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Title	Coastal climate adaptation in Ireland: The effects of climate change in Portrane (Fingal, Co. Dublin) and future perspectives
Authors	Stori, Fernanda Terra;O'Mahony, Cathal
Publication date	2021
Original Citation	Stori, F. T. and O'Mahony, C. (2021) Coastal climate adaptation in Ireland: The effects of climate change in Portrane (Fingal, Co. Dublin) and future perspectives. Cork, Ireland: MaREI, the SFI Research Centre for Energy, Climate and Marine.
Type of publication	Report
Link to publisher's version	https://www.marei.ie/project/coastal-communities-adapting-together/
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Download date	2026-11-16 10:50:15
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COASTAL COMMUNITIES ADAPTING TOGETHER / CCAT

COASTAL CLIMATE ADAPTATION IN IRELAND:

The Effects of Climate Change in Portrane (Fingal, Co. Dublin) and Future Perspectives



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2021

How to cite this document:
STORI, F. T. and O'MAHONY, C. 2021. Coastal Climate Adaptation in Ireland: The Effects of Climate Change in Portrane (Fingal, Co. Dublin) and Future Perspectives. MaREI the SFI Research Centre for Energy, Climate and Marine; Environmental Research Institute; University College Cork. Coastal Communities Adapting Together – CCAT Project. 202p.

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Acknowledgements

The Coastal Communities Adapting Together (CCAT) team would like to acknowledge the European Regional Development Fund through the Ireland Wales Cooperation programme for the support. The authors acknowledge all the CCAT partners – Fingal County Council, University College Dublin, Cardiff University, Pembrokeshire Coastal Forum and the Port of Milford Haven – for the substantial knowledge exchange process throughout these 24 months of cooperation; special thanks to Brenda McNally, Emma McKinley, Hans Visser, Karen Foley, Kevin Halpenny, Pauline Power, and Saul Crowley for their thoughtful comments and assistance in critically reviewing this study. We acknowledge Chiara Cocco and Xinrui Gong for their outstanding support in organising the interactive graphic timeline and the ArcGIS StoryMaps collection "Coastal Climate Adaptation in Ireland". Special thanks to Anne Marie O'Hagan for her great contribution to the in-depth examination of legislation, policies and plans. The authors thank MaREI, the SFI Research Centre for Energy, Climate and Marine / Environmental Research Institute / University College Cork for the outstanding support offered to the development of the research activities, and the MaREI colleagues for their cooperation and helpful inputs with this study. To the community of Portrane, Fingal – may this study assist you in finding sustainable solutions for your place.

Executive Summary

Coastal Communities Adapting Together (CCAT) aims to support coastal communities in understanding the impacts of climate change and how to adapt (i.e., build adaptive capacity to change). This aim is achieved by raising awareness and engaging communities through outreach, research, and the development of digital technologies. CCAT is part-funded by the European Regional Development Fund through the Ireland – Wales Cooperation Programme 2014-2020 and is led by University College Dublin in partnership with Fingal County Council and MaREI, the SFI Research Centre for Energy, Climate and Marine (Environmental Research Institute, University College Cork) in Ireland, as well as Cardiff University, Pembrokeshire Coastal Forum and the Port of Milford Haven in Wales.

The study presented herein was conducted by members of MaREI, in order to support Fingal County Council in managing responses to the impacts of climate change observed at Portrane, illustrated by the continuous process of coastal erosion at Burrow Beach, Portrane (Fingal, North Co. Dublin) and prospective flooding scenarios. There is an urgent need to address a policy gap in coastal management and climate adaptation in Ireland, hereafter called "Coastal Climate Adaptation". This gap poses challenges for coastal communities and local authorities across Ireland in dealing with past and current impacts of coastal erosion and flooding and presents a potential weakness in how Ireland will cope with future climate change impacts. The objective of this report is to present a baseline assessment aimed at providing a greater understanding of the coastal changes experienced over time at Burrow Beach, of the current and future impacts due to climate change scenarios, and to examine relevant legislation, plans and policies in relation to the debate on coastal climate adaptation strategies both locally and nationally.

This assessment is both timely and necessary. Despite the production of many assessments and reports over the past decades on the problem of coastal erosion and flooding in Portrane, a lack of continuity and coordination between these studies and a lack of a coherent response was observed over time, leaving the information dispersed and hampering the decision-making process. A thorough collation of those studies was necessary to gather all relevant information in one single document and provide a coherent evidence base to support policy development at national and local levels and decision making for the area.

This report collates the key findings of existing studies that have been prepared regarding the environmental aspects and impacts of climate change in Portrane. The methodology consisted of a bibliographical search for studies previously published in white papers, grey literature, and peer-reviewed scientific literature concerning: the geological formation of Portrane's ecosystems, biodiversity and conservation areas; historical aspects of Portrane; climatology of the region; climate change predictions; current and expected future scenarios of coastal erosion and flooding; and recommended adaptation measures. The research also targeted the large body of climate change and adaptation technical reports across international, national, and local scales. Relevant studies about Portrane were selected for in-depth analysis, grouped thematically, and presented in chronological order.

Subsequently an extensive examination of legislation, policies and plans related to coastal climate adaptation across multiple geographical scales is presented. A detailed compilation of these documents is presented in the Appendix to this report. Finally, perspectives for implementing a coastal management framework that incorporates coastal climate adaptation and resilience is discussed and recommendations are provided.

This report is especially intended to support Fingal County Council in their decision making; however, other local authorities and policymakers may find its content informative. Local residents and practitioners working with coastal erosion, flooding, and climate change adaptation may also benefit from the information contained herein.

Report Structure and Key Findings

This report is structured in six sections and one Appendix. The main structure and key findings of this study are detailed below:

Section 1 – Introduction

Section 1 presents an introduction to the impacts of climate change on the coastal zone worldwide and provides information about global warming, past and future predictions of sea level rise (SLR) and introduces the issue for the Republic of Ireland. The case study of Burrow Beach, Portrane, Fingal (Co. Dublin) is briefly introduced, and the aim of this report is presented. From section 1, it is taken that global mean sea level has risen about 21–24 centimetres since 1880 and it will continue to rise over the 21st century even if emissions decline in line with the Paris Agreement objectives. It is predicted that 200 million people

globally could live permanently below the high tide line by 2100. In Ireland, a country with more than 7,000 km of shoreline and more than 50% of the population living within 15 km of the coastline, approximately 350 km^2 of coast is vulnerable under a sea level rise of 1 metre. For these reasons, it is crucial to act immediately both in terms of mitigation and adaptation.

Section 2 - Geological, Environmental and Historical Aspects of Portrane

Section 2 describes the geological formation of the peninsula, its environmental characteristics (including its fauna, flora and existing protected areas) and, finally, historical aspects of Portrane over time is also discussed. The peninsula of Portrane is a sandy spit (barrier-island system) located between the Rogerstown Estuary and the Irish Sea formed during the Quaternary geological period. The peninsula hosts a variety of coastal habitats, such as beach, sand dunes, salt marshes, mudflats and the Rogerstown Estuary – habitats and species protected by the European Natura 2000 ecological network of protected areas, the estuary contains both a Special Protection Area (SPA) and a Special Area of Conservation (SAC). The settlement of Portrane dates back from the 12th century when it was an important fishing centre, further developed in the 19th century due to the construction of St. Ita's hospital and turned into a popular beach resort in the North Co. Dublin during the 20th century.

Section 3 - The Changing Climate and its effects on Portrane Coast

Section 3 presents the evidence of climate change and its effects on the coast of Portrane. It starts with an overview of climate change on the coast of Ireland, then provides information about the morphogeological and physical aspects of Burrow Beach (Portrane, Co. Dublin) and the climate patterns in the Portrane region. Then, information about coastal erosion in Burrow Beach is presented, including aspects of the coastal dynamics of saltmarshes, coastal dynamics of dunes systems, anthropogenic impacts over Burrow Beach coastal systems, and the chronological analysis of the coastal erosion assessments produced from 1998 to the most recent published report in 2020. Thereafter, the section outlines the most recent studies about coastal and flooding predictions for Burrow Beach under different climate scenarios. Solutions and opportunities for restoring existing natural habitats and dealing with coastal erosion and flooding are provided at the end of this section.

Section 3 outlines future changes to Ireland's weather system; mean annual temperatures and heatwaves are projected to increase in Ireland, along with the increase in heavy precipitation events and in the frequency of storms, especially in the autumn and winter months. Studies have found that sea level around Ireland has risen from approximately 2–3 mm per year and it

is predicted to continue to rise in line of international assessments. Studies have found that dominant waves that affect Burrow Beach generally approach from the south easterly sector and the longshore drift transport sediments from south to north; an observed deficit in the sediment supply has increased erosion pressures along Burrow Beach. Regarding coastal change at Burrow Beach, studies report that episodes of erosion have been observed since the mid-19th century, alternating with episodes of accretion; however, erosional episodes have been predominant in the past 20 years and some sections of the beach have already experienced more than 30 metres of erosion. Recent studies estimate the average rate of coastal erosion along Burrow Beach to be 0.60m/yr (±0.92m), with a maximum rate of retreat of 1.29m/yr. The coastline at Burrow Beach could retreat by 48, 68 and 88 metres by 2100 according to three different scenarios (current, MRFS and HEFS respectively), posing up to 46 buildings at risk when considering the worst-case scenario (HEFS). Considering the flood risk assessment, up to 286 buildings were found to be at risk when considering the HEFS scenario to 2100, and costs could range between €154k to €2.8m depending on the scenario considered and the consequent rate of erosion. Since the 1950s, a number of coastal interventions have occurred, including dune restoration and coastal monitoring programs have been suggested and implemented in order to deal with the problem of erosion at Burrow Beach. Recent assessments recommend the installation of a series of groynes combined with a beach re-nourishment scheme and flood embankments to deal with current and future impacts of coastal erosion, works that would cost approximately €16m, with an additional beach recharge cost of approximately €8.5k per year. When considering the worst climate scenario, a wiser cost-effective solution would be to gradually remove the houses and allow ecosystems to re-balance (Managed Retreat).

Section 4 - Coastal Climate Adaptation Frameworks in Ireland

Section 4 presents a summary of the coastal climate adaptation frameworks in Ireland, including legislation, policies and plans, at national, regional and local levels, addressing coastal management, planning and development, climate change adaptation (including biodiversity). The documents examined are comprehensively presented in the Appendix. An online interactive graphic timeline and a webpage for online visualisation of the documents analysed were created using the platforms *TimeGraphics* and *ArcGIS StoryMaps*, and can be accessed on http://www.ccatproject.eu/coastal-climate-adaptation-Ireland/.

Section 4 presents how Ireland still lacks a dedicated legal ICZM framework to guide planning, management, and the application of climate adaptation solutions specific to the coastal zone. A sectoral and fragmented approach to coastal governance and a divide between marine and terrestrial planning frameworks was often prevalent. National, regional, and local development and planning and the suite of climate adaptation frameworks analysed have direct application to coastal areas and comprise relevant baseline documentation to scale up a legal ICZM framework in Ireland and support coastal climate adaptation solutions. A number of typologies for climate adaptation solutions were identified: Grey adaptation; Hard engineering; Soft Engineering; Green adaptation; Green infrastructure; Nature-based Solutions; Ecosystem-based Solutions; Soft Adaptation; and, coastal management approaches that comprise 'Do nothing', 'Do minimum', 'Hold the line', 'Advance the line', and 'Managed re-alignment'. The solution 'Managed Retreat' was not found in any one of the documents examined. An update, organisation, and harmonization of those terminologies is recommended in order to support local governments in dealing with the reality of climate change impacts on the coast.

