confidence level) under the no active intervention scenario with complex cliffs considered.

These layers are illustrated in **Figure 19** for the stretch of coast near Folkestone. Looking at the national dataset, there is a large range in the retreat distances for each epoch. For example, the most dramatic retreat distance in the Short Term, No Active Intervention 5^{th} percentile scenario is 182m for 0-20 years (south of Kessingland). This rises to 455m in the Medium Term and 910m in the Long Term under the No Active Intervention 5^{th} percentile scenario. For this section of coast, the short, medium and long-term SMP response is managed realignment.

Whilst there is data to represent the short, medium and long term epochs that considers the SMP policy for each section in the erosion projections, it was decided that this information would not be used in the spatial analysis, but would be included as an overlay in the GIS mapping. The reason being that policies can change or not be implemented due to funding issues.



Type of coastline

- Complex Cliff
- Erodible
- Floodable

NCERM buffers

- Seaward of the NCERM baseline
- Short Term No Active Intervention (5th percentile)
- Medium Term No Active Intervention (5th percentile)
- Long Term No Active Intervention/no complex cliffs (5th percentile)
- Long Term No Active Intervention including complex cliffs (5th percentile)

Source: Environment Agency

Map Scale @A3: 1:10,000

Coastal Risk and Priority Places

Figure 19: NCERM projected erosion zones for an area near Folkstone

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CB:DM EB:Manson D LUC FIG19_10193_v2_NCERM_buffers_A3P 19/06/2019

Flood Map for Planning (Rivers and Sea)
As identified in the data review, data for Flood Zones 2 and 3 includes flooding from both rivers and the sea. For this assessment, fluvial flooding (rivers) was not of primary concern. Discussions with the Environment Agency identified that there is no precise way of removing fluvial flooding from the data layers. However, it was agreed that it was possible to use the attribution behind each layer to remove as much flooding that was from a fluvial source only as possible.

For Flood Zone 2, this meant removing any areas that had 'fluvial model' or 'fluvial event' as their source. Flooding from 'undefined sources' were retained in the dataset. For Flood Zone 3 this meant removing any areas that had 'fluvial models' as their source.

For both layers, some areas that had a combination of fluvial/tidal events/models could not be excluded. This is a known limitation of the data and analysis.

Each layer was combined with the Areas Benefiting from Defences layer to identify those areas that are likely to have much lower flood risk as a result of being behind a defence. It should be noted that these defences could still fail or not be maintained in the future. An extract of the resultant data layers for the area around The Wash is shown in **Figure 20**.

Sea level rise projections
This assessment drew on the Environment Agency's definition of climate change allowances for flood risk assessments[11] which are defined by epoch and region, together with the agency's H++ allowances for the country as a whole. These are summarised in **Table 49**.

[11] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#table-3

Table 49: Sea level allowance for each epoch in millimetres (mm) per year with cumulative sea level rise for each epoch in brackets

	1990 – 2025	2026 – 2055	2056 – 2085	2086 – 2115	Cumulative rise 1990 - 2115
East, East Midlands, London, South East	4 (140)	8.5 (255)	12 (360)	15 (450)	1205
South West	3.5 (122.5)	8 (240)	11.5 (345)	14.5 (435)	1142
North West, North East	2.5 (87.5)	7 (210)	10 (300)	13 (390)	987
	1990 – 2025	2026 – 2050	2051 – 2080	2081 – 2155	Cumulative rise 1990 - 2115
UK H++ scenario	6 (210)	12.5 (362.5)	24 (696)	33 (957)	2225

Using Ordnance Survey Terrain50 topography data, raster analysis was used to add the following heights to the current mean sea level for the whole of England:

- Short term 0.21m (H++ scenario 1990-2025)
- Medium term 0.572m (H++ scenario 1990-2055)
- Long term 2.225m (H++ scenario 1990-2115)

It needs to be noted that this is largely an academic exercise to test the method as the vertical accuracy of Terrain50 data is not appropriate for modelling this level of detail. The resultant layers are shown in **Figure 21**. Lidar data is available to increase the resolution of the modelling, but it is only available in individual tiles and the stitching together of a national layer was seen as beyond the scope of this study.

Scoring coastal vulnerability

In order to establish the level of risk to each of the heritage assets, a scoring system was devised to differentiate between the levels of risk relating to each of the above layers (coastal hazards). This scoring is presented in **Tables 47, 48 and 48** below. A three point scale was considered appropriate for this strategic assessment. It was not considered appropriate to develop a 'conflated' scoring

system covering all three risks given the significantly differing scenarios each risk presents.

This initial spatial assessment considers only whether any part of the site is within the risk zones – rather than the proportion of the site within the risk zone. Where possible, this was done for the short, medium and long term scenarios. For coastal erosion, as discussed previously, two versions were assessed for the long term – one including complex cliffs and one excluding complex cliffs. For coastal flooding, future flooding scenarios have not been evaluated.

Table 50: Coastal erosion vulnerability scores

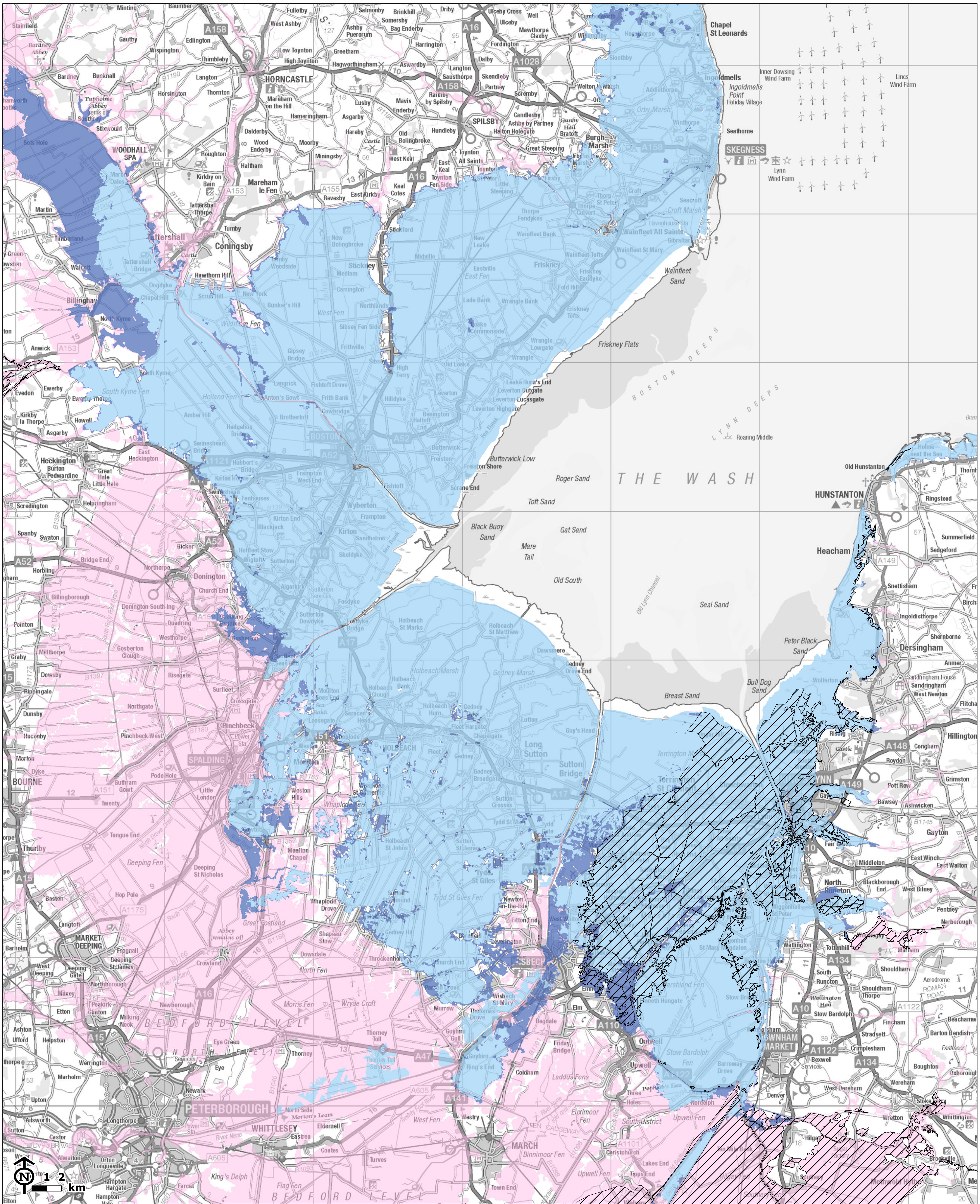
Coastal zone	Risk category	Score
Within 'No Active Intervention' coastal erosion zone in NCERM (5th percentile confidence level)	High	3
Outside of coastal erosion zone	None	0

Table 51: Coastal flooding vulnerability scores

Coastal zone	Risk category	Score
Flood risk zone 3 (excluding fluvial-related flooding)	High	3
Flood risk zone 2 (excluding fluvial-related flooding)	Medium	2
Flood risk zone 2 or 3 (excluding fluvial-related flooding) but within an area benefitting from coastal defences	Low(er)	1
Outside of (non-fluvial) flood risk zones	None	0

Table 52: Sea level rise vulnerability scores

Coastal zone	Risk category	Score
Within sea level rise inundation area	High	3
Outside of sea level rise inundation areas	None	0



- Flood Zone 3 (excluding fluvial)
- Flood Zone 2 (excluding fluvial)
- Areas benefiting from flood defences
- Flooding from fluvial sources (not included)

Source: Environment Agency

Coastal Risk and Priority Places

Figure 20: Layers used in coastal flooding assessment

LUC

Historic England

Map Scale @A3: 1:250,000

CB:DM EB:Manson D LUC FIG20_10193_v2_Flood_A3P 19/06/2019

Sea level rise scenarios

- Short term sea level rise (0.21m H++ scenario 1990-2025)
- Medium term sea level rise (0.572m H++ scenario 1990-2055)
- Long term sea level rise (2.225m H++ scenario 1990-2115)

Source: Environment Agency

Map Scale @A3: 1:200,000

Coastal Risk and Priority Places

Figure 21: Sea level rise layers

LUC

Historic England

CB:DM EB:Manson D LUC FIG21_10193_v2_SLR_A3P 19/06/2019

Assessing heritage sensitivity
The heritage asset data used in the study is drawn from HE's National Heritage List for England database. This combines the various designated asset datasets maintained by HE, and incorporates additional information used to populate the NHLE online database and facilitate the 'advanced search' functionality. Most importantly, this includes asset typology and main material types not present in the publicly-available data.

