REPORT

Hoylake Beach Geomorphology and Ecology Study

Non-Technical Summary

Client: Wirral Borough Council

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Acronyms

BMP	Beach Management Plan
HAT	Highest Astronomical Tide
MHWS	Mean High Water Spring
NTS	Non-Technical Summary
NVC	National Vegetation Classification
OD	Ordnance Datum
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SWL	Sill Water Level

1 Introduction

1.1 Background

There are a wide range of views regarding the management of Hoylake Beach, which extends from the Dee Estuary (Red Rocks) in the southwest to the RNLI Lifeboat Station in the northeast (**Figure 1**). One set of views advocates the continued removal of vegetation. Other views support the development of the natural succession of habitats and features. Wirral Borough Council (Wirral Council) is looking to reach an agreement on a way forward for managing the beach at Hoylake by developing a new Beach Management Plan (BMP). The BMP will be developed through an inclusive engagement process with a wide range of stakeholders, and which will define the requirements for future management of the beach for coastal defence, amenity and nature conservation.

To support the development of the BMP, there is a need for a better understanding of coastal change (such as changes in the supply of sediment, currents and waves) and how habitats will develop (such as saltmarsh and sand dunes) at Hoylake Beach. This study therefore was commissioned by Wirral Council to investigate these aspects in order to provide an evidence base upon which the BMP can be developed.

1.2 Purpose of this Report

This document presents a Non-Technical Summary (NTS) of the 'Hoylake Beach Geomorphology and Ecology Study' report, providing an overview, in non-technical language, of the main findings of the study. It does not, and is not intended to, convey all the information relating to the study but rather summarises the main points and outcomes.

1.3 This Study

The study looks at how Hoylake Beach could change (in terms of beach levels and habitat development) over the next 50 years as a result of coastal processes (including sediment supply, currents and waves) and the effects of sea level rise, resulting from climate change.

Three future years, 2032, 2042 and 2072 (i.e. ten, 20 and 50-years' time), have been used as a basis for the study, which provide a short to medium term outlook upon which appropriate beach management options can be based. Future sea level rise for the future years was predicted using the UK Climate Projections (UKCP18) database under the medium CO_2 emissions (50% confidence level) scenario.

To understand the overall implications of future beach management, the following two shoreline management scenarios were examined to cover the range of potential options which the BMP would consider:

- Do Nothing: allow the beach to develop without intervention; and
- Do Everything: manage the beach by continually removing all vegetation.

Legend:

Study Area

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Wirral Borough Council	Hoylake Beach Geomorphological Review

Title:

Study Area

Figure: 1	Drawing No: PC2553-RHD-ZZ-XX-DR-Z-0014				
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To provide a robust evidence base upon which the BMP can be developed, the following tasks were undertaken:

- a review of coastal geomorphology[1] and ecology at Hoylake Beach;
- an analysis of how the beach levels at Hoylake have changed in the past;
- predictions of future changes in beach levels and ecology based on the future sea-level rise predictions;
- a Natural Capital Value assessment to understand the contribution of the selected shoreline management scenarios to ecosystem services[2];
- a review of present and future flood risk under the selected shoreline management scenarios; and
- potential opportunities and constraints of the selected shoreline management scenarios.

2 Coastal Geomorphology and Ecology at Hoylake Beach

2.1 Coastal Geomorphology

Hoylake Beach is located at the northwest corner of the Wirral Peninsula bounded by the Dee Estuary to the southwest, the Mersey Estuary to the northeast and Liverpool Bay and the Irish Sea to the northwest (see **Figure 1**). As the coast changes direction to the northeast along North Wirral (including Hoylake), it is characterised by sand beaches and large intertidal sand banks. One of the largest features at Hoylake is East Hoyle Bank, a sand bank which extends from the mouth of the Dee Estuary to Leasowe Lighthouse (Halcrow, 2010).

The prevailing wind direction across the eastern Irish Sea and northwest England coast is from the west to southwest (Pye and Blott, 2009; Brown *et al.*, 2013). The predicted spring and neap tide ranges are 8.27m and 4.29m, respectively (National Tidal and Sea Level Facility, 2021). Sediment transport at Hoylake Beach mainly occurs by waves, currents and wind.