Section 5 - Coastal Climate Adaptation Perspectives in Ireland

Section 5 presents a range of studies that address the perspectives for coastal climate adaptation in Ireland. In summary, these studies highlight that coastal erosion and flooding may lead to and increase the impacts on several sectors (Natural and cultural capital; Critical infrastructure; Water resources and flood risk management; Public health and well-being), however, these issues have been historically managed in a reactive and localised manner, with little national co-ordination. An imbalance between coastal erosion and flooding is apparent and some local authorities (LAs) are gathering data on coastal erosion for the first time in order to develop their strategies for coastal climate adaptation. Coastal management in Ireland has been progressing through local project-based initiatives/good practice experiences, despite the lack of an ICZM approach. Key barriers to coastal climate governance in Ireland are the fragmentation of institutions and administrative functions, ill-defined responsibilities among the actors and institutions involved, short-term planning and top-down management, and lack of experience of cross-sectoral cooperation and stakeholder involvement.

Section 6 – Final Remarks and Recommendations

Section 6 concludes the report by summarizing the main results of this study and offering recommendations for progressing a coastal climate adaptation framework in Ireland. In short, the key conclusions are that despite the extensive available information on coastal erosion and

future impacts of climate change, the current governance system has failed to respond to past and current coastal changes in Burrow Beach, demonstrating a lack of capacity to deal with the problem. This is probably due the centralized characteristics of the Irish governance system while a fragmented and sectoral approach to deal with coastal planning and management issues is observed. In addition, there is no legal approach to facilitate a strategic and structured process for implementing coastal climate adaptation solutions, especially in face of up-to-date sea level rise predictions. Managed retreat may be required in some coastal areas of Ireland, however, no policy examined assists in implementing this type of solution. This study recommends that a statutory National Coastal Management Framework should be instituted in Ireland to deal with the current and future risks of coastal erosion and flooding and support the implementation of sustainable adaptation solutions in coastal areas. This framework should be based on integrated, participatory/adaptive multi-level governance, and ecosystem-based approaches and it could be built by reframing existing legal instruments, policy objectives and government bodies. A national funding scheme should be established and provide clear guidance, administrative structures and technical oversight to support the implementation of coastal adaptation solutions. The perimeter of the "Coastal Zone" should be defined in order to overcome the current land-sea divide and facilitate coastal-marine governance, including coastal climate adaptation. LAs should be empowered to adopt a proactive approach to decision making, with the participation of coastal communities, that is responsive to the uncertainty of climate change and coastal processes. Coastal adaptation guidelines based on best practices of coastal management should be developed. Dialogue on coastal climate adaptation in Ireland should be fostered to increase local level capacity in dealing with coastal erosion and flooding. Finally, the impact of climate change in coastal areas should be widely communicated across all audiences in order to raise awareness and co-develop coastal climate adaptation solutions and build social-ecological resilience.

Appendix

The Appendix presents in detail all the documents examined in section 4, i.e., legislation, policies and plans, at national, regional and local levels, addressing coastal management, planning and development, climate change adaptation (including biodiversity). The Appendix supports a further understanding of section 4.

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ii. List of Acronyms

AA – Appropriate Assessment

CARO – Climate Action Regional Office

CBD – Convention on Biological Diversity

CCAT – Coastal Communities Adapting Together

CFERM – Coastal Flooding and Erosion Risk Management

CFRAM – Catchment Flood Risk Assessment and Management Programme

CPA – Coastal Planning Authorities

DAFM – Department of Agriculture, Food and the Marine

DBTF – Dublin Bay Taskforce

DCCAE – Department of Communications, Climate Action & Environment

DCHG – Department of Culture Heritage and the Gaeltacht

DECLG – Department of the Environment, Community and Local Government

DHLGH – Department of Housing, Local Government and Heritage

DHPLG – Department for Housing, Planning and Local Government

DMNR – Department of the Marine and Natural Resources

DTTAS – Department of Transport, Tourism and Sport

EC – European Commission/Council

EEZ – Exclusive Economic Zone

EIA – Environmental Impact Assessment

EIAR – Environmental Impact Assessment Report

EMRA – Eastern and Midland Region Assembly

EPA – Environmental Protection Agency

EU – European Union

FCC – Fingal County Council

FCDP – Fingal County Development Plan

FEM-FRAMS – Fingal East Meath Flood Risk Assessment and Management Studies

HEFS – High-End Future Scenario

HWM – High Water Mark

ICPSS – Irish Coastal Protection Strategy Study

ICZM – Integrated Coastal Zone Management

IPCC – Intergovernmental Panel on Climate Change

LAs – Local Authorities

MAP – Maritime Area Planning Bill

MARA – Maritime Area Regulatory Authority

MCA – Multi-Criteria Analysis

MPPS – Marine Planning Policy Statement

MRFS – Mid-Range Future Scenario

MSP – Maritime Spatial Planning

NAF – National Adaptation Framework

NBAP – National Biodiversity Action Plan

NCCAF – National Climate Change Adaptation Framework

NDP – National Development Plan

NHAs – Natural Heritage Areas

NMPF – National Marine Planning Framework

NPF – National Planning Framework

NPWS – National Parks and Wildlife Service

NSS – National Spatial Strategy

OPW – Office of Public Works

PFRA – Preliminary Flood Risk Assessment

pNHAs – Proposed Natural Heritage Areas

RGP-GDA – Regional Planning Guidelines for the Greater Dublin Area

RSES-EMR – Regional Spatial and Economic Strategy for the Eastern and Midland Region

SAC – Special Area of Conservation

SEA – Strategic Environmental Assessment

SFRA – Strategic Flood Risk Appraisal

SPA – Special Protection Area

UN – United Nations

1. Introduction

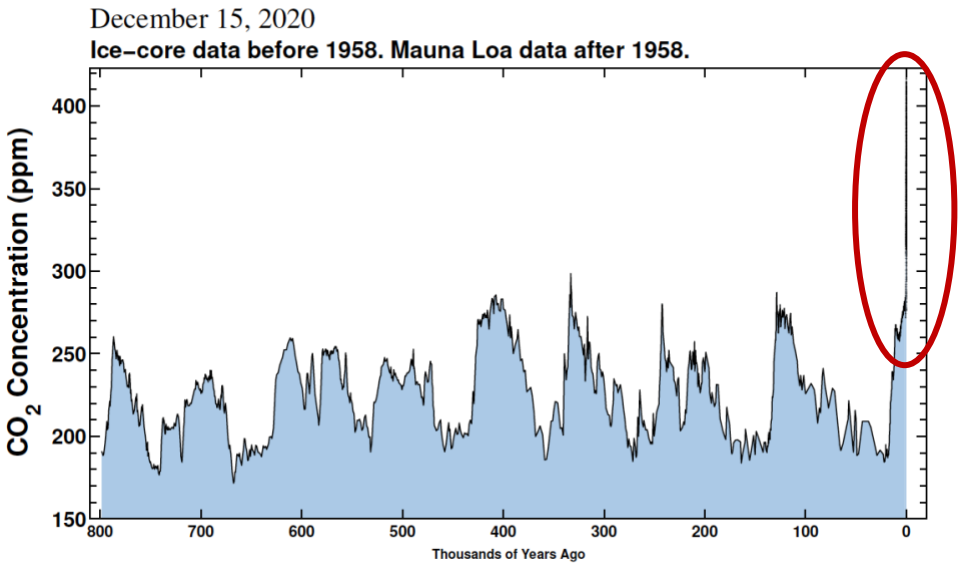
1.1. The Impacts of Climate Change on Coastal Zones

Climate change is undoubtedly the biggest challenge of this century, with consequences for global ecosystems, fauna and flora species, human settlements, and economies. The effects of climate change can already be observed worldwide and are likely to increase, such as droughts, wildfires, heatwaves, storms, floods, ice melting, sea level rise, ocean acidification, loss of biodiversity and habitats (NASEM, 2016; IPCC, 2018; Hoegh-Guldberg et al., 2018).

According to the Intergovernmental Panel on Climate Change (IPCC) AR6 report, it is unequivocal that human activities have induced climate change affecting every region across the globe (IPCC, 2021). There is evidence of observed changes in the many weather and climate extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, the contribution of human influence, has strengthened since the last IPCC AR5 report (IPCC, 2021). Over the past three years, climate-related disasters have cost the world U$ 650bn – more than 0.25 percent of global GDP for those years (DiChristopher, 2019; GCA, 2020). The United Nations has warned that by 2040 damages associated with climate change globally could soar to U$ 54 trillion (Hoegh-Guldberg et al., 2018; GCA, 2020).

Rising sea levels and associated coastal flooding are risks most commonly associated with global warming. Studies have proven a strong correlation between the concentration of greenhouse gases in the atmosphere, the global mean temperature and the global mean sea level, with evidence dating back circa 800 thousand years before present (Figures 1.a and b) (Hansen et al., 2013; Englander, 2021; UCSD, 2021). The sharp increase in the concentration of greenhouse gases in the atmosphere since the industrial revolution has proven to be the main cause of the recent rise in the global mean temperature and, consequently, in sea levels (Keeling, 1960; Hansen et al., 2013; NASEM, 2016; UCSD, 2021). Global surface temperature was on average 1.09°C higher in 2011–2020 than in pre-industrial times (from 1850 to 1900) and, if it continues to increase at the current rate, global warming is likely to reach 1.5°C between 2030 and 2052 (IPCC, 2018.a; IPCC, 2021). Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO2) and other greenhouse gas emissions (such as methane) occur in the coming decades (IPCC, 2021).

a)



b)

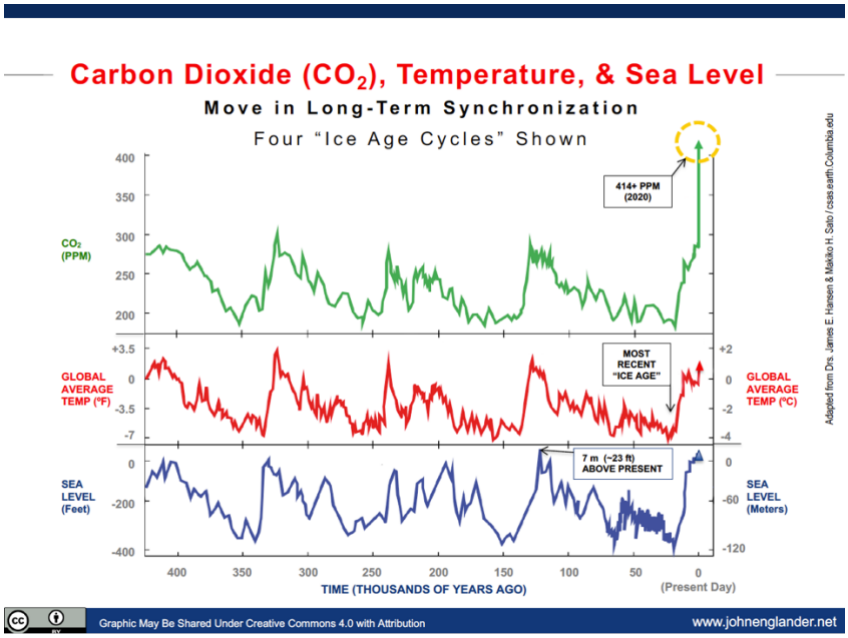


Figure 1: (a) CO_2 concentration in parts per million (ppm) dating back 800 thousand years before present (Source: UCSD, 2021); (b) Correlation between CO_2 concentration, temperature and sea level dating back 400 thousand years before present. The red circles highlight the recent rise in CO_2 emissions (Source: Englander, 2021).