The NHLE records and maps the following assets:

- World Heritage Sites
- Registered Battlefields
- Registered Parks and Gardens
- Scheduled Monuments
- Listed Buildings
- Protected Wrecks
- Heritage at Risk

As part of the data review, a range of datasets were explored for use within this study. Each of these was investigated and **Table 53** provides an overview of this data review. It became clear early on that some of the assumptions about availability of national datasets were optimistic, and it would not be possible to obtain all of the datasets identified as useful in our original Project Design.

Table 53: Review of data to support assessment of heritage sensitivity

Data owner	Availability for this study	Description of dataset	Limitations for this study
National Heritage List for England (NHLE) database			
Historic England	Data needs to be extracted 'manually' from the NHLE database held by HE. The data was initially made available in a series of spreadsheets for the pilot areas, but was later made available for an area within 60km of the coastline. A spreadsheet per asset type was provided. Data is made available to the public via a searchable website https://historicengland.org.uk/listing/the-list/non-listed-sites/	• The National Heritage List for England is the only official, up to date, register of all nationally protected historic buildings and sites in England - listed buildings, scheduled monuments, protected wrecks, registered parks and gardens, and battlefields. • In addition to a number of location fields, attributes available in the database held by HE include: ○ List Entry Number ○ Heritage Category ○ Grade ○ Heritage Asset Name ○ Alternative Name ○ Monument Type ○ Vessel Type ○ Aircraft Type ○ Period Name ○ Phase Display Date ○ Main Material ○ Covering Material ○ First Designation Date ○ Last Amendment Date ○ Legacy Number	• It was not possible to extract full national coverage of the NHLE in a single file for analysis. • Data was provided in a series of individual spreadsheets that needed to be stitched back together. • Key fields for analysis included the Monument type and Materials type. Both of these fields contain controlled terms from FISH thesauri (see below). • There can be multiple Monument types and Materials types per asset record. These values are not prioritised and are stored in a single field as comma separated values. This format makes analysis of the records difficult. • The majority of records have a Monument Type assigned, but only Listed Buildings and a small number of scheduled monuments have a Material Type assigned.
National Heritage List for England (NHLE) GIS datasets			
Historic England	GIS datasets are available for download via the HE website: https://services.historicengland.org.uk/NMRDataDownload/default.aspx	• GIS data layers for the following asset types: ○ World Heritage Sites (core areas and buffer areas) ○ Registered Battlefields ○ Registered Parks and Gardens ○ Scheduled Monuments ○ Listed Buildings ○ Protected Wrecks ○ Heritage at Risk (includes Conservation Areas)	Listed Buildings are mapped as points rather than their actual footprints.
Rapid Coastal Zone Assessment Survey (RCZAS)			
Various	Data is not held centrally by HE	• Rapid Coastal Zone Assessment Survey (RCZAS) is a national attempt to quantify the English coastal archaeological resource.	Data not obtained for examination.
Historic Environment Record (HER)			
Various	Data is not held centrally by HE. Heritage Gateway provides contact details for each HER by location: http://www.heritagegateway.org.uk/	• HERs contain details on local archaeological sites and finds, historic buildings and historic landscapes and are regularly updated.	• Mainly county council or unitary authority based, but may also be held by joint services (i.e. more than one authority working together), district councils, and national parks. Similar records are maintained by major landowners, such as, the National Trust. • Too many individual sources to interrogate. • HERs charge for data.
Thesaurus of Monument Types			
FISH/HE	Available for download via FISH website: http://thesaurus.historicengland.org.uk/	• Types of monuments relating to the built and buried heritage in England. • 18 Class Names (CL) • Narrow Terms (NT) are 'grouped' under Broad Terms (BT). • Scope notes are provided for each Term (Broad and Narrow).	• The Thesuarus is distributed as a series of tables that need to be rebuilt within a database environment to re-establish the hierarchical links. • Owing to the number of Narrow Terms, it was agreed that the risk assessment should be undertaken at Broad Term level. • Considerable effort was required to rebuild the database links to generate a clear hierarchical structure showing Narrow Term, Broad Term and Class Name.

Data owner	Availability for this study	Description of dataset	Limitations for this study
			• There are a number (over 1500) of Narrow Terms that fall within more than one Class Name or Broad Term. • Although attribution is controlled by thesauri, there exist some invalid terms in the database (80 invalid types in the extract used for this study, some used multiple times).
Thesaurus of Materials Types			
FISH/HE	Available for download via FISH website: http://thesaurus.historicengland.org.uk/	• Construction materials for monuments relating to the built and buried heritage. • 9 Class Names (CL) • Narrow Terms (NT) are 'grouped' under Broad Terms (BT). • Scope notes are provided for each Term (Broad and Narrow).	• The Thesuarus is distributed as a series of tables that need to be rebuilt within a database environment to re-establish the hierarchical links. • Considerable effort was required to rebuild the database links to generate a clear hierarchical structure showing Narrow Term, Broad Term and Class Name. • Although attribution is controlled by thesauri, there exist some invalid terms in the database (24 invalid types in the extract used for this study, some used multiple times). In some cases, top term material types are used instead of narrow terms. For example, Stone is used over 65,000 times.

Datasets used in the assessment of heritage sensitivity

- NHLE GIS
- NHLE data
- HE Heritage at Risk
- HE/FISH Thesaurus of Monument Types[12]
- HE/FISH Thesaurus of Material Types[13]

The vulnerability of heritage assets to coastal processes is derived principally from the substrate on which the asset stands (i.e. how resilient it is to the effects of erosion), its elevation above current and projected sea level and, to a lesser extent, its physical character and the materials from which it is constructed. In terms of erosion, this has little influence as even the most robustly-constructed asset will be lost if it is undermined by wave action. For this reason, the evaluation of asset sensitivity to coastal erosion is a function of its coastal vulnerability only. For coastal flooding and sea level rise, consideration of physical character and materials type was considered important and this section sets out the approach to developing sensitivity ratings for coastal flooding and sea level rise.

The heritage asset data used in the study to date is drawn from Historic England's (HE) National Heritage List for England database (NHLE). This combines the various designated asset datasets maintained by HE[14], and incorporates additional information used to populate the NHLE online database and facilitate the 'advanced search' functionality[15]. Most importantly, this includes asset typology and main material types not present in the publicly-available data.

Preparing the NHLE and Thesauri data for analysis

Attribute tables

The NHLE extracts were provided in a series of spreadsheets – each covering an asset type. Given the data structure limitations listed in **Table 53** above, the data needed to be reformatted before it could be of use in this assessment. This involved:

- Stitching the spreadsheets together into a single list covering all asset types;
- Splitting out the range of Monument Types (Narrow Terms) held against each list record (by default, there can be multiple Monument Types per record stored in a single cell as comma separated values);

[12] http://thesaurus.historicengland.org.uk/thesaurus.asp?thes_no=1&thes_name=FISH%20Thesaurus%20of%20Monument%20Types

[13] http://thesaurus.historicengland.org.uk/thesaurus.asp?thes_no=129&thes_name=FISH%20Building%20Materials%20Thesaurus

[14] Scheduled Monuments; World Heritage Sites; Listed Buildings; Registered Parks and Gardens; Registered Battlefields; Protected Wrecks

[15] https://historicengland.org.uk/listing/the-list/advanced-search?searchType=nhleadvancedsearch

- Splitting out the range of Material Types (Narrow Terms) held against each list record (by default, there can be multiple Material Types per record stored in a single cell as comma separated values);
- Reformatting the list so that each List Entry has a line entry for each different Monument or Material Type.

GIS data
GIS data for each asset type is provided as polygon data for all but Listed Buildings. Whilst GIS data was provided for the extract areas by Historic England, it was decided that the full England datasets would be used so that it was possible to get an understanding of the proportion of assets at risk out of all designated assets in England.

All polygon data was merged together into a single polygon dataset for analysis efficiency. A dataset that represents each Listed Building as a small triangle is available from Historic England, but the triangles do not represent building footprint, just a notional footprint area that is consistent across all Listed Buildings. Consideration was given to creating a small footprint buffer for the Listed Buildings data using a circular buffer or using these triangular 'points' so that area-based calculations could be undertaken, but this was discounted as the areas would have been spurious. Listed Buildings data was therefore kept as a standalone point dataset.

Monument and Materials thesaurus data
For the most part, Narrow Terms are recorded in the NHLE. For the reasons given below, Monument Type sensitivity ratings were assigned at Broad Term level (rather than Narrow Term).

The Monument Type thesaurus and Materials Type thesaurus needed to be recompiled in a database environment in order to establish the hierarchical relationships between Top terms, Broad Terms and Narrow Terms.

Scoring heritage sensitivity

Monument Type Broad Term sensitivity rating
Using the typological information, drawn from the HE/FISH Thesaurus of Monument Types, vulnerability to coastal flooding has been assigned to each 'Broad Type'. This has been done at the 'Broad Type' level to ensure a measure of proportionality appropriate to a national study. This is necessarily strategic, given the potential for a range of types to occur as upstanding, occupied and maintained buildings or as archaeological assets. This underlines the importance of regarding the outputs of this study as providing a starting point for further investigation for those sites where significant risks are identified.

A high, medium and low scale of vulnerability has been used for this assessment with scores of 3, 2 and 1 respectively applied to database records.

Notes relating to each sensitivity rating are given in **Table 54**.

Table 54: Monument Type Broad Term sensitivity rating

Rating	Notes
High	Asset type particularly vulnerable to inundation; likely to result in significant effects, equating to substantial harm / loss of significance Consider: effects to structural, chemical or biological stability; potential for erosion of fabric by through-flow of water; effects of wetting/drying (expansion/contraction)
Medium	Default rating: inundation likely to result in some change / harm, but not to an extent that would compromise the significance of the asset.
Low	Inundation not likely to result in change to significance.

As each asset frequently has more than one Monument Type listed, the Monument Type with the highest scoring Broad Term has been used. This approach is not able to consider the relative 'contribution' that each Type makes to the 'whole'.

Following review of the emerging risk ratings by internal stakeholders at HE, it was decided that it was too difficult to classify assets on this basis and it was inherently subjective, potentially undermining the robustness of the overall approach if used. Some of the reasons for this include:

- the break down in levels of character type between broad type and sub-types varies. Some broad types are very specific (e.g. craft centre), some are very general (e.g. enclosed settlement). A fishing site could be anything from a fish trap, to an oyster bed to a bait shed, all of which could have different levels of vulnerability but using this approach require a single rating.
- the transfer of the rating values to undesignated sites might be problematic. For example, if Mineral Extraction Sites are given a 'High' sensitivity rating at broad type level, and then this rating system was applied to undesignated sites, this might inappropriately inflate the sensitivity of undesignated Mineral Extraction Sites.