Hoylake Beach has a shallow slope (1:400), which provides a large surface area for wind to dry intertidal sand and transport it landward (Jemmett and Smith, 2000), onto the upper beach (Halcrow, 2018). Anecdotal evidence suggests that the seawall was 6-10 feet (2-3m) above the beach surface in the 1940s but was 0.6m above the beach in some locations in 2016 (Jemmett and Smith, 2000, Halcrow, 2018). The increase in beach levels, associated seaward movement of the low water mark and extension of East Hoyle Bank is likely to reduce the importance of waves and tidal current sand transport relative to wind-blown sand transport.

2.2 Ecology of Hoylake Beach

Hoylake Beach is subject to the following, overlapping, national and international designations for nature conservation:

- North Wirral Foreshore Site of Special Scientific Interest (SSSI), designated for features such as non-breeding birds, intertidal sediments, and saltmarshes.
- Mersey Narrows and North Wirral Foreshore Special Protection Area (SPA) and Ramsar site, designated for non-breeding birds.

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[1] Coastal geomorphology is the study of the morphological development (the shape of the beach) and evolution of the coast as a result of winds, waves, currents, and sea-level changes.
[2] Ecosystem services can be defined as the direct and indirect contributions of ecosystems to human wellbeing, and have an impact on our survival and quality of life.

- Dee Estuary SSSI and Special Area of Conservation (SAC), designated for features including intertidal sediments, reefs, saltmarsh and sand dunes.

A National Vegetation Classification (NVC) survey was undertaken of Hoylake Beach in August 2021 to classify and map the habitats present within the survey area and to provide a conservation assessment of the vegetation communities present. A total of 103 plant species and one bryophyte specie were recorded in the survey area. Two vegetation communities were recorded:

- approximately 10ha of SM13 *Puccinellia maritima* saltmarsh community: a species-poor grassland dominated by the grass *Puccinellia. maritima* (Common Saltmarsh-grass), with associates such as *Tripolium pannonicum* (Sea Aster), annual *Salicornia* agg (annual Glasswort agg) and *Suaeda maritima* (Annual Sea-blite); and
- approximately 0.6ha of SM6 *Spartina anglica* saltmarsh community at the west end of the site dominated by Common Cordgrass *Spartina anglica*.

The NVC survey recorded whether the vegetation was dense or sparse as shown in **Figure 2**. This shows a tendency for denser vegetation landward, with sparser vegetation towards the sea. The average height of the seaward boundaries of the dense and sparse vegetation were approximately 4.5m Ordnance Datum (OD) and 4.3m OD, respectively, which is around the Mean High Water Spring (MHWS) tide mark of 4.46m OD.

Figure 2. Distribution of dense (black hashed lines) and sparse (red lines) vegetation (source; Ruffino, 2021)

From a conservation perspective, the vegetation communities on site are of high conservation value; SM13 *Puccinellia maritima* saltmarsh community is of importance for conservation at international level. This habitat is also the primary reason for selection of the Dee Estuary as an SAC. At national level, coastal saltmarsh as a habitat of principal importance in England. The NVC survey specifically identified the rare and/or notable plant species shown in **Table 1**.

Table 1 Rare and/or notable plant species

Species	Status
Catabrosa aquatica	Classified as vulnerable in England
Triglochin palustris	classified as Near Threatened in England
Crithmum maritimum	Locally Rare in VC58 Cheshire
Polygonum oxyspermum	Locally Rare in VC58 Cheshire

3 Historic Changes in the Morphology of Hoylake Beach

Historic morphological change (i.e. past changes in beach level) of Hoylake Beach was investigated using satellite (LiDAR) data captured in 2002, 2008, 2013, 2018 and 2021. To understand the rate of change in beach levels over these years, the change in beach levels within the dense vegetation, as mapped by the NVC survey was calculated. This area was chosen as the future evolution of Hoylake Beach will largely depend on the future beach levels (particularly the upper beach where the vegetation has developed) in relation to the position of future seawater levels.

The comparison of satellite data showed that the average increase in beach levels along the upper beach, where the current dense vegetation is located, has varied depending on the time series assessed. Shorter-term averages ranged from 13mm/year (0.08m increase) to 42mm/year. Longer-term average rates ranged from 18mm/year to 25mm/year (0.33m increase).