There is a scientific consensus of the need to limit the average global temperature below 2.0°C above pre-industrial levels to avoid the worst climate change scenario, and this target can only be achieved if the human civilisation achieves net zero emissions by 2100 or sooner (IPCC, 2018.a, IPCC, 2021). However, according to the Emissions Gap Report 2020 (UNEP, 2020), the world is still heading for a temperature rise in excess of 3°C this century – far beyond the Paris Agreement goals of limiting global warming to below 2°C and pursuing the 1.5°C target (UN, 2015). A green recovery discourse, following the COVID-19 pandemic of 2020, has been

identified as having the potential to realign 2030 emissions with the 2.0°C target (UNEP, 2020). However, many changes due to past and future greenhouse gas emissions, are irreversible for centuries to millennia, especially changes in the ocean, ice sheets and global sea level (IPCC, 2021).

It is virtually certain (99–100% probability) that global mean sea level will continue to rise over the 21st century (IPCC, 2021). The IPCC AR6 report (2021) considered five illustrative future scenarios[1]. According to IPCC (2021), if a reasonably optimistic scenario is achieved (SSP1-2.6), it is likely that global mean sea level will rise to around 0.5 metres above the baseline level by 2100 and up to 3 metres by 2300. Considering the worst emissions scenario (SSP5-8.5), the global mean temperature may exceed the pre-industrial level to around 4.0°C (±1°C) by 2100 and sea levels may rise more than 1 metre (Figure 2). Sea levels may reach 7 metres by 2300 in the worst-case scenario, however, sea levels greater than 15 metres cannot be ruled out with high emissions (IPCC, 2021).

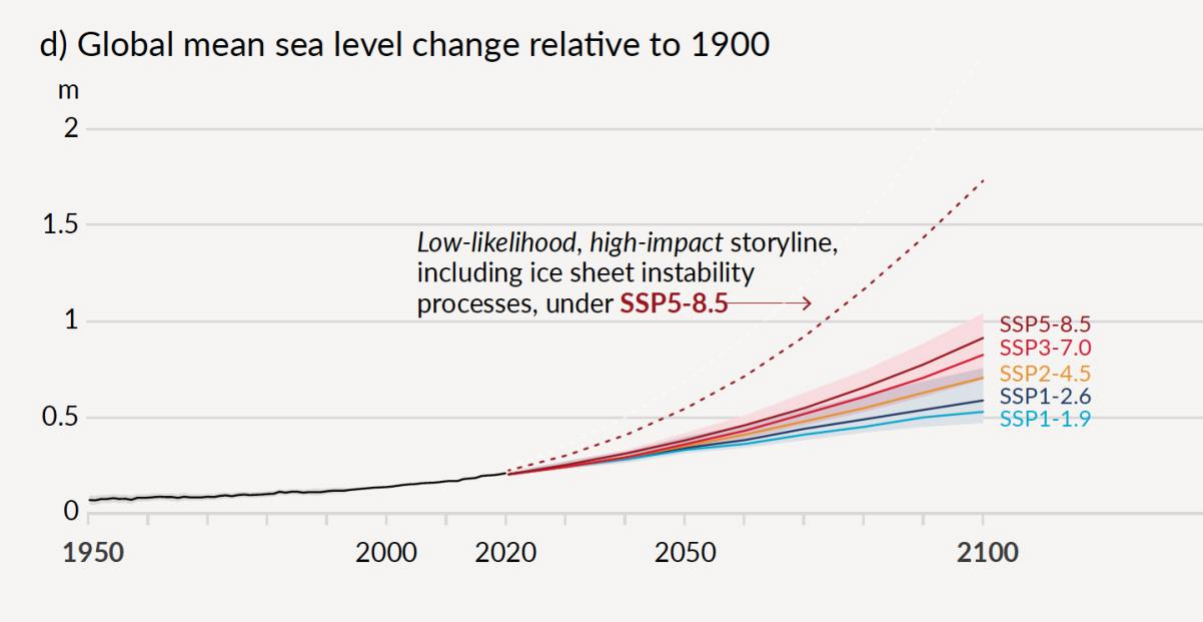


Figure 2: Global mean sea level rise predictions according to the five IPCC AR6 scenarios (Source: IPCC, 2021).

[1] IPCC AR6 (2021) five illustrative scenarios are referred to as SSPx-y, where 'SSPx' refers to the Shared Socio-economic Pathway or 'SSP' describing the socio-economic trends underlying the scenario, and 'y' refers to the approximate level of radiative forcing (in W m–2) resulting from the scenario in the year 2100. The five scenarios are:

- SSP3-7.0 and SSP5-8.5: scenarios with high and very high GHG emissions and CO2 emissions that roughly double from current levels by 2100 and 2050;
- SSP2-4.5: scenarios with intermediate GHG emissions and CO2 emissions remaining around current levels until the middle of the century;
- SSP1-1.9 and SSP1-2.6: scenarios with very low and low GHG emissions and CO2 emissions declining to net zero around or after 2050, followed by varying levels of net negative CO2 emissions.

The rise in the global mean sea level is a consequence of both combined land-based ice melting and the thermal expansion from ocean warming (IPCC, 2019; IPCC 2021; Lindsey, 2020). Global mean sea level increased about 21–24 centimetres since 1880, with about a third of that occurring in just the last 25 years (Lindsey, 2020). From 2006–2018, global mean sea level increased by an average of 3.7 millimetres per year (IPCC, 2021), which is more than 2.5 times the average of 1.4 millimetres per year observed throughout most of the twentieth century (Lindsey, 2020). Sea level rise leads to coastal erosion, inundations, storm floods, tidal waters encroachment into estuaries and river systems, contamination of freshwater reserves and food crops, loss of nesting beaches, as well as displacement of coastal lowlands and wetlands (UN, 2017).

Ocean warming has been linked to extreme weather events as increasing seawater temperatures provide more energy for storms that develop at sea, leading to fewer but more intense tropical cyclones globally (UN, 2017). The gradual sea level rise, added to the increased frequency of severe storms, are the main causes of coastal erosion and flooding (Devoy, 2008; IPCC, 2019; Flood et al., 2020). Considering that more than 600 million people (around 10% of the world's population) live in coastal areas that are less than 10 meters above sea level (UN, 2017; Bassetti, 2020), these threats will bring critical social and economic consequences for vulnerable coastal communities.

When talking about sea level rise, accurate predictions are fundamental for both mitigation and adaptation policies. For mitigation, knowing that different emissions pathways will have a direct effect on future sea levels can act as an added incentive for reducing emissions. For adaptation, accurate predictions and a multi-risk approach are crucial when choosing what strategies to adopt and where, and when, to apply them (Bassetti, 2020).

Projecting flood risk involves estimating future sea level rise and comparing it against land elevations models. The CoastalDEM digital elevation model (Climate Central, 2020; Kulp and Strauss, 2018) shows that many of the world's coastlines are far lower than generally believed (Kulp and Strauss, 2019). Based on sea level projections for 2050, land currently home to 300 million people will fall below the elevation of an average annual coastal flood, and 200 million people could live permanently below the high tide line by 2100 (Kulp and Strauss, 2019).

Prediction models also consider the stability of the Antarctic ice sheet. Melting ice in the Antarctic alone could raise sea levels by 2.5 metres in a 2.0ºC warming scenario (Garbe et al,

2020). The homes of 150 million people globally could be permanently below the high tide line by 2050 when considering a stability in the Antarctic sheet (Kulp and Strauss, 2019). If an instability of the Antarctic ice sheet is assumed, circa 300 million people are estimated to be currently living on lands at risk (Kulp and Strauss, 2019).

Rising seas and greater storm surges will certainly impact urban economies and force hundreds of millions of people in coastal cities from their homes, with an estimated cost of more than $1 trillion each year by 2050 (GCA, 2019). A slower rate of sea level rise will enable greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas (IPCC, 2018.a). However, sea levels will continue to rise even if emissions decline in line with the Paris Agreement objectives (UN, 2015) and, for this reason, it is important to act immediately both in terms of mitigation and adaptation (Bassetti, 2020).

The IPCC defines adaptation as "*the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities*" (IPCC, 2018.b). The Global Commission on Adaptation states that investing $1.8 trillion globally in climate adaptation schemes over the next decade could generate $7.1 trillion in total net benefits. The World Bank estimates that an extra three per cent of upfront adaptation investment in resilient infrastructure would be offset by savings of up to four times the cost of the loss and damage that would have occurred without said investment (GCA, 2019; Hallegatte et al., 2019).

Sea level rise, changes in the frequency and intensity of storm surges, and the consequential coastal inundation and erosion are expected to cause significant ecological damage, economic loss and other societal problems along low-lying coastal areas across Europe unless additional adaptation measures are implemented (EEA, 2017).

Climate change impacts are expected across the coasts of Ireland, a country with more than 7,000 km of shoreline and in which more than 50% of the country's population lives within 15 km of the coastline, concentrated mainly in the coastal cities of Dublin, Cork, Limerick and Galway (Devoy, 2008; Flood et al., 2020). Changes in Ireland's climate are in line with global trends where temperatures have increased approximately 0.9°C over the last 120 years, an average of 0.07°C per decade over this period (Dwyer, 2012; Flood et al., 2020; García and Dwyer, 2021). Climate change will have diverse and wide-ranging impacts in Ireland, both negative and positive, on managed and natural ecosystems, water resources, agriculture and

food security, human health and critical infrastructure (Coll and Sweeney, 2013; Desmond et al., 2017; Flood et al., 2020).

Sea level rise, coastal storms and flooding represent the most immediate risks on a national basis, with heat-related risks identified as an increasing risk on a longer-term basis (Flood et al., 2020). Rising sea levels, when combined with potential increases in levels of storminess and the increased risk of storm surges, will result in increased coastal inundation and erosion of beaches and cliffs, and degradation of coastal ecosystems (Dwyer, 2012; Flood and Sweeney, 2012; Flood et al., 2020). Estimates indicate that approximately 350 km^2 of land along the Irish coast is vulnerable under a sea level rise of 1 metre, increasing to 600 km^2 under a sea level rise of 3 metres (Flood et al., 2020). Potential economic costs relating to property insurance claims are in the region of €1.1bn under the 1 metre scenario, increasing to over €2.1bn under the 3 metres scenario (Flood, 2012; Flood and Sweeney, 2012).

Burrow Beach, Portrane (Fingal/North County Dublin) faces the main risks of climate change described in this introductory section, especially risks related to coastal erosion due to sea level rise and flooding as a result of storm surges (Gault et al., 2007; Kozachenko and Gault, 2009). These factors will exacerbate the current situation of the sustained coastal erosion at Portrane and are explored in-depth throughout this report.

1.2. Burrow Beach, Portrane, Case Study

In this report, we analyse the effects of climate change at Burrow Beach, Portrane (Fingal/North County Dublin, Ireland), especially focusing on the challenge of coastal erosion at Burrow Beach, as well as the risk of flooding in this barrier-island system.

Fingal County Council is responsible for an area that covers over 450 square kilometres and includes 88km of scenic coastline. This area stretches from the River Liffey and the Dublin City boundary in the south to the Meath boundary north of Balbriggan, and eastwards from the coast to the Meath and Kildare boundaries in the west. Fingal has the youngest population in the State (total population, 296,214 in 2016 Census), which is a key characteristic of the area as it accommodates an expanding Dublin population (FCC, 2017).