Although a draft sensitivity rating has been applied to all Broad Monument Types in the thesaurus, it was agreed that monument type sensitivity ratings would be excluded from the emerging algorithm. For the purposes of this study, it was too complex to develop an approach that would be widely accepted.

Materials Type sensitivity rating

For Listed Buildings, and a small proportion (11%) of Scheduled Monuments, information on the main construction materials of the asset is provided. This enables further judgement on the likely vulnerability of assets to the effects of inundation. This allows scores to either be moderated or amplified depending on the likely susceptibility of key materials to wetting (e.g. engineering brick or concrete structures being more resilient than, for instance, cob walls or earthworks). A high, medium and low scale of vulnerability has been used for

this assessment with scores of 3, 2 and 1 respectively. The main materials sensitivity ratings are included in **Appendix 2**. It should be recognised that this particular use of the information captured in the Materials Type field (assessment of sensitivity to coastal risk) was likely not anticipated when the data was captured, and use of the data in this way may simplify potentially complex relationships.

Unfortunately, information on the main construction materials is not available for other NHLE assets. Broad assumptions have been applied in the absence of detailed information as detailed in **Table 55**.

Table 55: Approach to scoring main materials sensitivity

Heritage designation	Assumption	Score
Listed Buildings	Use main materials vulnerability ratings as set out in **Appendix 1.** As each asset frequently has more than one Material Type listed, the Material Type with the highest scoring Type has been used.	3, 2 or 1
Scheduled Monuments	In the absence of material type information, all sites are considered to have high vulnerability in terms of their likely 'main materials' equivalent. This is in recognition of the high proportion of earthwork and buried archaeological assets covered by the designation.	3
World Heritage Sites	No broad assumption can be applied as there is such variation within this category. Each site is to be assessed on its own.	3, 2 or 1
Registered Battlefields	All are considered to have high vulnerability in terms of their likely 'main materials' equivalent. Battlefield archaeology is necessarily ephemeral and is often concentrated in the topsoil (unlike the majority of archaeological assets). It can be particularly vulnerable to change through erosion or reworking as a consequence of periodic inundation. The evidential value expressed is often through understanding of spatial patterning of findspots and object scatters – rather than deposits and cut features.	3
Registered Parks and Gardens	All are considered to have high vulnerability in terms of their likely 'main materials' equivalent.	3

Developing a heritage vulnerability index
Here, it is useful to consider techniques applied in Environmental Impact Assessment (EIA), as a tried-and-tested approach to understanding change to heritage assets.

In essence, the approach used is little different to that applied in EIA to understand the following properties; the:

- **Importance** (i.e. heritage significance) of a receptor – in this case a heritage asset;
- **Sensitivity to change** of the receptor (i.e. heritage vulnerability – combination of coastal vulnerability and inherent asset sensitivity); and
- **Magnitude of predicted change** (proportion of asset affected – in this case by erosion / inundation).

These properties can then be combined to understand the level of effect likely to be experienced by each asset using the following 'formula':

Importance (Heritage significance)	**x**	**Sensitivity to change** (Heritage asset sensitivity X coastal vulnerability)	**x**	**Magnitude of change** (Proportion of asset affected)	**=**	**Level of effect** (Accumulated score)

Importance (heritage significance)
For the purposes of heritage management, the concept of heritage significance is critical. However, it is important to be clear that the significance of a heritage asset has no intrinsic bearing on its physical vulnerability to coastal processes. Nevertheless, information on significance will be very important in helping to raise awareness of the issues (e.g. where assets may be affected) and influence management responses (e.g. where to invest limited funds).

Physical vulnerability is solely driven by substrate conditions, likelihood of effects and the fabric of the asset. For example, a Grade I-listed Martello Tower or Scheduled prehistoric trackway is no more or less physically susceptible to change than their non-designated equivalents.

While non-designated assets are not being considered in detail in this study, it is critical to ensure that the method is robust and can be applied without prejudice to available datasets at the regional and local level. This should not necessarily require stakeholders/HE to go through the potentially lengthy process of understanding the likely significance of assets. In any case, it is useful to be able to understand the likely risk to non-designated assets, potentially as a means to drive action to record and understand their significance.

Heritage significance of the assets therefore provides a means by which to understand the:

- Consequences of loss of or damage to assets;
- Policy responses required to mitigate harm; and
- Prioritisation of action necessary to either safeguard or record assets likely to be lost.

Deriving information on importance/heritage significance

Relying as it does on designated asset data, for this study deriving importance/heritage significance scores is relatively straightforward – albeit necessarily crude and with some caveats.

All Scheduled Monuments are inherently 'nationally important'; this being the principal criterion for designation. Similarly, World Heritage Sites are inherently of international importance, having been identified as having 'outstanding universal value' to humanity in terms of their cultural significance[16]. The study does not, however, advocate including a specific score for international significance, as a number of other designated assets could also meet this standard but there is no way to extract this information from available data as it stands. Only Core Areas from the World Heritage Sites dataset have been included in this assessment, not the buffers zones (where inscribed) around them. These areas are intended to aid conservation of assets' settings, but do not represent a physical asset.

The situation for Listed Buildings is slightly more complex as, in legislative terms, all such assets are afforded equal levels of protection. Grading is purely advisory, but nevertheless provides a convenient shorthand in making judgements on significance. A similar situation exists for Registered Parks and Gardens, although they are not afforded statutory protection[17]. All such assets are considered to be of high (national) importance, with Grade I and II* considered to be of the highest importance – in line with the approach set out in the National Planning Policy Framework (NPPF).

Registered Battlefields, although non-statutory, have strict selection criteria that – broadly – equate to national significance. (The key criteria are: securely-established spatial location; and, level of historical significance – often defined by its political impact[18].)

Scoring importance/heritage significance

A three point scale has again been used to score heritage significance to aid in prioritisation. The justification for each score is provided in **Table 56**.

[16] Here, it is necessary to exercise caution with regards to natural heritage-related WHSs. For example, the Dorset and East Devon Coast WHS which appears in the NHLE dataset, but is designated for its geological and palaeontological importance rather than cultural heritage.

[17] The Register, which Historic England is empowered to compile in Schedule 4 of the National Heritage Act 1983, was created by statute but no legal protection as such is conferred.

[18] https://content.historicengland.org.uk/images-books/publications/dsg-battlefields/heag072-battlefields-rsg.pdf/

Table 56: Asset significance ratings

Designation	Rating	Score	Notes
World Heritage Site	High	3	Of proven international importance, and of the 'highest significance' for the purposes of NPPF
Scheduled Monument	High	3	Inherently nationally important, and of the 'highest significance' for the purposes of NPPF
Listed Building			
Grade I and II*	High	3	Assets 'of the highest significance' for the purposes of NPPF
Grade II	Medium	2	Assets of sufficiently high levels of special architectural or historical importance to be worthy of national designation, and in receipt of statutory protection
Registered Park and Garden			
Grade I and II*	High	3	Assets 'of the highest significance' for the purposes of NPPF
Grade II	Medium	2	Assets of sufficiently high levels of special architectural or historical importance to be worthy of national designation, and in receipt of statutory protection
Registered Battlefield	High	3	Battlefields are selected based on whether their location can be delineated 'beyond reasonable doubt', and their significance in the context of the history of England. These are all nationally important (and, in some cases, internationally important) events, and are considered of the 'highest significance' for the purposes of NPPF

It is important to note that a rating of '1', the lowest score, is not attached to any of the designated assets; this is to ensure that an appropriate rating is available for assets of local/regional importance, or for non-designated sites where significance has not been determined. This will allow subsequent application of the approach to HER data. It is recognised that HERs contain many non-designated sites which have been assessed as of national importance and consideration of the treatment of these sites in future work will be required. It is anticipated that within HER data, the full range of scores will be applicable (i.e. they will not all receive a score of 1). Indeed, many HERs maintain a list of archaeological assets that are considered to be of demonstrably equivalent significance to scheduled monuments (to be treated as such for the purposes of planning, in line with NPPF paragraph 194, footnote 63).

Heritage significance therefore acts as a multiplier – moderated or further amplified by the physical vulnerability of the asset to coastal processes.
It is considered important to keep this element of the process separate from understanding physical vulnerability, so that element of the GIS analysis can be applied to a range of asset data.

Sensitivity to Change (physical vulnerability)
Separate scores have been developed for sensitivity to change for the different coastal risks; namely:

- Coastal flooding (current);
- Coastal erosion (short, medium, long term excluding complex cliffs and long term including complex cliffs); and
- Sea level rise (short, medium and long term).

The process for reconciling the coastal vulnerability and heritage asset sensitivity indices is illustrated in the boxes below.

This approach provides the ability to understand the extent to which assets are physically vulnerable to the effects of coastal erosion and/or inundation as a result of their spatial location and construction materials.

Coastal flooding Sensitivity
The algorithm used to establish heritage vulnerability to coastal flooding inundation is illustrated below:

Coastal Flooding Sensitivity score **(0 to 9)**	=	Heritage Assets Sensitivity Materials Type vulnerability rating (1, 2 or 3)	x	Coastal Flooding vulnerability risk rating (spatial analysis) (0, 1, 2 or 3)

The resultant scores will be zero where the Coastal Flooding vulnerability risk rating is zero – in other words, the asset is not within the areas vulnerable to coastal flooding. For assets within the areas vulnerable to coastal flooding, asset scores can range from 1 to 9.

The results of applying this algorithm to the NHLE data are illustrated in **Figure 22** for Listed Buildings and **Figure 23** for all other designated heritage assets.

Coastal erosion Sensitivity
The algorithm used to establish heritage vulnerability to coastal erosion is much simpler as vulnerability is based entirely on the characteristics of the substrate, not the asset:

Coastal Erosion sensitivity score	=	Coastal erosion vulnerability risk rating (spatial analysis) (0 or 3)

(0 to 3)		

The resultant scores will be zero where the costal erosion risk rating is zero – in other words, the asset is not within the areas vulnerable to coastal erosion. For assets within the areas vulnerable to coastal erosion, asset scores will be 3.

The results of applying this algorithm to the NHLE data for the medium term scenario are illustrated in **Figure 24** for Listed Buildings and **Figure 25** for all other heritage assets.