4 Future Evolution of Hoylake Beach

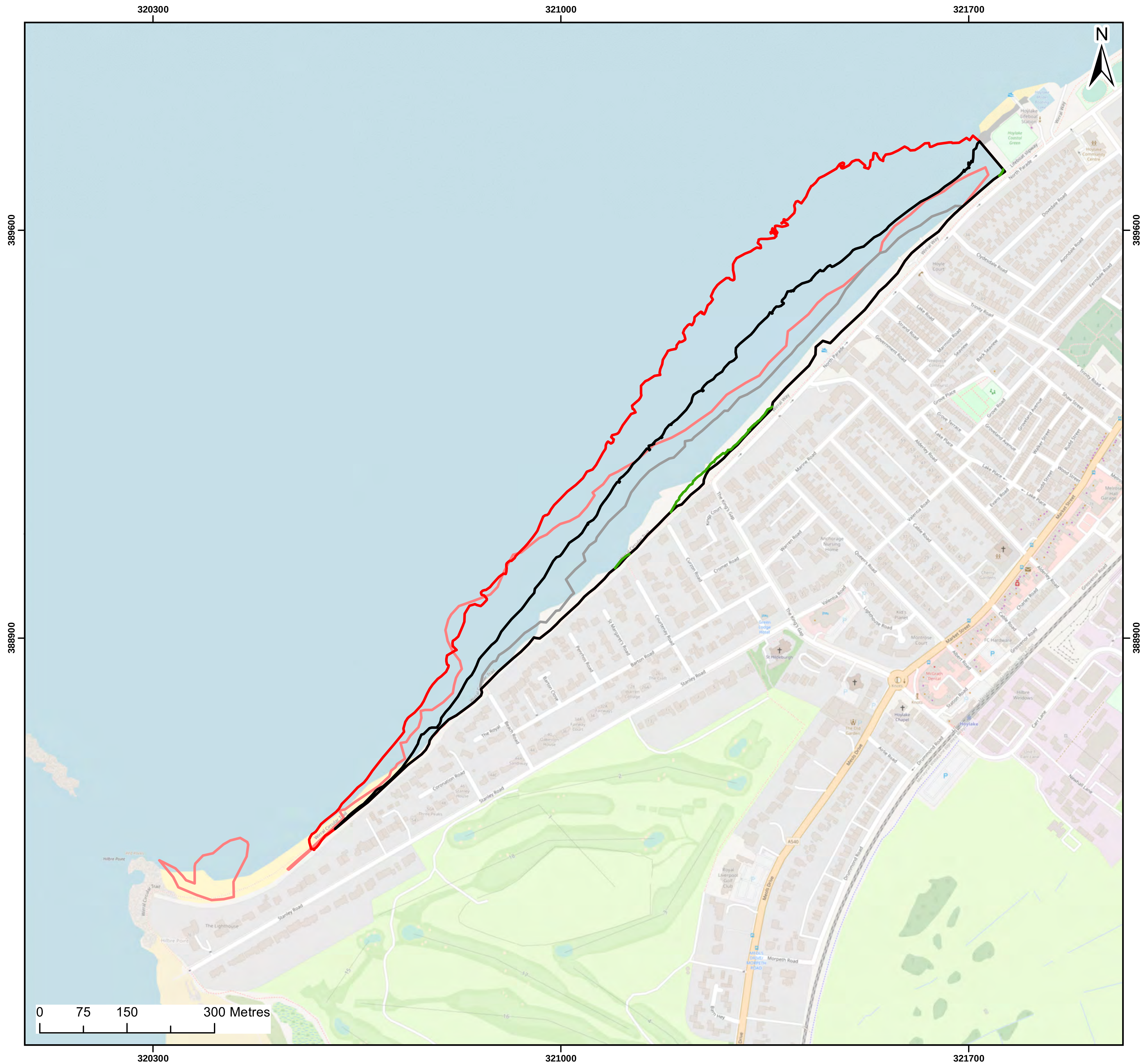
The future evolution of Hoylake Beach largely depends on how changes in beach level compare to the position of future seawater levels. This is because the presence of vegetation is directly linked to seawater level and the degree to which it is covered by the tide daily.

For the purposes of future prediction, the longest available datasets have been used to take account of any shorter-term differences. Taking into account sea level rise, beach levels at Hoylake have been predicted to increase, on average, by up to 0.87m over the next 50 years

4.1 Do Nothing Shoreline Management Scenario

Under the Do Nothing scenario Hoylake Beach would develop without any intervention, allowing for the natural growth and spread of the vegetation on the beach. The predicted increase in beach levels in the future years means that these boundaries would move seawards, as the beach rises. In addition, the location of the Highest Astronomical Tide (HAT) contour (5.4m OD) would also move seawards. The HAT contour is important as this is the maximum height that the tide reaches, so above this contour land would be created.

The future positions of the vegetation boundaries and HAT can be seen in **Figure 3**, **Figure 4** and **Figure 5** for years 2032, 2042 and 2072, respectively.