Burrow Beach in Portrane (Figure 3) is a sandy spit which separates the outer Rogerstown Estuary from the Irish Sea (Morton, 1998). A sandy beach extends for 1,800m along the peninsular portion of Portrane, between the rocky headlands to the south and the mouth of

Rogerstown Estuary to the north. Portrane is situated about 2km north of Donabate and 3 km south of Rush. This area is used for recreational purposes and presents a significant environmental importance, holding a variety of National and European designations such as a Special Area of Conservation (SAC) and a Special Protection Area (SPA) due to its habitats and species listed on Annex I / II of the E.U. Habitats Directive: Estuaries, Tidal Mudflats and Sandflats, Salicornia Mud, Atlantic Salt Meadows, Mediterranean Salt Meadows, Marram Dunes (White Dunes), and Fixed Dunes (Grey Dunes).

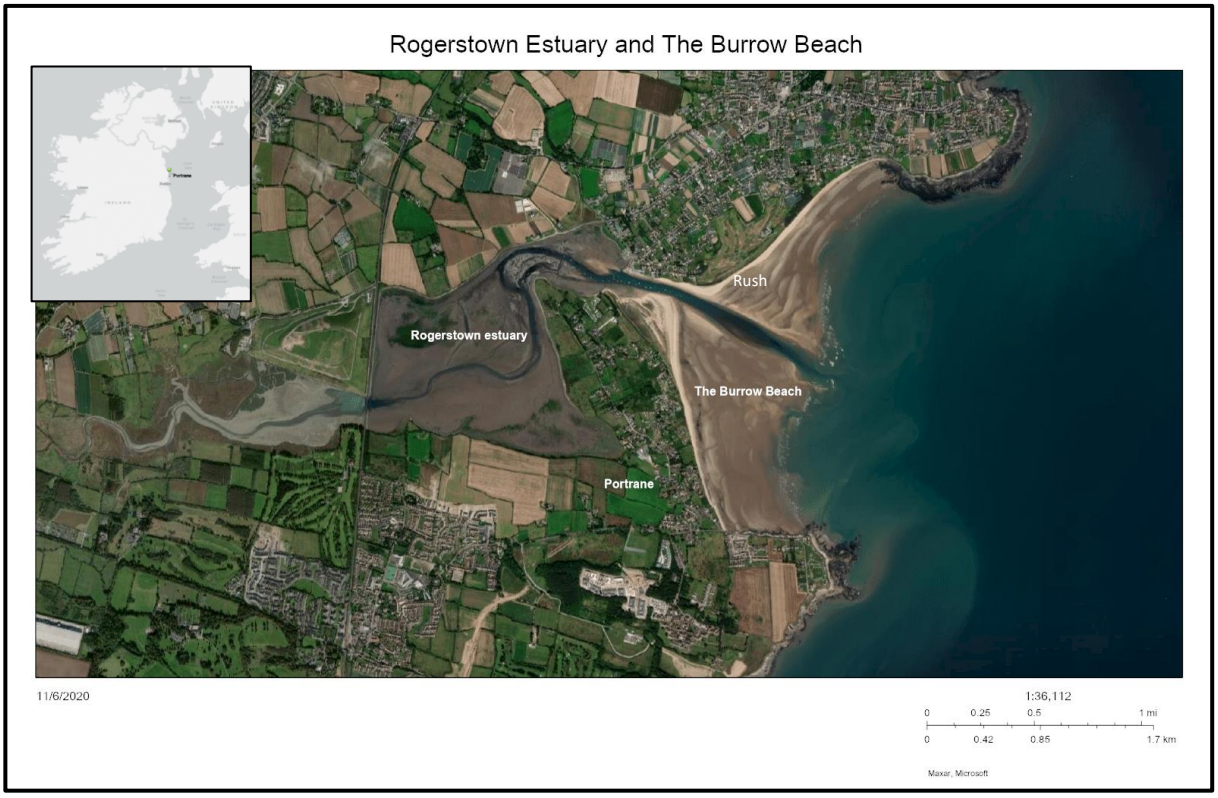


Figure 3: The location of Burrow Beach in Portrane peninsula, at the mouth of Rogerstown Estuary.

Coastal erosion at Burrow Beach (Figure 4) has been a longstanding concern for a number of decades. Since the late 1990s, studies have been undertaken to look at the options for coastal protection for this coastline. At present, the southern end of the beach is the area causing greatest concern. In recent years, coastal erosion has accelerated, and the sea is getting closer to private properties near the beach (RPS, 2013a). Recent studies found that Burrow Beach dune system retreated landward by more than 20 meters since 2013 (RPS, 2018a). Detailed information about Burrow Beach geological and environmental aspects, historical aspects, coastal erosion and future predictions are provided in the following sections.



Figure 4: Erosion observed at the dunes system of Burrow Beach, Portrane (February 2020).

1.3. Aims and Approach

There is an urgent need to address a current gap in policy related to coastal erosion management and climate change adaptation in Ireland. This gap has led to challenges for coastal communities and local authorities in addressing the impacts of climate change, since it has reduced the capacity to make decisions on coastal climate adaptation solutions. The study presented herein was conducted by members of MaREI with the collaboration of the University College Dublin and Fingal County Council (FCC) for the Coastal Communities Adapting Together (CCAT) project, in order to support Fingal County Council in managing responses to the impacts of climate change at Portrane, represented by the sustained process of coastal erosion at Burrow Beach and future flooding scenarios. This report aims to serve as a baseline assessment, providing a greater understanding of the coastal changes experienced around Portrane and the wider area over time and to examine the current and future impacts of climate change in order to support the development of adaptation plans and coastal management policies both locally and at a broader scale.

This assessment is both timely and necessary; despite the production of many reports over recent decades in regard to the problem of coastal erosion and flooding in Portrane, a lack of continuity and coordination between these studies over time was observed, i.e., the information was fragmented and dispersed, and this has hampered the decision-making process. A thorough collation of those studies was required in order to make this cohesive evidence base for decision and policy making available in a single document and provide a comprehensive understanding to support the choice of the best solution for Portrane.

This report collates the key findings of existing studies that have been produced up to 2020 in regard to the environmental aspects and impacts of climate change in Portrane. The methodology adopted consisted of a bibliographical search for studies previously published in white papers, grey literature, and peer-reviewed scientific literature concerning:

- the geological formation of Portrane peninsula;
- ecosystems, biodiversity and conservation areas;
- historical aspects of Portrane;
- climatology of the region;
- climate change predictions;
- current and expected future scenarios of coastal erosion and flooding; and
- screening for adaptation solutions.

A prioritisation of studies and reports for an in-depth analysis was made. The selected relevant information obtained from the literature survey is presented in this report according to the appropriate theme and displayed in chronological order.

The search also targeted the large body of coastal management, planning & development, and climate (including biodiversity) legislation, policies and plans at the national, regional and local levels. A detailed compilation of these documents is presented in the Appendix to this report.

This report is especially targeted at Fingal County Council, however, other local authorities across Ireland and relevant policymakers may find its content informative. Local residents and practitioners working with coastal erosion, flooding, and climate change adaptation can also avail from the information contained herein.

2. Geological, Environmental and Historical Aspects of Portrane

2.1. Geological Formation

Earth is 4.6bn years old. Ireland was covered by ice 2.6 million years before present (BP), during the Pleistocene epoch (Quaternary geological period) - the well-known "Ice Age". From 20 thousand years BP, the earth re-entered a warmer period and the ice sheet that covered Ireland started to melt, having completely gone from 10,000 years BP (Woodman and Devoy, 2021). The sea level, which had been settled 100 metres below its current position, started to slowly rise and revolved the seafloor sediment towards the coasts (Parkes, 2012; Woodman and Devoy, 2021). From 6,000 years BP the sea rose to a higher level than the present, flooding many coastal areas around Ireland (Woodman and Devoy, 2021). Subsequently, the sea receded to its current level and has remained stabilised for the past 5,000 years BP (Parkes, 2012).

The peninsula of Portrane is a sandy spit located between the Rogerstown Estuary and the Irish Sea (Morton, 1998). It forms part of the most northerly beach barrier system on the north coast of Dublin (Mulrennan, 1993). This kind of peninsula originated during the Quaternary geological period described above. The seafloor sediments revolved during these transgression and regression periods were exposed forming the so-called "barrier-island systems" (Parkes, 2012). A barrier-island system is a sand dune spit that separates the sea from coastal lagoons and estuaries. The exposed sediment has been moulded over thousands of years by this dynamic coastline system through the power of the wind, the sea and the waters of the Rogerstown Estuary, and these processes continue to reshape the coast.

The beach and dune systems at Burrow Beach, on the southern side of the mouth of the Rogerstown Estuary are part of one hydrogeological system, connected to the beach and dune system to the north of the estuary at Rush (Figure 3). This connection is reflected in the simultaneous growth and decline of the expanse of the beaches and the extent of the dunes at both locations. Sedimentation and erosion processes seem to occur on a cyclical basis within this sub-cell of the Irish Sea (Mulrennan, 1993; Gault et al., 2007).

The nature of the spit and beach is strongly influenced by the tidal action of the Rogerstown estuary, combining with the waves approaching the shoreline from the Irish Sea (Gault, et al. 2007). Lambay Island, which lies approximately 5km east of the beach, also influences both

the wave and tidal conditions seaward of the beach (Gault et al., 2007). A sand dune system occupies the spit but much of this has been lost over the last century with the conversion of fixed dunes to agricultural and residential land (Gault et al., 2007).

In the past, this wide and flat sandy beach together with an extensive dune system created an effective natural buffer against incident wave energy and erosive processes. In recent years acute erosion driven by climate change has exacerbated the loss of sand during frequent extreme waves and storm surges, and has increased the threat of further coastal erosion along the majority of Burrow Beach (RPS, 2018b). The erosion events will be described in detail in Section 3.

2.2. Ecosystems, biodiversity, and conservation areas

Portrane peninsula presents a variety of coastal ecosystems, such as beaches, sand dunes, salt marshes, mudflats and the Rogerstown Estuary. All these ecosystems are important and provide ecosystem goods and services that support life on earth, including biodiversity maintenance, food provision, erosion control of soils, water depuration, climate regulation, as well as recreational and cultural activities (MEA, 2015). The Rogerstown Estuary can be considered as a connector of all those environments.

Rogertsown Estuary is a relatively small estuarine site separated from the sea by a sand and shingle bar (NPWS, 2013a,b). The estuary is funnel shaped and extends for about 6km from east to west and up to 2km at its widest. The estuary is divided into two main sections by the Belfast-Dublin railway line, which crosses a viaduct built in 1840s: an inner and an outer section (McCorry, 2007). The outer larger section contains a large area of intertidal mudflats and is partially enclosed from the sea by Portrane Burrow. There is a small connection between the estuary and the sea north of Burrow Beach. The smaller inner section is fed by the Ballyboghil and Ballough Rivers that flow into the estuary to the west of the railway bridge draining an area of approximately 77 Km^2 (Morton, 1998; McCorry, 2007).

There is a large opening in the embankment that allows the tide to flood the inner section, although not all tides (low neaps) will flood the inner estuary (McCorry, 2007). Saltmarsh in the upper regions of the inner estuary is only covered significantly during higher spring tides (RPS, 2013a). The estuary drains almost completely at low tide and has a wide salinity range, from near full seawater at the mouth to near full fresh water at the estuary head (NPWS, 2013a).