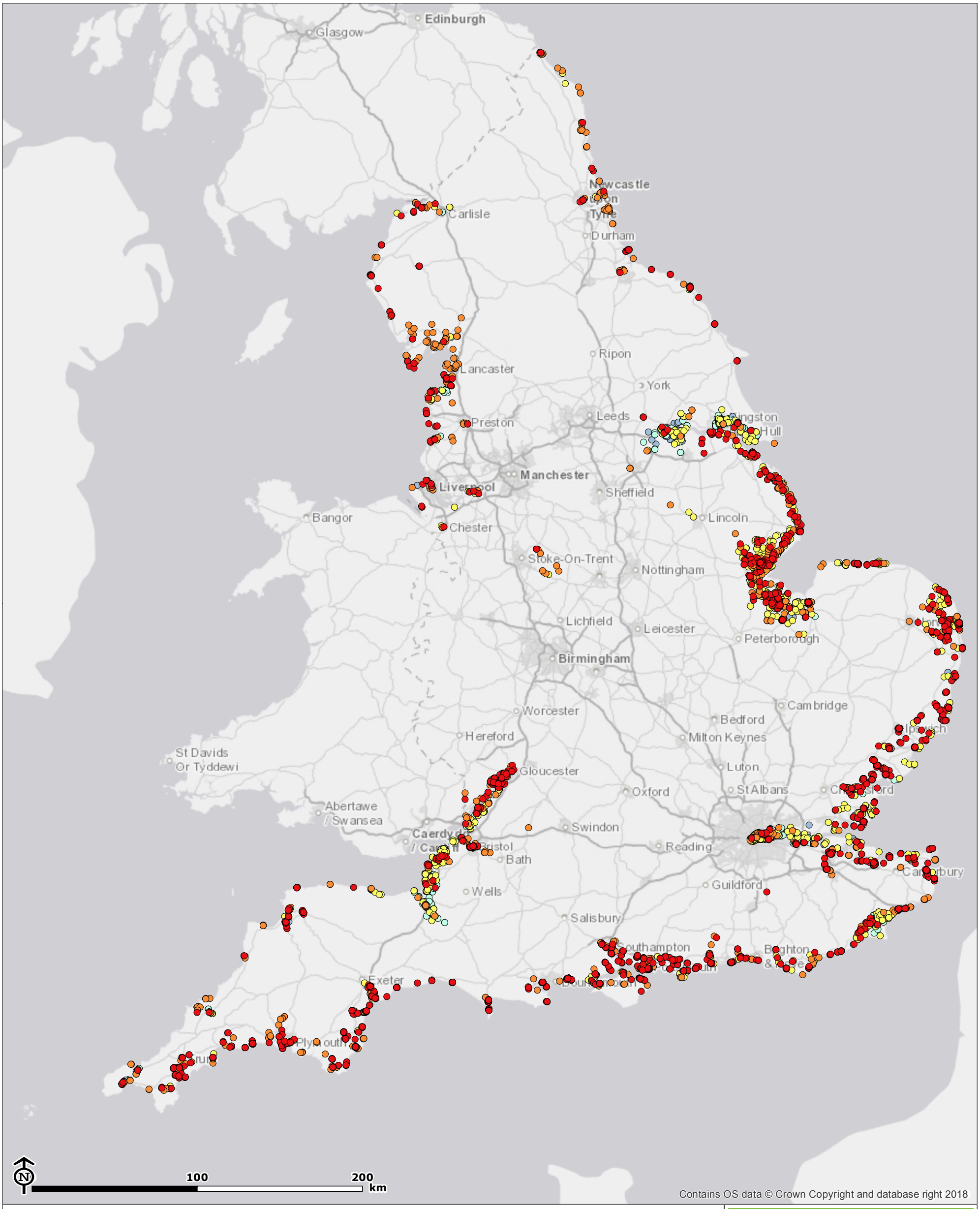
Sea level rise sensitivity

The algorithm used to establish heritage vulnerability to inundation as a result of sea level rise is illustrated below:

Sea level rise sensitivity score **(0 to 9)**	=	Heritage Assets Sensitivity Materials Type vulnerability rating (1, 2 or 3)	**x**	Sea level rise vulnerability risk rating (spatial analysis) (0 or 3)

The resultant scores will be zero where the sea level rise vulnerability risk rating is zero – in other words, the asset is not within the areas vulnerable to sea level rise. For assets within the areas vulnerable to sea level rise, asset scores can range from 3 to 9.

The results of applying this algorithm to the NHLE data (for the medium term) are illustrated in **Figure 26** for Listed Buildings and **Figure 27** for all other heritage assets.



Coastal Flooding sensitivity score

(Heritage asset sensitivity x coastal vulnerability)

- 1 (934)
- 2 (1,631)
- 3 (2,773)
- 6 (1,654)
- 9 (2,055)

Source: Environment Agency, Historic England

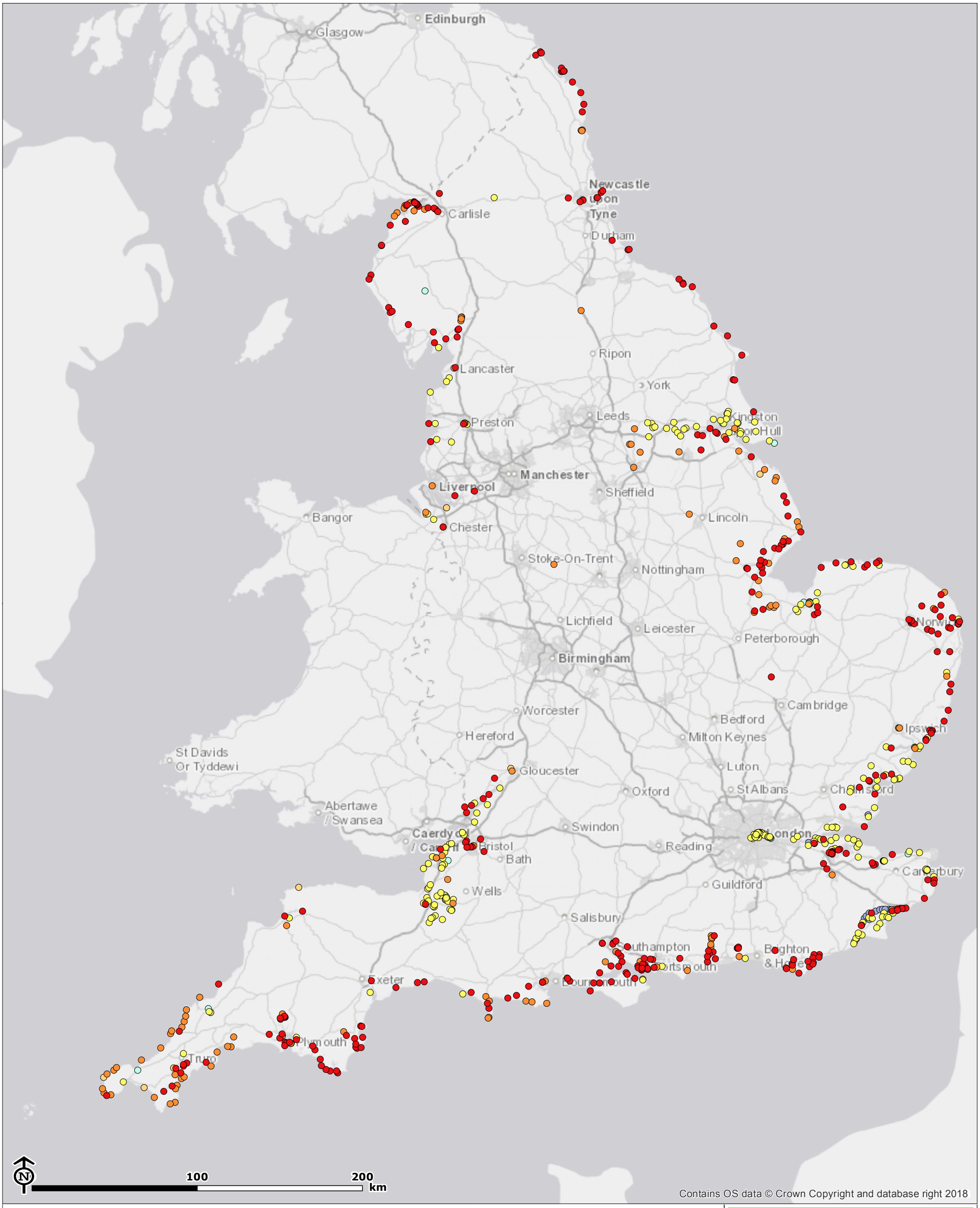
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 22: Listed Building coastal flooding sensitivity score

LUC Historic England

CB:DM EB:Manson D LUC FIG22_10193_v2_CF_LB_Sensitivity_A3P 26/06/2019



Coastal Flooding sensitivity score

(Heritage asset sesitivity x Coastal vulnerability)

- 1 (14)
- 2 (24)
- 3 (260)
- 4 (8)
- 6 (129)
- 9 (326)

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

Source: Environment Agency, Historic England

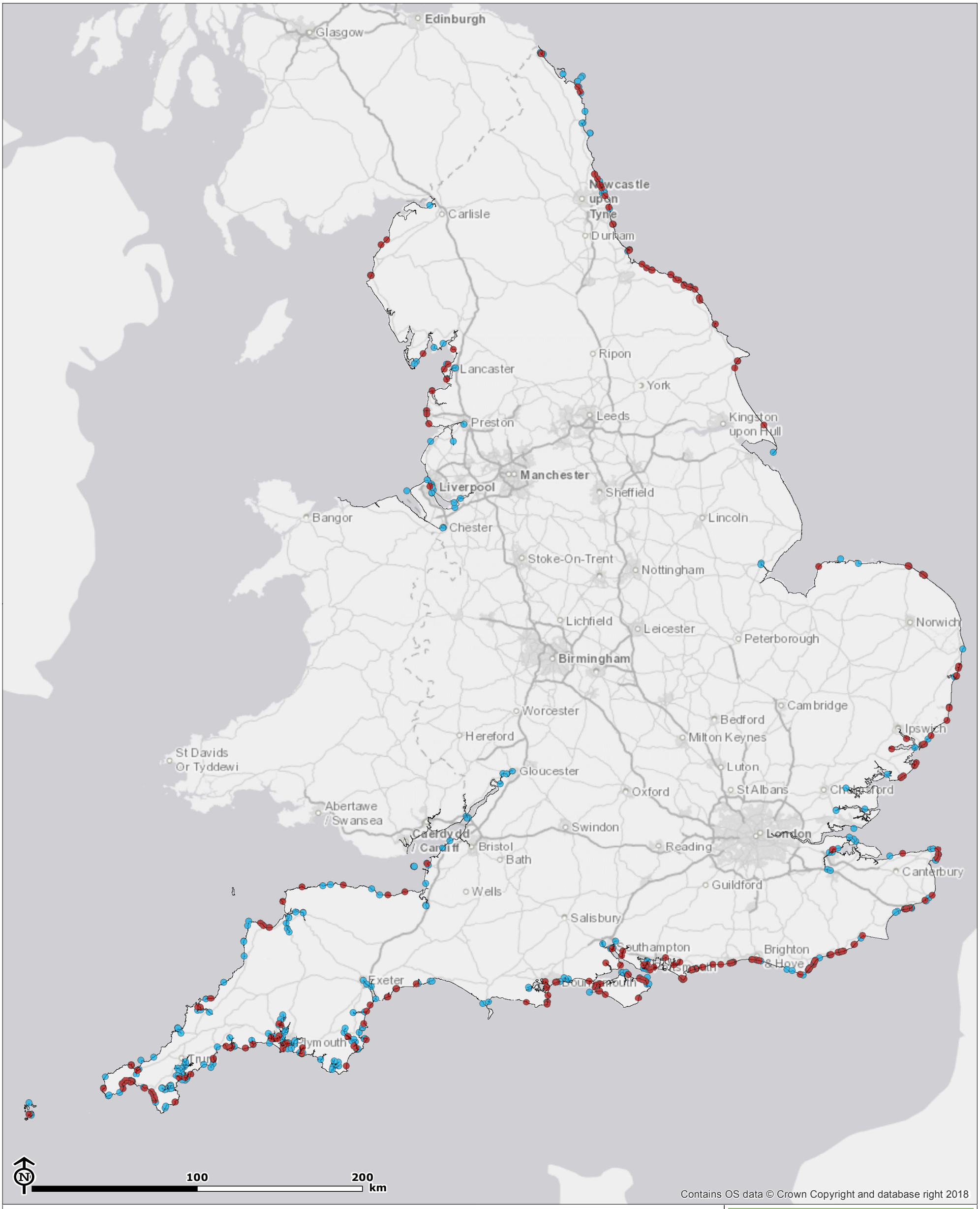
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 23: Other heritage assets coastal flooding sensitivity score