Legend:

- Predicted boundary of dense vegetation for the medium emissions 50th percentile sea-level rise scenario in 10 years' time (2032)
- Predicted boundary of less dense vegetation for the medium emissions 50th percentile sea-level rise scenario in 10 years' time (2032)
- Dense vegetation boundary mapped by the National Vegetation Survey (NVC) 2021 survey
- Less dense vegetation boundary mapped by the National Vegetation Survey (NVC) 2021 survey
- Predicted highest astronomical tide for the medium emissions 50th percentile sea-level rise scenario in 10 years' time (2032)

Client: Wirral Borough Council

Project: Hoylake Beach Geomorphology and Ecology Study

Title: Predicted positions of the dense and sparse vegetation, and HAT in 10 years (2032)

Figure: 3 | Drawing No: PC2553-RHD-ZZ-XX-DR-Z-0011

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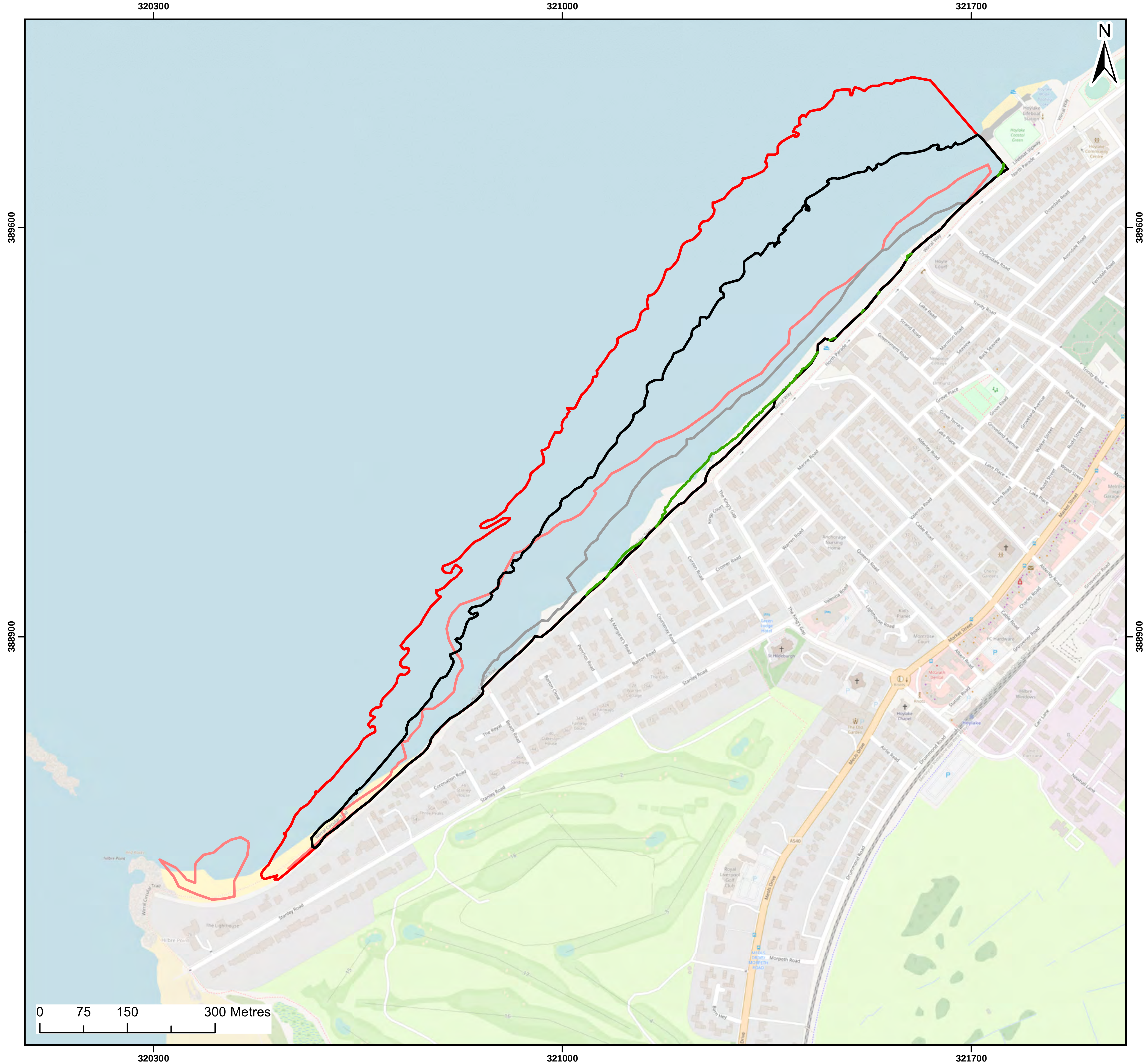