The intertidal flats of the outer estuary mainly consist of sands, with soft muds in the north-west sector and along the southern shore, while in the intertidal flats in the inner estuary the sediments are mostly muds (RPS, 2013a). Saltmarsh fringes the estuary, especially the southern shores and parts of the outer spit. Salt meadows and wet brackish fields occur along the tidal river. A sandy peninsula stretches across the outer part of the estuary, restricting water flow to a channel of 200m in width (McCorry, 2007). An 1,800 metre fine sandy beach and intertidal sandflats occur at the outer part of the estuary. Dunes occur as low sand hills on the outer spit, including some small areas of fixed dunes and white dunes (McCorry, 2007).

The beach and the estuary are areas of significant environmental importance and hold a variety of National, European and international designations such as a Special Protection Area (SPA - Site Code 4015) and a Special Area of Conservation (SAC - Site Code 208) (Figure 5). Additionally, the outer estuary was designated under the Ramsar Convention on Wetlands in 1988 and hosts a proposed Natural Heritage Area at the national level.



Figure 5: Area covered by the Rogerstown Estuary SPA (in green) and area covered by the Rogerstown Estuary SAC (orange contour).

SPAs and SACs form the cornerstone of Europe's nature conservation policy and establish the EU wide Natura 2000 ecological network of protected areas, safeguarded against potentially

damaging developments (EC, 2020). SPAs are areas that have been designated to ensure the conservation of certain categories of birds under the European Birds Directive (Directive 79/ 409/EC; Amended by the Directive 2009/147/EC). SACs are areas that ensure the conservation of a wide range of rare, threatened or endemic animal and plant species, and termed priority habitats under the EU Habitats Directive (Directive 92/43/EEC). Habitats that require designation and specific conservation measures are termed Annex I habitats. The Annex II list comprises species that must be afforded special protection. It is the responsibility of each EU Member State to protect Annex I habitats and Annex II species.

Portrane SAC sites have been selected from the prime examples of wildlife conservation areas, such as the habitats and species listed on Annex I and Annex II of the EU Habitats Directive: Estuaries, Mudflats and Sandflats not covered by seawater at low tide, *Salicornia* and other annuals colonising mud and sand, Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*), Mediterranean salt meadows (*Juncetalia maritimi*), Shifting dunes along the shoreline with *Ammophila arenaria* (White Dunes), and Fixed coastal dunes with herbaceous vegetation (Grey Dunes) – with the latter classified as a "priority habitat". The first category represents marine habitats, the following three categories represent saltmarsh habitats and the last two are associated with sand dune systems. These habitats are found in close association with each other.

Two plant species that are legally protected under the Flora (Protection) Order 1999, occur within the site: Hairy Violet (*Viola hirta*) occurring on the sand spit; and Meadow Barley (*Hordeum secalinum*) occurring in the salt marshes of the inner estuary. Meadow Barley distribution has declined apparently due to reclamation and embankment of lands fringing the estuaries. Another rare species, Green-winged Orchid (*Orchis morio*), occurs in the sandy areas of the outer estuary (NPWS, 2013a).

Fish recorded in Rogerstown Estuary include Sprat (*Sprattus sprattus*), Flounder (*Platichthys flesus*) and Sea Bass (*Dicentrarchus labrax*), and a total of 15 species were recorded during sampling for Water Framework Directive monitoring (CRFB, 2008; NPWS, 2013b). Records of juvenile bass in Rogerstown estuary highlights the importance of the estuary as a nursery ground for this species (NPWS, 2013b).

Bird species, marine habitats, saltmarshes and sand dunes systems protected under Rogerstown Estuary SPA and Rogerstown Estuary SAC are described in detail below.

a) Bird species protected under the Rogerstown Estuary SPA

Rogerstown Estuary is of high importance to wintering wildfowl and is rated as the most important estuary for wildfowl and waders in County Dublin after North Bull Island (NPWS, 2013a,b). Much of the outer part of the estuary is owned by NPWS and has been designated as a nature reserve (NPWS, 2013a,b). Birdwatch Ireland own two plots of land on either side of the estuary and these areas are managed as a nature reserve (McCorry, 2007). The overarching Conservation Objective for Rogerstown Estuary SPA is to ensure that waterbird populations and their wetland habitats are maintained at, or restored to, favourable conservation conditions. This includes, as an integral part, the need to avoid deterioration of habitats and significant disturbance; thereby ensuring the persistence of site integrity.

The site is selected as a Special Protection Area (SPA) and of special conservation interest (SCI) for the following wintering species: Greylag Goose (*Anser anser*); Light-bellied Brent Goose (*Branta bernicla hrota*); Shelduck (*Tadorna tadorna*); Shoveler (*Anas clypeata*); Oystercatcher (*Haematopus ostralegus*); Ringed Plover (*Charadrius hiaticula*); Grey Plover (*Pluvialis squatarola*); Knot (*Calidris canutus*); Dunlin (*Calidris alpina*); Black-tailed Godwit (*Limosa limosa*); and, Redshank (*Tringa totanus*).

The wetland habitats contained within the SPA are considered to be an additional Special Conservation Interest (SCI) because of its conservation importance for non-breeding (wintering) migratory waterbirds.

During the data period 1994/95 – 2009/10, the Irish Wetland Bird Survey (I-WeBS) recorded a total of 79 waterbird species within the Rogerstown Estuary, of these, 30 waterbird species occurred on a regular basis within the Rogerstown Estuary. Eleven of these species are listed as Special Conservation Interest (SCIs) for the SPA, and an additional 19 were non-SCI species. During the 2011/12 Waterbird Survey Programme, a total of 43 waterbird species were recorded.

b) Marine habitats protected under the Rogerstown Estuary SAC (Estuaries, Mudflats and Sandflats)

Marine habitats are protected under the qualifying interests of the SAC - Annex I “Estuaries and Mudflats and sandflats not covered by seawater at low tide”. The conservation objectives for these habitats are to: 1) maintain the favourable conservation condition of estuaries in Rogerstown Estuary SAC, which is defined by the following list of attributes and targets; and,

2) maintain the favourable conservation condition of mudflats and sandflats not covered by seawater at low tide in Rogerstown Estuary SAC (NPWS, 2013d).

Within Rogerstown Estuary SAC four community types are recorded: Sand to coarse sediment with *Nephtys cirrosa* and *Scolelepis squamata* community complex; Estuarine sandy mud to mixed sediment with *Tubificoides benedii*, *Hediste diversicolor* and *Peringia ulvae* community complex; *Mytilus edulis*-dominated community complex; *Zostera*-dominated community.

Sand to coarse sediment with *Nephtys cirrosa* and *Scolelepis squamata* community complex: This community complex has an indicative area of 160ha. This community complex is recorded on the eastern margins of this site from Rush south to the beach at Portrane. It extends westward to the pier at the mouth of the Rogerstown Estuary. In the bay at the eastern margins of the site the sediment is that of fine sand becoming coarser in the channel of the estuary. Fine sand and gravel account for 3.9% to 78.1% and 1.2% to 13.4% of the sediment fractions, respectively (NPWS, 2013d). This community complex is characterised by low numbers of species and individuals. It is distinguished by the polychaetes *Nephtys cirrosa* and *Scolelepis squamata*; the oligochaete *Tubificoides benedii* is also recorded throughout the complex in low abundances. The bivalves *Angulus tenuis* and *Donax vittatus* are recorded in moderate abundance in the subtidal at the north-eastern margins of the site. The polychaete Scoloplos armiger, the isopod *Eurydice pulchra* and unidentified crustaceans of the Gammarid family are not uniformly distributed within the complex. Extensive mats of *Ulva* spp. cover large areas of the intertidal at the village of Portrane (NPWS, 2013d).

Estuarine sandy mud to mixed sediment with *Tubificoides benedii*, *Hediste diversicolor* and *Peringia ulvae* community complex: This community complex has an indicative area of 198ha. This community complex is recorded extensively within the estuary to the west of Burrow. It occurs from the intertidal to the shallow subtidal. The sediment ranges from sandy mud to mixed sediment, with silt-clay and gravel accounting for 1.8% to 87.9% and 0.1% to 45.5% of the sediment fractions, respectively; the remaining sand fractions range from 9.8% to 98.1% (NPWS, 2013d). This community complex is characterised by the presence of the oligochaetes *Tubificoides benedii*, the polychaete *Hediste diversicolor*, the gastropod *Peringia ulvae*. The polychaete *Pygospio elegans* and the oligochaetes *T. pseudogaster* and *Heterochaeta costata* also occur. On the northern shore east of the railway bridge casts of the burrowing polychaete *Arenicola marina* are present in densities of 17 to 22m^2; the green algae *Ulva sp*. also occurs along with unidentified fucoids where rock outcrops occur (NPWS, 2013d).

Mytilus edulis-dominated community complex: This community complex has an indicative area of 11ha. Dense beds of the bivalve *Mytilus edulis* are recorded on the lower intertidal at the narrows between Rogerstown and Burrow Beach; these beds overlay a substrate of muddy sand. The complex is distinguished by dense aggregations of the bivalve *Mytilus edulis*; the gastropod *Littorina littorea* and small individuals of the crab *Carcinus maenas*. The barnacles *Balanus balanus* and *Semibalanus balanoides* occur as heavy encrustations on the *M. edulis* shells; the fucoid *Fucus vesiculosus* is also recorded attached to mussel shells. Where the beds are less dense the algal species *Fucus serratus*, *F. vesiculosus*, *Ascophyllum nodosum* and *Ulva sp*., along with the polychaete *Arenicola marina* are recorded (NPWS, 2013d).

Zostera-dominated community: This community complex has an indicative area of 1ha. This intertidal community occurs in the inner estuary at Portrane with a single bed dominated by *Zostera noltii* with a percentage cover of 50%. The sediment is that of "Estuarine sandy mud to mixed sediment complex". Dense aggregations of the gastropod *Hydrobia acuta neglecta* occur and the green algal species *Ulva sp*. is also abundant. The polychaete *Arenicola marina* is recorded in densities of between 6 to 12m^{-2} and the crustaceans *Carcinus maenas* and *Crangon crangon* are also recorded within this community. The infauna is that of the "Estuarine sandy mud to mixed sediment complex" (NPWS, 2013d).

c) Saltmarshes protected under the Rogerstown Estuary SAC

Saltmarshes are areas of vegetation that occur along sheltered coasts, mainly on mud or sand, and are flooded periodically by the sea. They are restricted to the area between mid neap tide level and high water spring tide level. Saltmarshes contain several distinct zones that are related to elevation and frequency of flooding. The lowest part along the tidal zone is generally dominated by the most halophytic (salt-tolerant) species including common saltmarsh-grass (*Puccinellia maritima*) and species more usually associated with Salicornia muds. The mid-marsh zone is generally characterised by sea thrift (*Armeria maritima*), sea plantain (*Plantago maritima*) and sea aster (*Aster tripolium*). This mid-zone vegetation generally grades into an herbaceous community in the upper marsh, dominated by red fescue (*Festuca rubra*), sea milkwort (*Glaux maritima*) and saltmarsh rush (*Juncus gerardii*).

In Portrane, three saltmarsh habitats are listed under Annex I of the EU Habitats Directive (92/43/EEC): Salicornia and other annuals colonising mud and sand, with a total area of 0.90ha; Atlantic salt meadows (ASM) (*Glauco-Puccinellietalia maritimae*), with a total area of 37.2ha;

and Mediterranean salt meadows (MSM) (*Juncetalia maritimi*), comprising a total area of 2.18ha (NPWS, 2013a).