LUC Historic England

CB:DM EB:Manson D LUC FIG23_10193_v3_CF_Assets_Sensitivity_A3P 26/06/2019



National Coastal Erosion Risk Mapping (NCERM) baseline

Medium term coastal erosion sensitivity (= Coastal erosion vulnerability risk rating)
All have a score of 3

- Landward of NCERM Baseline and within medium term coastal erosion zone* (740)
- Seaward of NCERM baseline (457)

* No Active Intervention 5th percentile scenario

Source: Environment Agency, Historic England

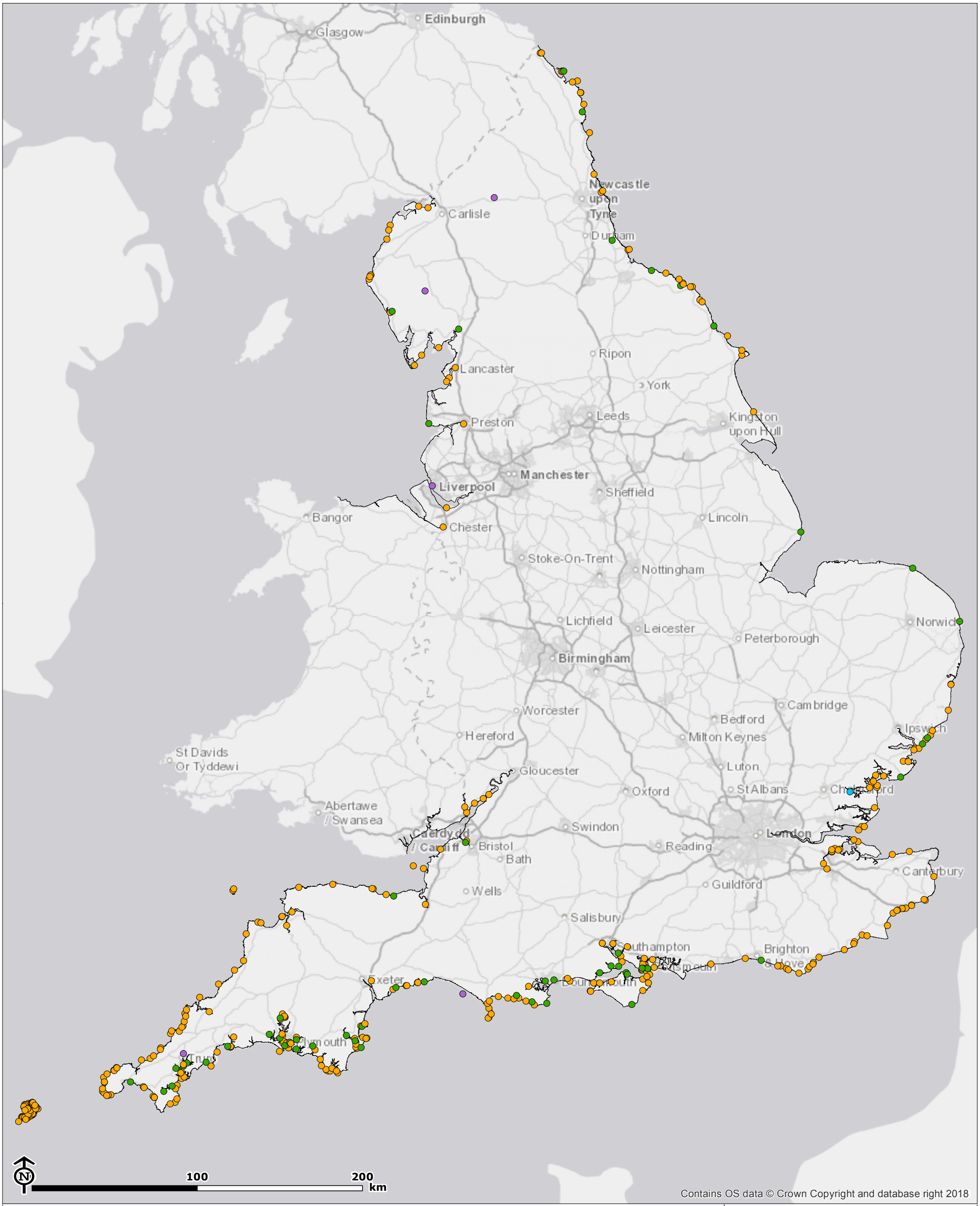
Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 24: Listed Building coastal erosion sensitivity (medium term)

LUC Historic England

CB:DM EB:Manson D LUC FIG24_10193_v2_CE_LB_Sensitivity_A3P 19/06/2019



National Coastal Erosion Risk Mapping (NCERM) baseline

Medium term coastal erosion sensitivity (= Coastal erosion vulnerability risk rating)
All have a score of 3

- Battlefield (1)
- Parks and Garden (55)
- Scheduling (374)
- World Heritage Site Core Area (5)

* No Active Intervention 5th percentile scenario

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

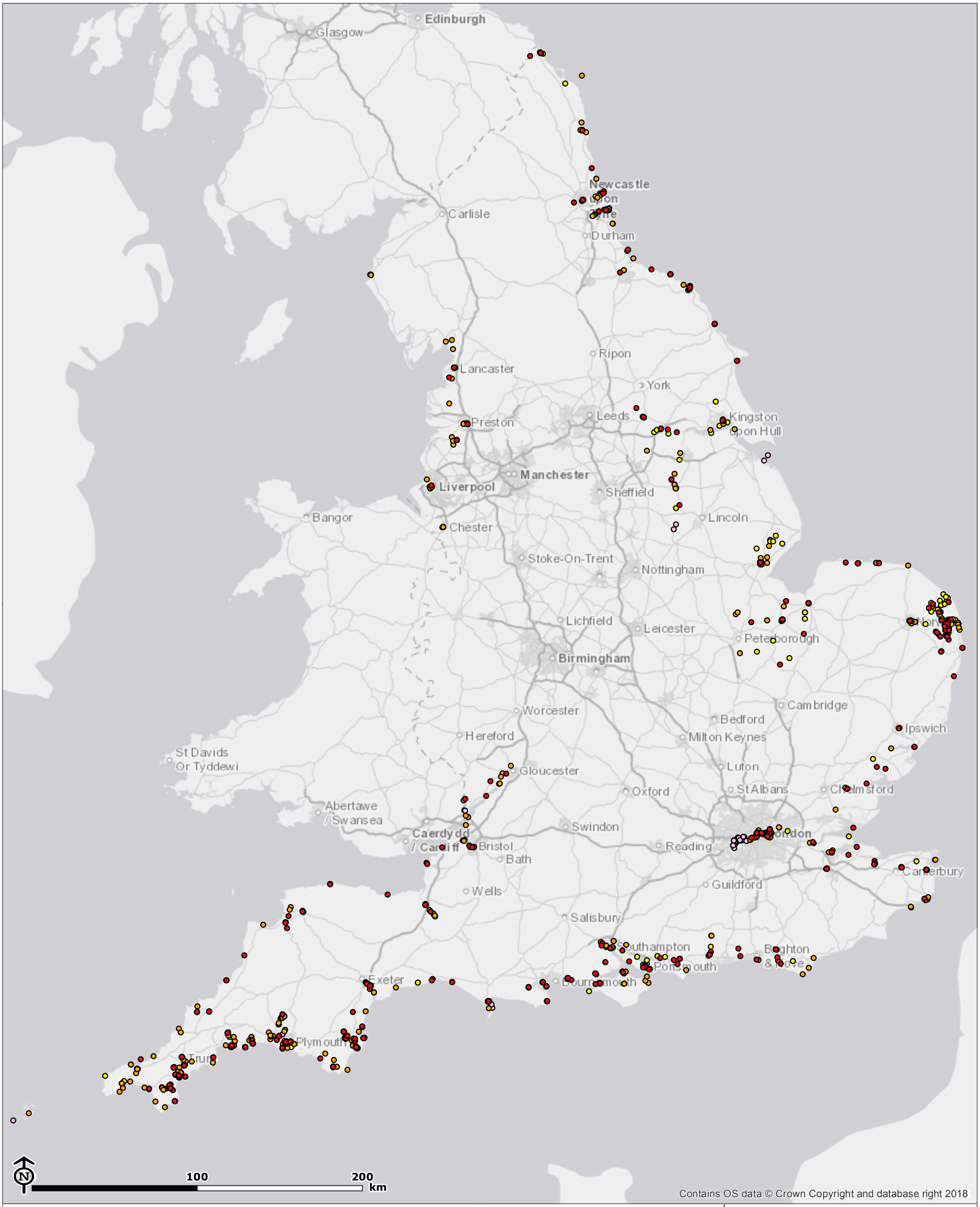
Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 25: Other heritage asset coastal erosion sensitivity (medium term)

LUC Historic England



Sea level rise sensitivity score (medium term)

(Heritage asset sensitivity x coastal vulnerability)