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- Predicted boundary of dense vegetation for the medium emissions 50th percentile sea-level rise scenario in 20 years' time (2042)
- Predicted boundary of less dense vegetation for the medium emissions 50th percentile sea-level rise scenario in 20 years' time (2042)
- Dense vegetation boundary mapped by the National Vegetation Survey (NVC) 2021 survey
- Less dense vegetation boundary mapped by the National Vegetation Survey (NVC) 2021 survey
- Predicted highest astronomical tide for the medium emissions 50th percentile sea-level rise scenario in 20 years' time (2042)

Client:	Project:
Wirral Borough Council	Hoylake Beach Geomorphology and Ecology Study

Title:

Predicted positions of the dense and sparse vegetation, and HAT in 20 years (2042)

Figure: 4 | Drawing No: PC2553-RHD-ZZ-XX-DR-Z-0012

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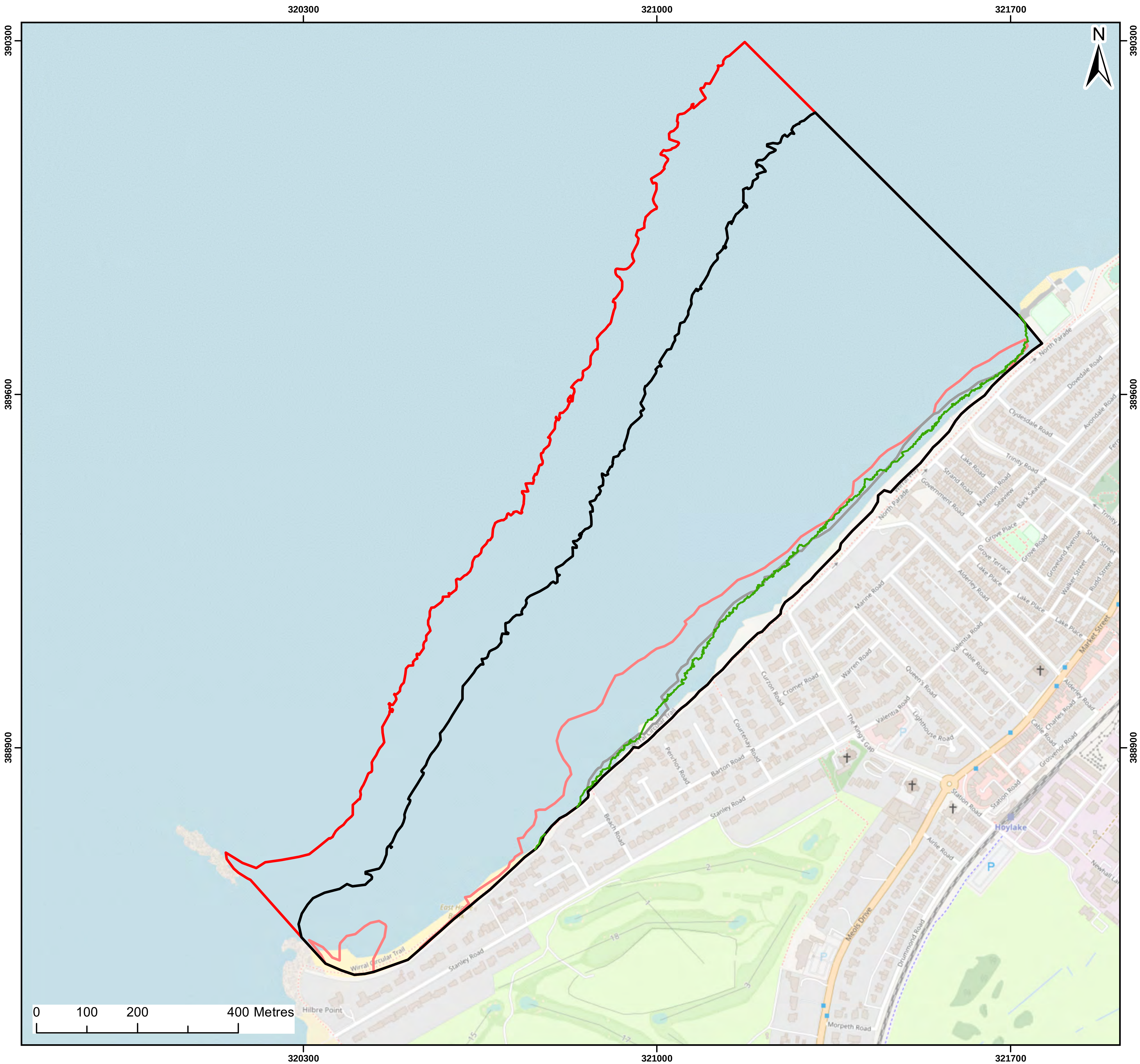