Within the SAC, ASM and Salicornia flats are particularly well represented, while MSM is present only in small amounts along the southern side of the inner estuary (NPWS, 2013a). Salicornia mudflats habitat occurs at several locations within the inner and outer estuary. Small strips of glasswort (Salicornia sp.) between 1-5m wide occur along the seaward edge of the ASM, along the southern side of the inner estuary. Narrow strips of this habitat 2-5m wide are also situated along the edge of the berm along the northern side of the inner estuary. This habitat also occurs at the tip of Portrane Burrow as a narrow strip about 5m wide on sandy mud. This habitat also occurs on the south-eastern corner of the outer estuary, where small patches of Salicornia flats occur on a narrow band of exposed mud between the Spartina swards and the ASM vegetation along the shore (McCorry 2007; NPWS, 2013a).

The overall objective for Salicornia and MSM is to 'maintain the favourable conservation condition', and for ASM is to 'restore the favourable conservation condition'. For the three habits the target is that their areas should be stable or increasing, subject to natural processes, including erosion and succession (NPWS, 2013a).

The conservation value of the saltmarsh at Rogerstown Estuary is also enhanced by the presence of rock sea lavender (*Limonium binervosum*), a Red Data Book Species (Curtis and McGough, 1988). This species is present in the sandier parts of the mid marsh zone and is associated with patches of bare substrate (McCorry, 2007; NPSW, 2013a).

The only invasive and non-native species recorded on saltmarshes during the Saltmarsh Monitoring Project was common cordgrass (*Spartina anglica*), species that should be absent or under control (NPSW, 2013a). This species was recorded frequently in the SAC where it forms swards on the intertidal mudflats and mosaics with ASM (McCorry, 2007).

In the outer estuary at Portrane Burrow, there are zonations between saltmarsh and sand dune habitats (McCorry, 2007; Ryle et al., 2009).

d) Sand dunes protected under the Rogerstown Estuary SAC

Portrane sand dune system is located on Burrow Beach sand spit, which partly covers the mouth of the outer section of the Rogerstown Estuary. The narrow band of sand dune edges the eastern and the northern side of the spit (Ryle et al., 2009). A saltmarsh habitat occurs behind the sand

dunes at the northern tip and the southern end of the spit is bounded by a sea wall beyond which is a rocky headland (NPWS, 2013a).

The Coastal Monitoring Project (Ryle et al., 2009) categorised this habitat as a "Sand Dune System". Sand dunes systems are hills of wind blown sand that have become progressively more stabilised by a cover of vegetation. In general, most sites display a progression through annual vegetation of driftlines (strandline), embryonic dunes (foredunes), mobile dunes (White Dunes), and fixed dunes (Grey Dunes) (NPWS, 2013a). These four dune habitats were recorded by Ryle et al. (2009) in Rogerstown Estuary SAC but only two habitats are listed as Qualifying Interests: Shifting dunes along the shoreline with *Ammophila arenaria* (White Dunes); and Fixed coastal dunes with herbaceous vegetation (Grey Dunes).

The overall conservation objectives for 'Shifting dunes along the shoreline with *Ammophila arenaria'* and for 'Fixed coastal dunes with herbaceous vegetation' in Rogerstown Estuary SAC is to 'restore the favourable conservation condition'. The target is to maintain the natural circulation of sediment and organic matter throughout the entire dune system, without any physical obstructions (NPWS, 2013a).

The total area of Portrane sand dune system is 9.5 ha. The embryonic dunes are located in the accreting centre section of the site and comprise 1.672 ha in area. The mobile dunes (White Dunes) are largely confined to the centre section of the site due to erosion in the north and pressure from human activities in the south, and accounts for 1.232ha of sand dune habitat. The priority habitat fixed dune comprises 5.712ha of the total sand dune habitat. The overall computation excludes approximately 40ha of fixed dunes that have been lost to housing and caravan parks (Ryle et al., 2009).

Four Red Data Book plant species have been recorded from this SAC site including green-winged orchid (*Orchis morio*), hairy violet (*Viola hirta*), meadow barley (*Hordeum secalinum*) and rough poppy (*Papaver hybridum*). The last three are also listed under the Flora (Protection) Order (1999) and are legally protected. *Orchis morio* and *Viola hirta*, which have been previously recorded at fixed dunes at Portrane, were not found during the Coastal Monitoring Project (Ryle et al., 2009).

Ryle et al. (2009) classified this dune system as having a poor prospect of sand dune habitat, mainly due to the impact of existing recreational disturbance, the spread of scrub, and a high cover of unhealthy specimens of marram grass (*Ammophila arenaria*). Negative indicators

include the presence of non-native species, such as bracken (*Pteridium aquilinum*) recorded in fixed dune at Portrane along with spear thistle (*Cirsium vulgare*), ragwort (*Senecio jacobaea*) occurring occasionally in the mobile dunes, and bramble (*Rubus fruticosus*). Sea buckthorn (*Hippophae rhamnoides*) has been planted at the southern end of the site and is advancing towards the fixed dune (Ryle et al. 2009).

According to monitoring research conducted in 2007 (Gault et al., 2007), sea buckthorn stands were observed at a small area of foredune in the middle section of Burrow Beach. Although stands presented a limited extent (100m^2), adjacent areas of dune were being colonised by young sea buckthorn suckers, and if it continues to grow unchecked its rapid spread is inevitable.

2.3. Historical Aspects of Portrane

Fingal Development Plan considers Portrane as a small town adjacent to the larger agglomeration of Donabate. Speculations around the origins of the name Donabate, suggest that it can be derived from "du-na-bhaid-at", meaning "the region of the swelling sea", as descriptive of a locality over which the tide flows to a large extent (Moylan, 1960b). Portrane is composed of three distinct areas: Portrane Village, Burrow Beach, and St. Ita's Hospital.

The settlement of Portrane dates back from the 12th century when it was an important fishing centre (Moylan 1960a). Moylan portrays the history of Portrane, specially describing the heritage buildings, landowners, and recounting the influence of the church in the area. Natural aspects of Portrane were described by Moylan (1960a) as "*consisting of approximately 5,000 acres enclosed between two arms of the sea – the Rogerstown Creek on the North and the Malahide Estuary on the south. The eastern end, shaped somewhat like the head of a hammer, is largely composed of sand dunes at its northern and southern extremities, with a rocky portion in the centre*". Moylan (1960a) calls attention to the natural flood in a central area of Portrane demesne named Ballymastone, describing that in 1641 it was a bog 80 acres in extent, which was seasonally inundated in winter.

Important heritage sites are a round tower erected about 1844, a church, the St. Ita's hospital, a castle, and there is evidence of a buried rath (Moylan 1960a). The establishment of the St. Ita's Hospital in 1887 (a mental health facility in Portrane), led to great changes in the estate. The demesne was much more densely wooded, and a great clearance of matured timber had to be made during war years to provide fuel to power plants (Moylan 1960a).

The building of a round tower in the north-eastern elevated portion of Portrane dates back to 1844, during the Evans family tenure. The area also comprised a deer park, however, there is no trace that this portion was ever wooded to justify such park classification (Moylan 1960a). In the northern portion of the park, there seems to have been many habitations known as the Oldtown, and ruins of some of these structures are still alongside the road (Moylan, 1960a). The remains of the old church of Portrane are located near the north access to the hospital. A short distance from the north-west of this church there are also ruins of a Norman Peel tower, one of three found on the peninsula (Moylan 1960a).

Today, Portrane has a population of approximately 1,500 inhabitants. A progressive decline in the population is due to the reduction in the institutional population of the hospital, which has been subject to a gradual phasing out of residential care over the past two decades (RPS, 2013a).

This part of Fingal is low-lying and dominated by agricultural land with arable crops prominent. There are also many urban areas of various sizes around the estuary. A large part of the north-east corner of the inner estuarine mudflats was infilled as a landfill site. Balleally Landfill operated from 1971 to 2004 and was the largest landfill in the Dublin region (FCC, 2003a). It was designed on a 'dilute and disperse' principle with no leachate containment measures put in place. A subsequent licence for an engineered landfill was granted and following a further extension the landfill finally closed at full capacity in May 2012.

Rogerstown Estuary has a history of pollution and water quality issues including eutrophication (Fahy et al., 1975) and heavy metal pollution attributed to emissions from Balleally Landfill. Furthermore, the estuary catchment includes a large market gardening area and, as the soils are sandy, they are conducive to substantial run-off from fields (FCC, 2003b; NPWS, 2013a.b). More recently, the water quality of Rogerstown Estuary has been classified as moderate as per the Eastern River Basin District Management Plan (transitional waters) (ERBD, 2010); the largest contributory factor to poor quality being identified as wastewater. Physical modifications and water abstraction are also identified as pressures on the system (ERBD, 2010). The imbalance of nutrients from anthropogenic origins can distress saltmarshes and algae growth, and affect marine fauna distribution, with consequently impact on the waterfowl of the designated areas (NPWS, 2013b).

A new purpose-built 65,000 PE (population equivalent) Wastewater Treatment Plant was opened at Portrane in June 2012. It serves the communities of Portrane, Donabate, Rush and Lusk. Prior to its completion the four communities had separate wastewater schemes including combinations of treatment, septic tanks and discharges of effluent to Rogerstown Estuary as well as untreated marine discharge into the Irish Sea. The new plant has a 600 metres long marine outfall from Portrane, outside the SPA boundary (NPWS, 2013b). Burrow Beach achieved Blue Flag status in 2006 - Blue Flag is a well-recognised eco-label, awarded to beaches with excellent environmental management (FCC, 2007).

Burrow Beach is a valuable and popular amenity with residents and visitors alike including a significant population of summer residents who stay in the caravan parks and beach houses dotted along that part of the peninsula (FCC, 2007; Gault et al., 2007; NPWS, 2013a,b). Historical photographs from the 1950s show that the middle section of Burrow Beach was relatively undeveloped when compared to the present time. Most of the properties constructed during this period consisted of small cottages and holiday caravans, although none of these properties was as near to the shoreline as currently observed (RPS, 2020b). In the 2000s there has been an increase in the number of buildings and level of planning applications (Gault et al., 2007). However, despite the privilege of having a house with a sea view, the close proximity of these developments to the dune system places them in a risky position, especially in relation to the challenge off climate change. According to the Fingal Development Plan (FCC, 2017 – further discussed in section 4), the gradual removal of temporary mobile homes, huts and wooden chalets at the site (which are often accompanied by poor wastewater infrastructure) is encouraged.

3. The changing climate and its effects on Portrane coast

3.1. Climate Change in the Coast of Ireland

Climate change effects are expected across Ireland's more than 7000km of coastline (Devoy, 2008). Ireland has a total population of 4,761,865, of which approximately 1.9 million people (40%) reside within five kilometres of the coast; within this, 40,000 reside less than 100 metres away from the sea (CSO, 2016).

A study evaluated the effects of climate change on the future climate of Ireland by comparing simulations for the reference period (1981–2000) to simulations for the future period (2041–

2060) (Nolan and Flanagan 2020). The study indicates that mid-century mean annual temperatures are projected to increase by 1–1.2°C and 1.3–1.6°C considering the IPCC SSP2-4.5 and SSP5-8.5 scenarios respectively, and temperature projections show a west-to-east gradient, with the largest increases in the east (Nolan and Flanagan 2020). Heatwave events are expected to increase by the middle of the century from 1 to 8 for the SSP2-4.5 scenario and from 3 to 15 for the SSP5-8.5 scenario (with the largest increases in the south-east), while the number of frost days (days when the minimum temperature is lower than 0°C) is projected to decrease by 45% and 58% for the SSP2-4.5 and SSP5-8.5 scenarios, respectively (Nolan and Flanagan 2020).