- 3 (259)
- 6 (651)
- 9 (465)
- No NHLE data* (51)

*Outside of NHLE search area for this study

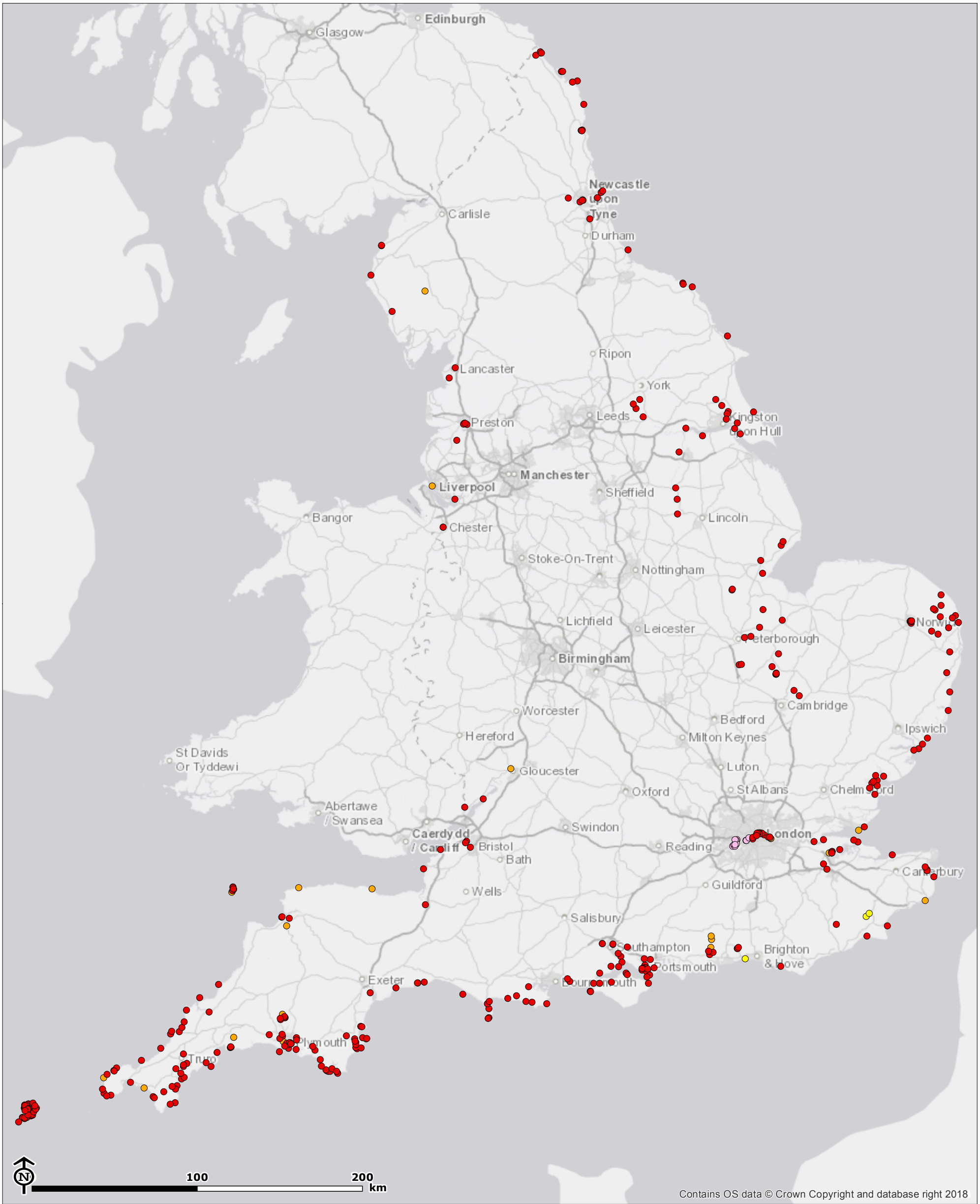
Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 26: Listed Building sea level rise sensitivity score

LUC Historic England



Sea level rise sensitivity score (medium term)

(Heritage asset sensitivity x coastal vulnerability)

- 3
- 6
- 9
- No NHLE data

Note: Assets have been assessed using their full footprint area, but illustrated on this map as points for clarity.

*Outside of NHLE search area for this study

Source: Environment Agency, Historic England

Map Scale @A3: 1:2,250,000

Coastal Risk and Priority Places

Figure 27: Other heritage assets sea level rise sensitivity score

LUC Historic England

CB:DM EB:Manson D LUC FIG27_10193_v3_SLR_Asset_Sensitivity_A3P 26/06/2019

Magnitude of change
It is possible to crudely evaluate the likely magnitude of change based on area lost to coastal processes. Whilst recognising that assets at risk will need to be evaluated more closely, it is useful to organise the outputs in terms of the likely proportion of the total asset footprint lost to coastal processes. This study has used a simple four point scale assessment based on GIS analysis – as shown in **Table 57.**

It is, however, important to note that any potential loss/harm to designated assets is a serious issue and this is intended as a way of ranking the severity of effects.

Table 57: Magnitude of change assessment

Area 'lost' to coastal processes	Multiplier/score
0%	0
>0 - 25%	1
25.1 - 50%	2
50.1 - 75%	3
75.1 - 100%	4

This is a crude measure of the scale/magnitude of effect, however it does help to highlight where assets are potentially at risk of total or very substantial loss. Significant caveats need to be applied to the use of this measure:

- Listed Building data is not available as accurate asset extent polygons. It has therefore been assumed that if a Listed Building point is within a coastal risk zone, it will suffer complete loss (Score of 4). This inevitably creates a margin for error, particularly for more extensive listed structures.
- For larger area-based designation data, not all areas within the designated area will make an equal contribution to the overall significance of the asset; therefore the precise extent of harm to the significance of the asset cannot be assumed based on the calculation. For the purposes of the assessment, loss of designated area will be adopted as the best available proxy – in that this would be an important consideration and indicator of harm for any other type of change.
- For coastal flooding, areas that benefit from flood defences have reduced risk. For the calculation of proportion of assets affected, only the area that is undefended has been used in the calculation. Where the entire asset is in the defended area, the Magnitude of Change multiplier has been set to '1' so as not to nullify the calculation (if it were set to '0').
- For sea level rise scenarios, the same limitations with regards to the accuracy of the spatial extent of the sea level rise mapping as set out in earlier sections apply.

Additional risk factors
In addition to the vulnerability of coastal change, it is possible to use the Heritage at Risk Register (HAR) to highlight those assets that are already considered to be at risk for other reasons. The scores for these assets are multiplied by 2. The HAR doesn't necessarily recognise all assets at risk, but presence on the register is recognition of those assets' vulnerability.

Whilst it can be argued that more information on the source of the risk is required to make this multiplier less 'blunt', the benefit in holding this information in GIS is that it can be 'unpicked' when looking at specific assets.

Understanding the overall level of effect
As set out at the beginning of this chapter, the approach used in this study borrows the principles used in EIA; considering the following factors:

- **Importance** (i.e. heritage significance) of a receptor – in this case a heritage asset;
- **Sensitivity to change** of the receptor (i.e. heritage vulnerability – combination of coastal vulnerability and inherent asset sensitivity);and
- **Magnitude of predicted change** (proportion of asset affected – in this case by erosion / inundation).

In addition, in order to incorporate additional known risk factors, the overall Level of Effect is multiplied by 2 where assets are on the Heritage at Risk Register – as set out in the algorithm below.

Importance (Heritage significance)	**X**	**Sensitivity to change** (Heritage asset sensitivity X coastal vulnerability)	**X**	**Magnitude of change** (Proportion of asset affected)	**=**	**Level of effect** (Accumulated score)
						X Heritage at Risk multiplier

The resultant range of scores possible is set out in **Table 58** with examples of how the highest scores can be reached.

Table 58: Range of possible scores for overall level of effect

Coastal Risk	Importance scores	Sensitivity to change scores	Magnitude of change scores	Level of effect scores	Heritage at Risk Multiplier
Coastal Flooding					
Score range	2 or 3	0 to 9	1-4	0 to 108	2
Max possible score	3 (e.g. Grade I Listed Building)	9 (e.g. Material Type sensitivity high, located in Flood Zone 3)	4 (e.g. entire area is within Flood Zone 3)	108	216 (Asset is on Heritage at Risk Register)
Coastal Erosion					
Score range	2 or 3	0 or 3	1-4	36	2
Max possible score	3 (e.g. Grade I Listed Building)	3 (e.g. Located in area vulnerable to erosion)	4 (e.g. entire area is within Flood Zone 3)	36	72 (Asset is on Heritage at Risk Register)
Sea Level Rise					
Score range	2 or 3	0 to 9	1-4	0-108	2
Max possible score	3 (e.g. Grade I Listed Building)	9 (e.g. Material Type sensitivity high, located in inundation zone)	4 (e.g. entire area is within inundation zone)	108	216 (Asset is on Heritage at Risk Register)

APPENDIX 2

Material type sensitivity ratings

TERM	Vulnerability
ABERDEEN GRANITE	Low
ALABASTER	Medium
ALUMINIUM	Low
ANODIZED ALUMINIUM	Low
ARTIFICIAL SLATE	Low
ARTIFICIAL STONE	Medium
ARTIFICIAL TIMBER	Medium
ASBESTOS	Low
ASHLAR	Low
ASPHALT	Low
BAKELITE	Low
BAMBOO	High
BARGATE STONE	Medium
BASALT	Low
BATH STONE	Medium
BEER STONE	Medium
BEMBRIDGE LIMESTONE	Medium
BITUMEN	Low
BITUMINOUS FELT	Medium
BLUE LIAS	Medium
BONE	High
BRASS	Low
BRECCIA	Medium
BREEZE BLOCK	Low
BRICK	Low
BRICKEARTH	High
BRONZE	Medium
BUNGAROOSH	Medium
CAEN STONE	Medium
CAMPAN MARBLE	Medium
CANVAS	High
CARBONIFEROUS LIMESTONE	Medium
CARRARA MARBLE	Medium
CARSTONE	Medium
CAST IRON	Medium
CEDAR	Medium
CEMENT	Medium
CEMENT MIX	Medium
CERAMIC	Medium
CHALK	Medium
CHERT	Low
CLAY	High
CLAY LUMP	High