Legend:

- Predicted boundary of dense vegetation for the medium emissions 50th percentile sea-level rise scenario in 50 years' time (2072)
- Predicted boundary of less dense vegetation for the medium emissions 50th percentile sea-level rise scenario in 50 years' time (2072)
- Dense vegetation boundary mapped by the National Vegetation Survey (NVC) 2021 survey
- Less dense vegetation boundary mapped by the National Vegetation Survey (NVC) 2021 survey
- Predicted highest astronomical tide for the medium emissions 50th percentile sea-level rise scenario in 50 years' time (2072)

Client: Wirral Borough Council

Project: Hoylake Beach Geomorphology and Ecology Study

Title: Predicted positions of the dense and sparse vegetation, and HAT in 50 years (2072)

Figure: 5

Drawing No: PC2553-RHD-ZZ-XX-DR-Z-0013

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4.1.1 Potential Future Saltmarsh Development

Saltmarshes are categorised as low, medium or high marsh, depending on the height of the beach and characteristic plant assemblages. The vegetation communities (SM13 and SM6) recorded during the NVC survey and associated species are typical of low marsh.

How the zonation of the saltmarsh will actually develop over time is uncertain, as saltmarsh zones vary in location and land cover; however, given the continued increase in beach levels over the next 50 years, more distinct low, middle, and high marsh zones (and comprising species) would likely develop as the vegetation migrates seaward.

4.1.2 Potential Future Sand Dune Development

The similarities of the coast between Birkdale and Ainsdale, located on the Sefton shoreline between Liverpool and Southport and Hoylake Beach can be used as an analogy as to how the ecology at Hoylake Beach could potentially develop over time. From 1986 onwards, the area between Birkdale and Ainsdale began to be colonised by common saltmarsh-grass, which in turn trapped sand, eventually forming a zone of embryo dune, with the area becoming known as 'Birkdale Green Beach'. This change in habitat from scattered common saltmarsh-grass to embryo dune occurred over a period of two- to three-years, and was 0.5-1m in high in five years (Smith and Lockwood, 2021).

At Hoylake, the oldest areas of habitat above HAT would be nearest to the current seawall, with new dunes likely to extend seaward as land above HAT increases in area. How these dunes will develop will be influenced by a multitude of factors, including disturbance and erosion, the climate, changes in soil chemistry and composition, and impacts of species present on their environment.

The presence of sand dune vegetation can further increase the accumulation of sand as it is trapped around both living and dead plant matter. Whilst this, and the development of saltmarsh, may reduce wind-blown sand nuisance, sand dune development has the potential to result in higher beach levels than that predicted by this study. Should dune height exceed that of the existing sea wall, there is the potential that the dune could migrate landwards, affecting local roads and houses.

4.2 Do Everything Shoreline Management Scenario

For the Do Everything scenario, Hoylake Beach would be managed over the next 10, 20 and 50 years, so that all vegetation is removed, i.e. there would be no ecological change. The changes in beach levels would be similar to the Do Nothing scenario because the supply of sand would remain the same and the clearing of vegetation (by whatever means is determined) would be completed without removal of the sediment. Whilst the removal of sand dune vegetation would reduce the rate of sand accumulated by dune formation, meaning that the higher beach levels resulting from dune formation would be less likely to occur, wind-blown sand nuisance would like increase due to the non-vegetated beach providing a larger source of sand.

5 Natural Capital Value

To support the study a Natural Capital Value assessment was carried out on the shoreline management scenarios by Liverpool John Moores University (see Appendix D of the main report).

Natural capital is defined as the "elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions"[3]. Ecosystem services are defined as being "the aspects of ecosystems utilised (actively or passively) to produce human well-being"[4].