Considering the precipitation scenarios – an important aspect to predict future floods events – mid-century precipitation climate is expected to become more variable with substantial projected increases in both dry periods and heavy precipitation events (Nolan and Flanagan 2020). The study published by Nolan and Flanagan (2020) indicates an expected substantial decrease in precipitation for the summer months and small projected changes in precipitation in other seasons, with the exception of winter when precipitation is expected to increase by approximately from 0 to 11% under the SSP5-8.5 scenario. Heavy precipitation events are expected to be more frequent over the year as a whole and a "likely" projected increases of 5–19% in the winter and autumn months (Nolan and Flanagan 2020). The report did not provide an explicit precipitation scenario to the east coast of Ireland. The authors considered that regional details were not reliable because of a large spread in the datasets. Nevertheless, it was noticed that annual precipitation was 6% higher in the period 1989–2018, compared with the 30-year period 1961–1990, and the decade 2006–2015 has been the wettest on record (García and Dwyer, 2021).

Mid-century mean wind speeds are projected to decrease for all seasons, especially for summer months under the SSP5-8.5 scenario (from 2% to 5.4%). Considering wind storms, the study results suggest an overall reduction of approximately 10% in the numbers of less intense storms and suggest an eastward extension of the more severe wind storms over Ireland from the middle of the century (Nolan and Flanagan 2020). Previous projections of future extreme storm events over Ireland are in broad agreement with Nolan and Flanagan (2020) results, such as Semmler et al. (2008a,b), Nolan (2015), and McGrath and Nolan (2017). As extreme storms are rare events, the storm projections should be considered with a high level of caution and future work

will focus on a more robust statistical analysis of extreme storm track projections (Nolan and Flanagan 2020).

A climate risk screening process for Ireland (Flood et al., 2020) indicated that, in the short term, priority climate risks are associated with rising sea levels, increased frequency and intensity of flooding, increased frequency and intensity of wind storms, freezing conditions and overall changes in climate. In the medium to long term, risks associated with rising sea levels are expected to increase, particularly in the context of projected increases in the intensity of coastal storms. Risks associated with projected increases in temperature and low levels of precipitation, resulting in heatwaves and drought, are expected to increase in the long term, while risks associated with freezing conditions are expected to decrease (Flood et al., 2020).

Studies using satellite observations indicate that the sea level around Ireland has risen from approximately 2–3 mm per year (García and Dwyer, 2021) to 4–6 mm per year (EEA, 2012; Flood and Sweeney, 2012) since the early 1990s. Analysis of sea level data from Dublin Bay show a rise of approximately 1.7 mm per annum since 1938 (Dwyer, 2012; García and Dwyer, 2021), consistent with global average rates.

Estimates of land inundation on the Irish coast indicate that approximately 350 km^2 of land is vulnerable to flooding under the sea level rise scenario of 1 metre, expanding to 600 km^2 of vulnerable land for a sea level rise scenario of 3 metres (Devoy, 2008; Flood and Sweeney, 2012). According to the studies, although the east coast of Ireland receives only about 20% of the wave energy levels occurring on western Atlantic shoreline, coastal erosion rates on "soft coasts" (i.e., coasts constituted by sandy systems and glacial sediments), can reach average values of 0.2–0.5 m/year, commonly rising to 1–2 m/year on southern and eastern coasts (Devoy, 2008).

3.2. Morphogeological and Physical Aspects of Burrow Beach, Portrane

Burrow Beach is situated between the rocky headlands at Portrane and the mouth of Rogerstown Estuary. On the northern side of the estuary mouth lies Rush Beach. The section of the coastline between Rush and Portrane forms a mini sub-cell within the east coast sub-cell from Howth to Skerries (Mulrennan, 1993) (Figure 6).

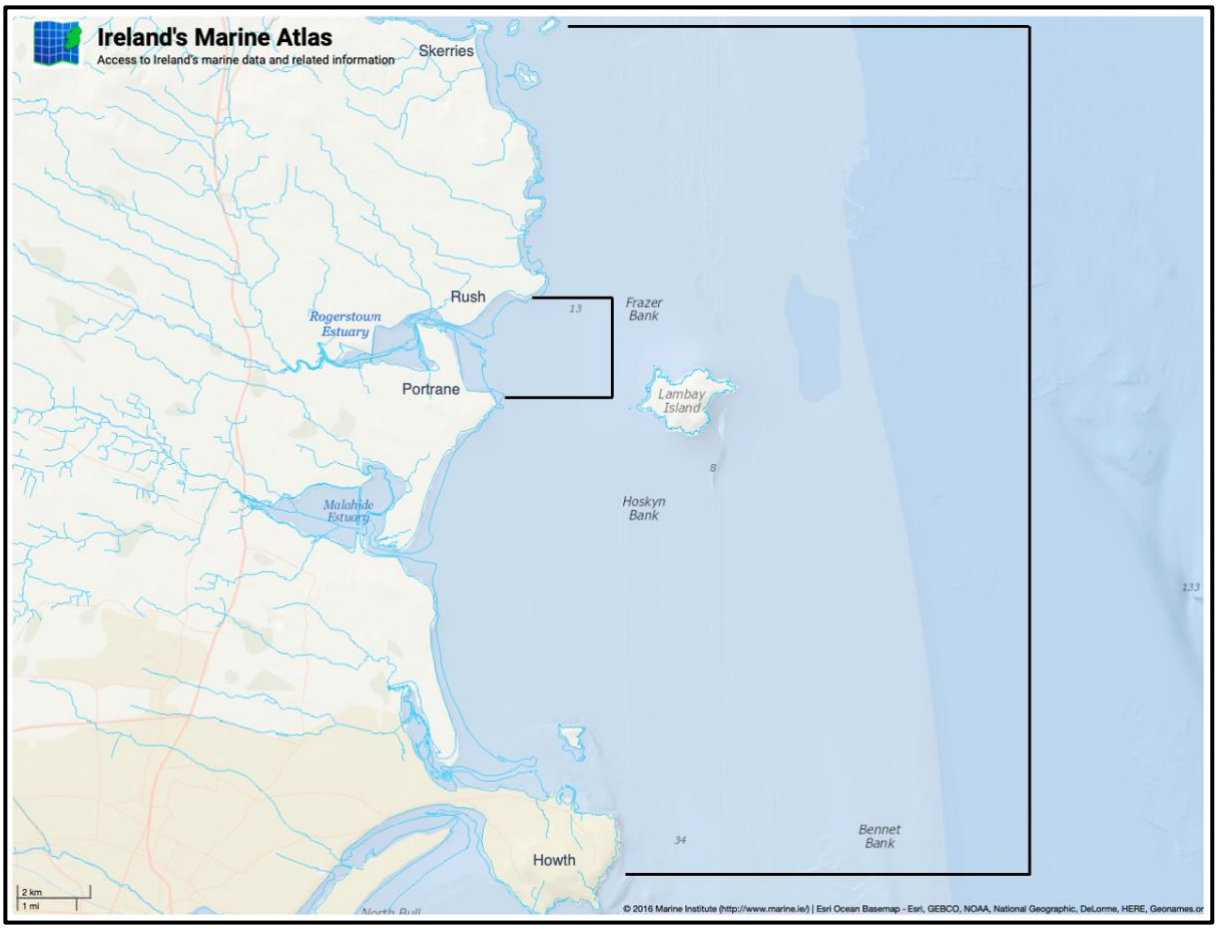


Figure 6: Location of Portrane peninsula within the east coast sub cell from Howth to Skerries (Adapted from Ireland's Marine Atlas, Source: Marine Institute).

The beach is adjacent to an extensive shallow tidal flat (Figure 7). Sediment analysis conducted by the consulting company RPS (RPS, 2013a) showed that the majority of Burrow Beach sediment consists of fine sand, with size of the grains ranging from 0.18 to 0.2mm. This size grain infers that saltation will be the most significant mode of sediment aeolian transport (transport by the wind). The threshold wind velocity for the commencement of transport is about 5.5 m/s and above this velocity the rate of transport will be proportional to the cube of the wind speed. Thus, during onshore winds of Beaufort Force 4 (classified as Moderate Breeze: 5.5–7.9 m/s) and above, large amounts of sand can be transferred from the upper dry beach to the dunes. Based on 15 years of wind records (from 1997 to 2011), these conditions are likely to occur for about 19% of the time at the Portrane beach in an average year (RPS, 2013a).

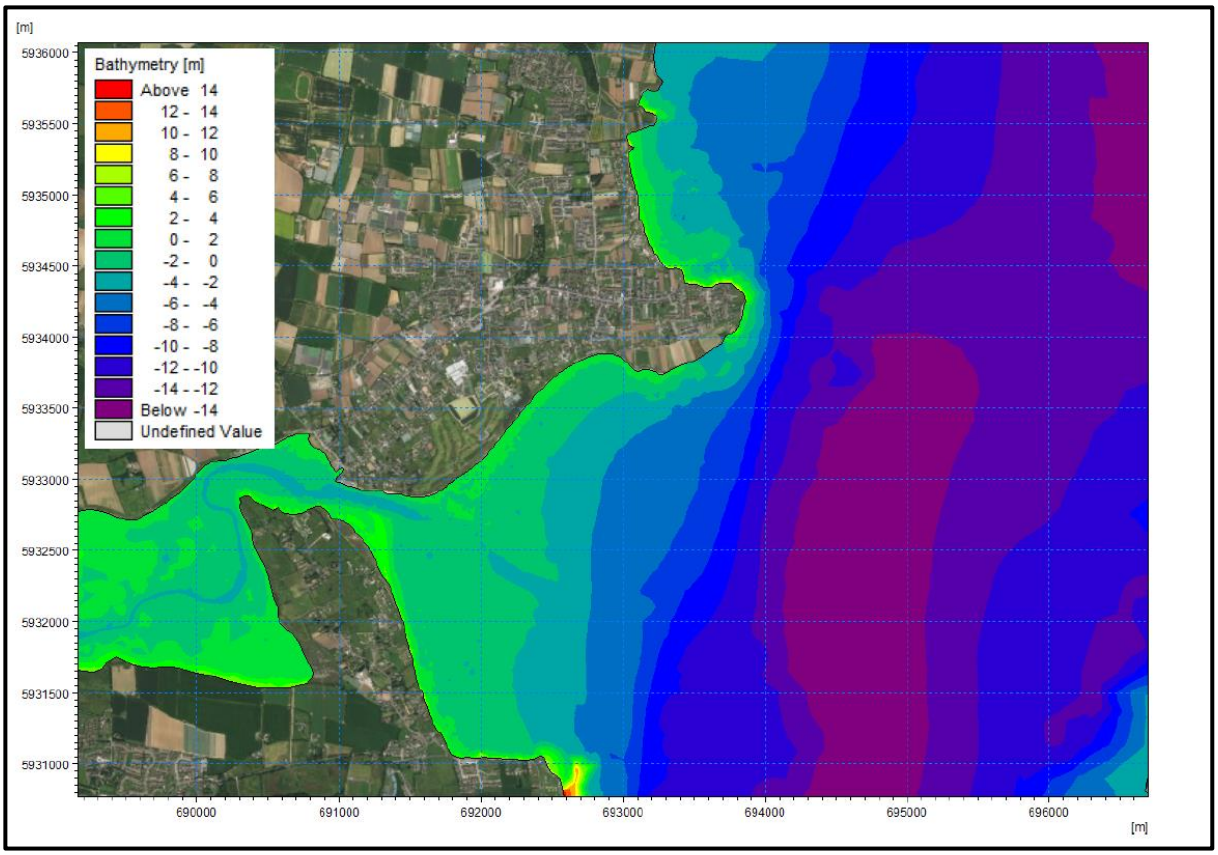


Figure 7: Bathymetric chart of Portrane marine area (Source: RPS, 2020a).