TERM	Vulnerability
CLINKER	Medium
CLUNCH	Medium
COADE STONE	Medium
COB	High
COBBLE	Low
COMBED WHEAT REED	High
CONCRETE	Low
CONGLOMERATE	Medium
CONNEMARA MARBLE	Medium
COPPER	Low
CORK	High
COTSWOLD STONE	Medium
CRETACEOUS LIMESTONE	Medium
DAUB	High
DECORATIVE PLASTER	High
DECORATIVE PLASTER	High
DEVONIAN LIMESTONE	Medium
DIORITE	Low
DOLERITE	Low
DOLOMITE	Medium
DOUBLE ROMAN TILE	Medium
EARTH	High
ELM	High
ELVAN	Medium
ENCAUSTIC TILE	Medium
ENGINEERING BRICK	Low
ETHYLTETRAFLUOROETHYLENE FOIL	Low
FAIENCE	Medium
FELDSPAR	Low
FELT	High
FIBREBOARD	High
FIBREGLASS	Low
FIRESTONE	Medium
FLINT	Low
FLUORITE	Medium
FOREST STONE (LEICESTERSHIRE)	Medium
FOSSIL	Medium
FREESTONE	Medium
GALVANIZED IRON	Low
GALVANIZED STEEL	Low
GLASS	Low
GNEISS	Low
GOLD	Low
GORSE	High
GRANITE	Low
GRASS	High
GRAVEL	Medium
GREENSTONE	Medium

TERM	Vulnerability
GRITSTONE (LIMESTONE)	Medium
GRITSTONE (SANDSTONE)	Medium
HAM HILL STONE	Medium
HEATHER	High
HERTFORDSHIRE PUDDINGSTONE	Medium
HIGH TENSILE STEEL	Medium
HORNBLENDE	Medium
HORNTON STONE	Medium
HORSHAM STONE	Medium
IONA MARBLE	Medium
IRON	Medium
IRONSTONE	Medium
JURASSIC LIMESTONE	Medium
KEINTON STONE	Medium
KENTISH RAGSTONE	Medium
KILLAS	Low
LAKE DISTRICT SLATE	Low
LATH	High
LEAD	Medium
LEATHER	High
LIAS	Medium
LIGHTWEIGHT CONCRETE	Low
LIME	High
LIMESTONE	Medium
LINCOLNSHIRE LIMESTONE	Medium
LONG STRAW	High
MAGNESIAN LIMESTONE	Medium
MAJOLICA	Medium
MALMSTONE	Medium
MARBLE	Medium
MARL	Low
MARLSTONE	Medium
MATHEMATICAL TILE	Low
MOORSTONE	Low
MORTAR	High
MOUNTSORREL GRANITE	Low
MUD	High
OAK	Medium
OOLITIC LIMESTONE	Medium
PAINTED PLASTER	High
PANEL BOARD	High
PANTILE	Low
PAPER	High
PARGETING	High
PARGETING	High
PEAT	High
PEBBLE	Low
PEBBLEDASH	Medium

TERM	Vulnerability
PENNANT STONE	Low
PETERHEAD GRANITE	Low
PINE	Medium
PISE	High
PLANT	High
PLASTER	High
PLASTIC	Low
PLYMETAL	Medium
PLYWOOD	Medium
POLYCARBONATE	Low
POLYPHANT	Medium
POLYVINYL CHLORIDE	Low
PORPHYRY	Low
PORTLAND CEMENT	Medium
PORTLAND STONE	Medium
PRESTRESSED CONCRETE	Low
PUDDINGSTONE	Medium
PULHAMITE STONE	Medium
PURBECK STONE	Medium
QUARTZ	Low
QUARTZITE	Low
RAGSTONE	Medium
REED	High
REIGATE STONE	Medium
REINFORCED CONCRETE	Low
RENDER	High
RESIDUE	High
RHYOLITE	Low
ROMAN CEMENT	Medium
ROMAN TILE	Medium
ROUGHCAST	Medium
RUBBER	Low
RUBBLE	Medium
SAND	High
SANDSTONE	Medium
SARSEN STONE	Low
SCAGLIOLA	Low
SCHIST	Low
SCOTTISH SLATE	Low
SEAWEED	High
SEPTARIA	Low
SERPENTINE	Low
SHALE	Medium
SHAP GRANITE	Low
SHEET LEAD	Medium
SHELL	Low
SHINGLE	High
SHINGLE	High

TERM	Vulnerability
SILTSTONE	Low
SILVER	Low
SKYE MARBLE	Medium
SLAG	Medium
SLATE	Low
SLURRY	High
SOLAR CONTROL GLASS	Low
SPANISH TILE	Medium
STEEL	Medium
STRAW	High
STUCCO	High
SUSSEX STONE	Medium
SYENITE	Low
TAR	Low
TARMACADAM	Medium
TERRACOTTA	Medium
TERTIARY LIMESTONE	Medium
TESSERA	Medium
THATCH	High
TILE	Medium
TIMBER	High
TIN	High
TRIPLE ROMAN TILE	Medium
TUFACEOUS LIMESTONE	Medium
TUFF	Medium
TURF	High
WATTLE	High
WEALDEN STONE	Medium
WEATHERBOARD	High
WEATHERING STEEL	Low?
WELSH SLATE	Low
WEST COUNTRY SLATE	Low
WHINSTONE	Low
WICHERT	High
WOOD	High
WOODWOOL SLAB	High
WROUGHT IRON	Medium
YORK STONE	Medium
ZINC	Low
ACRYLIC GLASS	Unknown*
ARDINGLY SANDSTONE	Unknown*
ASHDOWN SANDSTONE	Unknown*
BILLINGSHURST SANDSTONE	Unknown*
BOGNOR STONE	Unknown*
CEMENTSTONE	Unknown*
Clipsham Stone	Unknown*
CUCKFIELD SANDSTONE	Unknown*
DODDINGTON SANDSTONE	Unknown*

TERM	Vulnerability
EARTH MIX	High**
FERRICRETE	Unknown*
GLASS REINFORCED PLASTIC	Unknown*
HYTHE SANDSTONE	Unknown*
LAVANT STONE	Unknown*
LODSWORTH SANDSTONE	Unknown*
MAN MADE MATERIAL	Medium**
METAL	Medium**
MIDHURST SANDSTONE	Unknown*
MIXON STONE	Unknown*
PUDDING STONE	Medium***
PULBOROUGH SANDSTONE	Unknown*
STONE	Medium**
TEXTILE	High**
TUNBRIDGE WELLS SANDSTONE	Unknown

*Not in thesaurus
** Top term
*** Misuse of thesaurus term (spelling)

APPENDIX 3

GIS attributes

Table 59: HE_Assets_merged_2019: GIS Attributes

Field	Relating to	Description
OBJECTID	GIS	Autogenerated unique ID
Shape	GIS	Autogenerated GIS field
ListEntry	Asset details	NHLE List entry number
Name	Asset details	Name of asset
SchedDate	Asset details	Date of scheduling
AmendDate	Asset details	Amendment date
LegacyUID	Asset details	Legacy ID
NGR	Asset details	National Grid Reference
CaptureSca	Asset details	Scale of data capture
Easting	Asset details	Easting
Northing	Asset details	Northing
AREA_HA	Asset details	Area in hectares
Category	Asset details	Type of asset (World Heritage Site Cores Area/Scheduling/Park and Garden etc)
Grade	Asset details	Grade where relevant
Monument_Type	Asset details	Monument Type from FISH Thesaurus of Monument Types
Material_Type	Asset details	Material Type from FISH Thesaurus of Materials Types
MatRiskScore	Asset details	Material Type Risk Score (1, 2 or 3)
HAR	Heritage at Risk	Is the asset on the Heritage at Risk Register (Yes/No)
Perc_STNAI5	Coastal erosion (short term)	Percentage of area in Short Term No Active Intervention 5th Percentile projected erosion zone
Perc_MTNAI5	Coastal erosion (medium term)	Percentage of area in Medium Term No Active Intervention 5th Percentile projected erosion zone
Perc_LTNAI5	Coastal erosion (long term)	Percentage of area in Long Term No Active Intervention 5th Percentile projected erosion zone
Perc_LTNAI5CC	Coastal erosion (long term plus complex cliffs)	Percentage of area in Long Term No Active Intervention 5th Percentile projected erosion zone plus projected erosion zone for complex cliffs

Field	Relating to	Description
HerSignif	Coastal erosion	Heritage Significance (Grade)
STNAI5Vuln	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile vulnerability (0 or 3)
MTNAI5Vuln	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile vulnerability (0 or 3)
LTNAI5Vuln	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile vulnerability (0 or 3)
LTNAI5CCVuln	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs vulnerability (0 or 3)
STNAI5Magn	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
MTNAI5Magn	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
LTNAI5Magn	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
LTNAI5CCMagn	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs magnitude of change (1 to 4 based on percentage affected)
HAR_1	Coastal erosion	Heritage at Risk
STNAI5Total	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile overall effect score
MTNAI5Total	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile overall effect score
LTNAI5Total	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile overall effect score
LTNAI5CCTotal	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs overall effect score

Field	Relating to	Description
Shape_Length_1	GIS	Autogenerated
Shape_Area_1	GIS	Autogenerated
FZ2	Coastal flooding (current)	Is the asset in Flood Zone 2
FZ3	Coastal flooding (current)	Is the asset in Flood Zone 3
AOB	Coastal flooding (current)	Is the asset within an area benefitting from flood defences
FZ_Score	Coastal flooding (current)	What is the residual Flood score once areas benefitting from flood defences considered
Perc_UndefFZ	Coastal flooding (current)	What percent of the asset is not within an area benefitting from flood defences
UndefFZ_PercScore	Coastal flooding (current)	Undefended flood zone score (1-4 based on area categories)
HerSignif_1	Coastal flooding (current)	Heritage Significance (Grade)
MatSens	Coastal flooding (current)	Material Type Risk Score (1, 2 or 3)
CFVuln	Coastal flooding (current)	Coastal flooding vulnerability (FZ_Score)
CFMag	Coastal flooding (current)	Coastal flooding magnitude (UndefFZ_PercScore)
HAR_12	Coastal flooding (current)	Heritage at Risk
CFTotal	Coastal flooding (current)	Overall coastal flooding effect score
Shape_Length_12	GIS	Autogenerated
Shape_Area_12	GIS	Autogenerated
SLR_ST	Sea level rise (short term)	Is the asset in the short term sea level rise inundated area
SLR_MT	Sea level rise (medium term)	Is the asset in the medium term sea level rise inundated area
SLR_LT	Sea level rise (long term)	Is the asset in the longterm sea level rise inundated area
ST_Perc	Sea level rise (short term)	Percentage of the asset area in the short term sea level rise inundated area
MT_Pec	Sea level rise (medium term)	Percentage of the asset area in the medium term sea level rise inundated area
LT_Perc	Sea level rise (long term)	Percentage of the asset area in the long term sea level rise