The major benefits of natural capital to humans include ecosystem services such as: the supply of timber from trees, the supply of fish for consumption, erosion control, crop pollination, water filtration, carbon storage to reduce the impact of climate change, noise reduction, air pollution reduction and the maintenance of greenspaces and biodiversity for the benefit of ecosystems and human recreation, with benefits to mental and physical health. Natural capital is therefore critically important for the maintenance of a high quality of life for human populations.

In this study, ecosystem service models have been used to examine the change in ecosystem service provision from Hoylake Beach in its current state compared to projected future states of the beach caused by climate change-induced sea level rise, natural sediment supply and possible future beach management scenarios.

The findings of the Natural Capital Value assessment are as follows:

- The take up of carbon and its storage are expected to increase strongly under the Do Nothing scenario as vegetation spreads across the beach, with an additional 245 tonnes of carbon (tC) removed from the atmosphere and a 50% increase of current carbon stored after 50 years.
- The take up of carbon and its storage are expected to decrease slightly under the Do Everything scenario, with a 6% reduction in the removal of carbon and a loss of around 326 tC from current carbon stocks.
- The provision of ecosystem services is broadly predicted to increase under the Do Nothing scenario, with green space access, air purification, noise pollution reduction and pollination showing increasing capacity over time.
- The provision of ecosystem services is broadly predicted to decrease under the Do Everything scenario, with pollination, noise pollution reduction and air purification showing a decreasing trend over time. The exception is access to nature which is expected to increase.

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[3] Natural Capital Committee. 2014. Towards a Framework for Defining and Measuring Changes in Natural Capital. Working Paper 1, Natural Capital Committee.

[4] Fisher, B., Turner, R. K., Morling, P. 2009. Defining and classifying ecosystem services for decision making. Ecological Economics, 68(3): 643-653.

6 Flood Risk Assessment

The future flood risk at Hoylake Beach has been assessed for both management scenarios (Do Nothing / Do Everything). This has been based on the flood extent identified by the Environment Agency's Flood Risk Mapping dataset.

In the context of beach management, the dominant source of tidal flooding at Hoylake is Still Water Level (SWL) flooding, where the water level exceeds the height of the sea wall. Typically, coastal flooding can be caused by either SWL flooding, wave overtopping, or a combination of the two. Although wave run-up and overtopping of the seawall at Hoylake is likely to occur, especially along the promenade, it will not be a major source of flooding for the area behind the seawall. There is little opportunity for the overtopped volume to accumulate behind the defences as the beach slopes upwards in a landward direction, and the water will flow back to the sea instead. Coastal flooding at Hoylake is mainly confined to the frontage just behind the sea wall; however, wave run-up can cause a direct hazard or nuisance for the road and its users, and for the lower lying parts of properties.

Groundwater flooding is caused when the water table within the ground rises to above ground level, causing flooding to occur at the surface. The coastal fringes to the east and northeast together with the northwest of the Wirral could be susceptible to groundwater flooding.

In both shoreline management scenarios, the beach has no influence on SWL flooding. In the Do Nothing scenario the developing dune system could start to have a flood defence function, should the dunes potentially grow higher than the sea wall. This would however not affect the scale of the flood zone because that would require a continuous, uninterrupted row of dunes; any gap in the alongshore arrangement of the dunes would lead to a breach, in which case the risk of SWL flooding is similar. Therefore, in both scenarios, changes in future flood risk are expected to be similar, and SWL flooding will continue to be the dominant source of flooding. Should the Do Nothing and/or Do Everything scenarios affect groundwater levels, e.g. through changes in beach levels, this has the potential to affect groundwater flooding behind the sea wall.

7 Opportunities and Constraints

There is a critical balance to achieve between the need for management and the need to maintain the ability of the natural shoreline to adjust to change. This section appraises the opportunities and constraints of the Do Nothing and Do Everything scenarios using criteria included in four appraisal elements:

- environment: potential impacts on morphological and ecological systems;
- flood and coastal erosion risk: issues of flooding and coastal erosion related to sea-level rise;
- Natural Capital Value: potential impacts to ecosystem services; and
- beach use: implications for visitors and public access.

The method that was adopted is a RAG (Red, Amber, Green) traffic-light assessment (**Table 2**). For each scenario, the table provides the appraisal element and criteria, and columns where the results of the appraisal are summarised. The colours represent the following:

- Red shading: approach does not meet defined criterion;
- Amber shading: approach does meet defined criterion in some aspects, but there are aspects which are negative or undesirable; and
- Green shading: approach fully meets defined criterion.

Table 2 RAG assessment for Do Nothing and Do Everything scenarios at Hoylake

Element	Criteria	Do Nothing	Do Everything
Environment	Working with natural processes	Maintains the evolving nature of the coastal landscape	Significantly alters the natural development of the coastal landscape
	Biological diversity and longevity	Increased through the development of more complex saltmarsh and sand dunes	Significant decrease from the prevention of vegetation growth
	Wind-blown sand hazards for adjacent road and properties	Increase if sand dune system develop close to the seawall	Increase due non-vegetated beach providing a larger source of wind-blown sand
Flood and coastal erosion risk	Flood zone extent	Area unchanged	Area unchanged
	Flood defence function	Developing dune system could have a flood defence function	No sand dunes that would perform a potential flood defence function
	Wave attenuation/dissipation	Vegetated beach would increase attenuation and/or dissipation of waves	Non-vegetated beach would provide less attenuation and/or dissipation of waves
Natural Capital Value	Carbon sequestration and storage potential	Increase due to vegetation colonisation	Decrease if vegetation is prevented from establishing
	Ecosystem services	Increase due to increased vegetation, green space access, air purification, noise pollution reduction and pollination	Decrease due to prevention of vegetation growth, with pollination, noise pollution reduction and air purification decreasing. Access to nature is expected to increase
Beach use	Recreational use	Decrease due to reduced beach area	Increase due to maintained sandy beach
	Impact on access to and along the coast	Development of saltmarsh and dunes could impede access	No change to access
	Management zoning	No management zoning in this scenario	No management zoning in this scenario

8 Conclusions and Recommendations

8.1 Conclusions

This study has shown that beach levels at Hoylake Beach will continue to rise over the next 50 years, based on how the beach has developed in the past and predicted sea-level rise. The rate of increase in beach levels is predicted to outpace sea-level rise and consequently beach levels will rise and migrate seawards.

Under the Do Nothing scenario, the existing vegetation would migrate seawards, increasing in area across the beach. In addition, the predicted seaward movement of HAT would create space landward for the development of sand dunes in front of the seawall. Under the Do Everything scenario, all vegetation would be removed, potentially increasing wind-blown sand nuisance due to the non-vegetated beach providing a larger source of sand. Beach levels would increase as for the Do Nothing scenario; however, the presence of sand dune vegetation can further increase the accumulation of sand as it is trapped around both living and dead plant matter. Whilst this, and the development of saltmarsh, may reduce wind-blown sand nuisance, sand dune development has the potential to result in higher beach levels than that predicted by this study. Should dune height exceed that of the existing sea wall, there is the potential that the dune could migrate landwards, affecting local roads and houses.

In terms of Natural Capital Value, there are differences depending on the scenario. For Do Nothing, the removal and storage of carbon would increase, whereas for Do Everything they would decrease. The provision of ecosystem services is likely to increase for Do Nothing, whereas there is a predominantly decreased provision for Do Everything. The exception is access to nature which is expected to increase.

From a flood-risk perspective, the beach would have no influence on SWL flooding, regardless of the scenario. The Do Nothing scenario would reduce the direct hazard and nuisance of wave run-up on the road, its users and the lower lying parts of properties; however, there is also a risk that a developing dune system could form a barrier against any overtopped water flowing back to the sea and could thus enhance flooding in some locations. Should the Do Nothing and/or Do Everything scenarios affect groundwater levels this has the potential to affect groundwater flooding behind the sea wall.

8.2 Recommendations

The following additional studies are considered necessary to support the development of the BMP:

- Before the BMP is developed it is recommended that a botanical survey be carried out in spring, summer, and early autumn to ensure that a full list of species growing on the site is generated.
- Should future beach management include for continuing Green beach development, a yearly botanical survey should be repeated to monitor the progress of colonisation. An NVC survey should be repeated in five years, to map the progress of vegetation communities colonising the site and document their evolution.
- Due to the nature of the flood risk mapping dataset, it is not clear from which initial study the flood extent at Hoylake originates, or which water level conditions were used to drive the modelling. It is recommended that a detailed flood risk assessment, informed by the latest data, focussed locally on Hoylake, is performed as part of any future BMP.
- A review of groundwater behaviour behind the sea wall and how potential future beach management actions could impact on behaviour should be undertaken to inform the BMP.
- Beach levels and sediment supply should be continued to be monitored to validate the assumptions made in this study and to inform future management of the beach.
- Further investigation of the effects of wind blown sand and sand dune development should be undertaken to understand how this could affect future beach levels.

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Royal HaskoningDHV is an independent, international engineering and project management consultancy with over 138 years of experience. Our professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water.

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