Field	Relating to	Description
		inundated area
ST_PercScore	Sea level rise (short term)	Short term sea level rise percentage of inundation score
MT_PercScore	Sea level rise (medium term)	Medium term sea level rise percentage of inundation score
LT_PercScore	Sea level rise (long term)	Long term sea level rise percentage of inundation score
HerSignif_12	Sea level rise	Heritage Significance (Grade)
MatSens_1	Sea level rise	Material Type Risk Score (1, 2 or 3)
ST_SLRVuln	Sea level rise (short term)	Short term sea level rise vulnerability score
MT_SLRVuln	Sea level rise (medium term)	Medium term sea level rise vulnerability score
LT_SLRVuln	Sea level rise (long term)	Long term sea level rise vulnerability score
ST_SLRMagn	Sea level rise (short term)	Short term sea level rise magnitude of change score (ST_PercScore)
MT_SLRMagn	Sea level rise (medium term)	Medium term sea level rise magnitude of change score (MT_PercScore)
LT_SLRMagn	Sea level rise (long term)	Long term sea level rise magnitude of change score (LT_PercScore)
HAR_12_13	Sea level rise	Heritage at Risk
ST_SLRTotal	Sea level rise (short term)	Short term sea level rise overall level of effect score
MT_SLRTotal	Sea level rise (medium term)	Medium term sea level rise overall level of effect score
LT_SLRTotal	Sea level rise (long term)	Long term sea level rise overall level of effect score
Shape_Length_12_13	GIS	Autogenerated
Shape_Area_12_13	GIS	Autogenerated
Shape_Length	GIS	Autogenerated
Shape_Area	GIS	Autogenerated
NORisk	GIS	Used to filter out unaffected assets
Region	Location	Region within which centroid of site falls
CFSens	Coastal flooding (current)	Interim coastal flooding Sensitivity score (heritage asset sensitivity x coastal vulnerability)
SLR_STSens	Sea level rise (short	Interim short term sea level rise

Field	Relating to	Description
	term)	sensitivity score (heritage asset sensitivity x coastal vulnerability)
SLR_MTSens	Sea level rise (medium term)	Interim medium term sea level rise sensitivity score (heritage asset sensitivity x coastal vulnerability)
SLR_LTSens	Sea level rise (long term)	Interim long term sea level rise sensitivity score (heritage asset sensitivity x coastal vulnerability)

Table 60: HE_LB_merged_2019: GIS Attributes

Field	Relating to	Description
OBJECTID	GIS	Autogenerated unique ID
Shape	GIS	Autogenerated GIS field
ListEntry	Asset details	NHLE List entry number
Name	Asset details	Name of asset
Location	Asset details	Location
Grade	Asset details	Grade where relevant
ListDate	Asset details	Date of listing
AmendDate	Asset details	Amendment date
LegacyUID	Asset details	Legacy ID
NGR	Asset details	National Grid Reference
CaptureSca	Asset details	Scale of data capture
Easting	Asset details	Easting
Northing	Asset details	Northing
Category	Asset details	Type of asset (Listed Building)
Monument_Type	Asset details	Monument Type from FISH Thesaurus of Monument Types
Material_Type	Asset details	Material Type from FISH Thesaurus of Materials Types
MatRiskScore	Asset details	Material Type Risk Score (1, 2 or 3)
HAR	Heritage at Risk	Is the asset on the Heritage at Risk Register (Yes/No)
Beyond_NCERM	Coastal erosion	Asset is seaward of the NCERM baseline
STNAI5_PercScore	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)

Field	Relating to	Description
MTNAI5_PercScore	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
LTNAI5_PercScore	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
LTNAI5CC_PercScore	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs magnitude of change (1 to 4 based on percentage affected)
HerSignif	Coastal erosion	Heritage Significance (Grade)
STNAI5Vuln	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile vulnerability (0 or 3)
MTNAI5Vuln	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile vulnerability (0 or 3)
LTNAI5Vuln	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile vulnerability (0 or 3)
LTNAI5CCVuln	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs vulnerability (0 or 3)
STNAI5Magn	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
MTNAI5Magn	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
LTNAI5Magn	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile magnitude of change (1 to 4 based on percentage affected)
LTNAI5CCMagn	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs magnitude of change (1 to 4 based on percentage affected)
HAR_1	Coastal erosion	Heritage at Risk

Field	Relating to	Description
STNAI5Total	Coastal erosion (short term)	Short Term No Active Intervention 5th Percentile overall effect score
MTNAI5Total	Coastal erosion (medium term)	Medium Term No Active Intervention 5th Percentile overall effect score
LTNAI5Total	Coastal erosion (long term)	Long Term No Active Intervention 5th Percentile overall effect score
LTNAI5CCTotal	Coastal erosion (long term plus complex cliffs)	Long Term No Active Intervention 5th Percentile plus projected erosion zone for complex cliffs overall effect score
FZ2	Coastal Flooding (current)	Is the asset in Flood Zone 2
FZ3	Coastal Flooding (current)	Is the asset in Flood Zone 3
AOB	Coastal Flooding (current)	Is the asset within an area benefitting from flood defences
FZ_Score	Coastal Flooding (current)	What is the residual Flood score once areas benefitting from flood defences considered
Perc_Undef_FZ	Coastal Flooding (current)	What percent of the asset is not within an area benefitting from flood defences
FZ_PercScore	Coastal Flooding (current)	Undefended flood zone score (1-4 based on area categories)
HerSignif_1	Coastal Flooding (current)	Heritage Significance (Grade)
MatSens	Coastal Flooding (current)	Material Type Risk Score (1, 2 or 3)
CFVuln	Coastal Flooding (current)	Coastal flooding vulnerability (FZ_Score)
CFMag	Coastal Flooding (current)	Coastal flooding magnitude (UndefFZ_PercScore)
HAR_12	Coastal Flooding (current)	Heritage at Risk
CFTotal	Coastal Flooding (current)	Overall coastal flooding effect score
SLR_ST	Sea level rise (short term)	Is the asset in the short term sea level rise inundated area
SLR_MT	Sea level rise (medium term)	Is the asset in the medium term sea level rise inundated area
SLR_LT	Sea level rise (long term)	Is the asset in the longterm sea level rise inundated area

Field	Relating to	Description
ST_PercScore	Sea level rise (short term)	Short term sea level rise percentage of inundation score
MT_PercScore	Sea level rise (medium term)	Medium term sea level rise percentage of inundation score
LT_PercScore	Sea level rise (long term)	Long term sea level rise percentage of inundation score
HerSignif_12	Sea level rise	Heritage Significance (Grade)
MatSens_1	Sea level rise	Material Type Risk Score (1, 2 or 3)
ST_SLRVuln	Sea level rise (short term)	Short term sea level rise vulnerability score
MT_SLRVuln	Sea level rise (medium term)	Medium term sea level rise vulnerability score
LT_SLRVuln	Sea level rise (long term)	Long term sea level rise vulnerability score
ST_SLRMagn	Sea level rise (short term)	Short term sea level rise magnitude of change score (ST_PercScore)
MT_SLRMagn	Sea level rise (medium term)	Medium term sea level rise magnitude of change score (MT_PercScore)
LT_SLRMagn	Sea level rise (long term)	Long term sea level rise magnitude of change score (LT_PercScore)
HAR_12_13	Sea level rise	Heritage at Risk
ST_SLRTotal	Sea level rise (short term)	Short term sea level rise overall level of effect score
MT_SLRTotal	Sea level rise (medium term)	Medium term sea level rise overall level of effect score
LT_SLRTotal	Sea level rise (long term)	Long term sea level rise overall level of effect score
NoRisk	GIS	Used to filter out unaffected assets
Region	Location	Region within which centroid of site falls
CFSens	Coastal flooding (current)	Interim coastal flooding Sensitivity score (heritage asset sensitivity x coastal vulnerability)
SLR_STSens	Sea level rise (short term)	Interim short term sea level rise sensitivity score (heritage asset sensitivity x coastal vulnerability)
SLR_MTSens	Sea level rise (medium term)	Interim medium term sea level rise sensitivity score (heritage asset sensitivity x coastal vulnerability)

Field	Relating to	Description
SLR_LTSens	Sea level rise (long term)	Interim long term sea level rise sensitivity score (heritage asset sensitivity x coastal vulnerability)

APPENDIX 4

Follow up questionnaire

The following short set of questions has been agreed with Historic England to explore the impact of this study. The questionnaire (which will be disseminated by Historic England 12 months after project completion) will ask stakeholders (internal and external) the following questions:

- How they have used the products to further their own work or interests;
- Whether they've used them in a personal or professional capacity;
- Whether the products have been useful and helped them achieve their aims;
- Whether the products have influenced decisions they have made;
- Do the findings reflect your own perception of risk to heritage assets in your region; including the balance of the different risk factors that have been considered;
- Has it been a useful study in terms of informing the way that you approach the management of sites;
- Would it be beneficial to add in other elements of climate risk into the framework;
- Have the findings been useful in terms of raising the profile of heritage assets in discussions on the wider climate change agenda;
- Whether they consider it essential that the resource is updated regularly, and if so, along what timescales; and
- Whether they have any further data that could be incorporated into the outputs.

It is anticipated that the stakeholders will include:

- Historic England staff;
- Local Authorities;
- Protected Landscape Officers;
- Association of Local Government Archaeological Officers (ALGAO);
- Coastal Partnerships;
- Environment Agency;
- Natural England;
- Defra
- English Heritage
- Coastal land owners and managers such as the National Trust or MoD;
- Coastal and Intertidal Zone Archaeological Network (CITiZAN);
- Committee on Climate Change;
- Marine Management Organisation;
- Crown Estate;
- British Geological Society.

APPENDIX 5

Glossary

Term	Definition
Buffer	Zone around a map feature measured in units of distance or time. A buffer is useful for proximity analysis.
Complex Cliffs	Complex cliffs are landslides with failure at more than one level, which interact with the sea at their toe. The erosion of these areas is driven by ground instability, which itself is driven by high groundwater. The groundwater is commonly increased by high rainfall. The toe may be destabilised by coastal processes but the driving force is often the weather. These locations are highly susceptible to compounded climate change impacts (rainfall, sea level rise, coastal erosion).
Flood Zone 2	Land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year.
Flood Zone 3	Land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Fluvial flooding	River flooding
GIS	Geographic Information Systems
LiDAR	Airborne lidar (light detection and ranging) measures the height of the ground surface and other features in large areas of landscape with a very high resolution and accuracy.
NCERM	National Coastal Erosion Risk Map
OS Terrain 50	Ordnance Survey Terrain 50 data is a grid of heighted points with regular 50 metre post spacing that can be used to generate a digital terrain model (bare earth) with 50m resolution.

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