The wind data for the years 1997-2011 showed consistency throughout the data set, with the majority of the wind coming from the north west, west and south west direction. Although, a change was observed in the 2004-2011 records as strong winds from the north east and south east become more frequent (RPS, 2013a).

Considering this wind pattern, Burrow Beach is most of the time sheltered by the coastline between Howth and Skerries against strong winds and main swell activity from the north west, south west, and west sectors. Even though less frequent, strong winds and swell activity originating in the north east and south east sectors have the potential to increase the amount of incident wave and swell energy that arrive at the beach (RPS, 2013a). Due to this shoreline configuration, the wave climate and tidal regime to seaward of the beach is influenced by Lambay Island and its associated Frazer and Hoskyn Banks.

The 3 hourly data set generated from UK Meteorological. Office and ECMWF (European Centre for Medium Range Forecasts) records for 1997-2011 showed that generally the swell wave activity was considerably lower during the summer months in comparison to the winter months of December through to January, when the highest swell waves are observed (RPS,

2013a). The dominant waves that affect Burrow Beach generally approach from the north east and south easterly sectors (RPS, 2020a). Waves from the south easterly direction are predominant, although storms from the north east occur occasionally (RPS, 2013a).

Consequently, the littoral currents and longshore sediment drift tend to move sand in the middle and lower beach in a north westerly direction during south/south easterly wave conditions (more frequent) and in a south westerly direction during north easterly wave conditions (less frequent) (RPS, 2013a). Studies suggest that there is potentially more sediment drift past the Portrane headland from the south during an average year than is transported north out of the system past the Rush headland (Morton, 1998). The net gain in sediment quantity to the Portrane-Rush beach system in an average year was calculated at 4,240 m^3 per year (RPS, 2013a).

The tidal currents around the study area are complex due to the interaction of Rogerstown Estuary and the Irish Sea tides influenced by Lambay Island (RPS, 2013a; RPS, 2020a). The Rogerstown Estuary exerts a strong influence on the sediment regime of the Rush and Portrane beaches with tidal currents of up to 1.4 m/s in the channel into the Rogerstown Estuary (RPS, 2013a). At low water, this current is met with little resistance from the main body of water outside of the estuary which facilitates an acceleration of flow at the mouth of the estuary, and when the tide begins to turn during mid-flood, current flows from the estuary are impeded which is reflected in a reduction in current velocities (RPS, 2020a).

In the 1840s, the Rogerstown Estuary was divided by a causeway and narrow bridge to carry the Dublin to Belfast Railway line (RPS, 2013a). The construction of the railway across North Dublin estuaries in conjunction with the increase in estuarine reclamation has reduced the volume of the tidal prism, weakening the ebb and flood currents. This disruption of the tidal regime has led to substantial hydrodynamic and morphological changes in the barrier-island systems of North Dublin, which combined with an increase in the recreational pressure, have been responsible for recent degradation and shoreline recession in many of these barrier-island systems (Mulrennan, 1993). Due to the constriction of tidal flow between the inner and outer sections of the Rogerstown Estuary caused by the railway viaduct, drainage from the inner estuary continues for 2-3 hours after low tide (NPWS, 2013b).

The current flows along the beach do not generally exceed 0.25m/s during any phases of the spring tidal regime, even though it was verified that even during mid-flood and mid-ebb

conditions, the tide almost reaches the toe of the dunes along Burrow Beach (RPS, 2020a). The amount and nature of the sediment transport is strongly influenced by the wave activity and the majority of the changes in the beaches and dunes only occur during significant wave events.

As the dominant wave direction at the Portrane beach is from the south east, the majority of the sediment movement occurs during south and south easterly gales. According to RPS assessment (2013a), during the upper part of the tidal cycle the drift along the upper Portrane beach is in a northerly direction and is in a westerly direction along the upper part of the western section of the Rush Beach. Sediment is also being fed north westerly towards the Portrane beach from the headland at Portrane. By mid ebb, when the ebb jet from the estuary becomes established, sediment is carried out by the estuary ebb flow and moves north towards the headland at Rush. At the same time there is also a small amount of northerly drift along the upper part of the southern section of the Portrane beach (RPS, 2013a). The model analysis undertaken by RPS in 2013 indicated that the sediment drift regime did not change since the analysis undertaken in 1998 by Morton. There is usually a northerly drift along the upper Portrane beach and a westerly drift along the western section of the Rush Beach. The sand that enters into the Rogerstown Estuary is then carried out by the ebb jet feeding back the beaches enabling a dynamic equilibrium under the existing climatic conditions (RPS, 2013a).

Previous studies of Burrow Beach area had identified a potential long-term pattern in the sediment transport regime whereby sand material was gradually eroded from the beach and dunes along Burrow Beach and transported to the beach at Rush South. However, a recent study found that the effect of the strong currents from the Rogerstown Estuary are likely to prevent any significant volumes of sediment being transported from along Burrow Beach to Rush south. These same strong currents are expected to prevent any significant volume of sediment being transported from Rush back to Burrow Beach which may contribute to a deficit in the sediment supply (RPS, 2020a).

RPS (2020a) assessed the long-term sediment transport at the Rogerstown estuary between 1979 and 2017. The net drift of sediment material at Burrow Beach was confirmed to be always in the northward direction (towards the Rogerstown estuary). The net annual average littoral drift along Burrow Beach was found to be nearly 13,000m^3 per year in a northerly direction towards the Rogerstown estuary. The net drift ranged from nearly 8,000m^3 in 1992 to as much as 21,000m^3 in 1996 and 2002. This variability is governed primarily by the frequency and magnitude of storm events which are most common during the winter months. Sediment

transport during winter (December to February) was found to be as much as four times greater than that observed during any other season (RPS, 2020a). During a south easterly event, sediment is transported along the beach of Burrow towards the north. The strong tidal jet from the Rogerstown estuary prevents the bulk of this material reaching Rush South. The currents from the Rogerstown estuary effectively intercepts the transport of sediment between Burrow Beach and Rush and transports it offshore. Over the long term, this could lead to a deficit in the supply of sediment to Burrow Beach and therefore contribute to erosional pressures. This material will instead be transported offshore and potentially lost from this local sediment cell. Given the distance of the beaches at Burrow Beach and Rush from the offshore region, it is unlikely that this material would be transported back onshore (RPS, 2020a).

The findings from this latest assessment indicate that the sediment transport regime along Burrow Beach is no longer in a state of dynamic equilibrium due to a deficit in the supply of sediment. This deficit enhances existing erosion pressures along Burrow Beach coastline. This shift can be attributed to an increase in the frequency and magnitude of intense storm events which have in turn lowered beach levels (see Section 3.5) and increased wave energy at the toe of the dunes along Burrow Beach. The supply of sediment to the beach is no longer believed to be in proportion to the volume of sand leaving the beach owing to this increased wave energy (RPS, 2020a).

3.3. Climate Aspects at Portrane Region

Windstorms and associated high wind speeds are a major factor of natural hazard risk for the Irish coast, with potential to cause societal impacts. Both Ireland and the United Kingdom were severely affected by an exceptional run of storms during the winter of 2013/2014, culminating in serious coastal damage and widespread, persistent flooding (Nolan and Flanagan, 2020). Records for precipitation totals and extreme wind speeds were set during winter of 2013/2014, recognised as the stormiest winter for at least 143 years when storm frequency and intensity are considered together (Matthews et al., 2014; Met Éireann, 2014; Kendon et al., 2015).

The frequency and intensity of extreme windstorms (cyclones associated with strong wind speeds) over the North Atlantic and western Europe is likely to increase by the end of the century during the winter and autumn seasons as a result of climate change (Haarsma et al., 2013; Zappa et al., 2013; Feser et al., 2014; Matthews et al., 2016; Nolan and Flanagan, 2020).

A study conducted by RPS in 2018 revealed that between late 2017 and early 2018, Ireland and the United Kingdom experienced 10 individual storm events, i.e., events that have potential to result in significant land-based impact or to severe wind events that give rise to orange or red status weather warnings. This accounted for five more events compared to the same period in 2016 to 2017. Analysis of data presented in the RPS report indicates that this succession of extreme weather events, when considered together as a group, points towards an accelerated change in the current climate (RPS, 2018b). These are represented by the following evidence:

- Hurricane Debbie in 1961 is acknowledged in historical records as the unique hurricane reaching Ireland whilst still at hurricane strength.
- Storm Ophelia hit Ireland in late 2017 and was downgraded from a hurricane to an extra-tropical cyclone just some hours before it made landfall.
- Storm Emma in early 2018 saw exceptionally high wave energy events from the east coupled with significant surge activity to result in some of the most arduous conditions experienced along the east coast. The significant wave height recorded during this event was 35% greater than the next greatest easterly wave recorded.
- Extreme offshore conditions analysis indicated that extreme offshore wave heights increased by 14% between 2013 and 2018.
- What was considered a 1 in 100 event based on the wave data recorded by the European Centre for Medium-Range Weather Forecasts between 1996 – 2013 is at present closer to a 1 in 10 or 20 year event.

The extreme wind calculations for the north east and south west sectors were calculated by RPS (2013a). The over water wind speed for 1 in 1 year return period storms from the south east to south west directions was found to be 22.5 m/s, whilst the value of the 1 in 100 year wind speed from the same direction was found to be 32.5 m/s. Storms of such magnitude have a 63% chance of occurring once in 100 years and a 1% chance of occurring in any one year.

The storm wave characteristics for the 1 in 1 year return period storms from the south east to south west direction were calculated to have significant wave heights of 4.38 metres with mean wave periods of 7.49 seconds. The equivalent for a 1 in 50 year return period storm were waves with significant wave heights of 6.2 metres and mean wave periods of 8.92 seconds. A 1 in 100 year return period storm had significant wave heights of 6.5 metres with mean wave periods of 9.14 seconds (RPS, 2013a).

Owing to the depth limited nature of the incident waves at Portrane, the waves that can be expected along the frontage of Burrow Beach during 1 in 200 return period events do not differ significantly to those during 1 in 50 year events. According to this information, it is reasonable to expect similar size waves to attack the dune system at Burrow Beach during a range of return period conditions (RPS, 2018b).

In a recent report published by RPS (2020a) it was found that a 1 in 200-year return period event from the easterly sector the significant wave height increased by approximately 10% between 2013 and 2018 from c.5.99m to c.6.61m. This analysis also indicates that Storm Emma could have equated to a c. 1 in 125-year event. This recent assessment analysed the M2 buoy data and found that despite greater gust speeds being recorded during previous storm events, it was during Storm Emma in 2018 that the highest offshore waves were recorded, about 35% greater than the next largest event, an unnamed storm event recorded in 2009 (RPS, 2020a). The impacts of Storm Emma on Burrow Beach will be further explained in the next section.

Extreme storm conditions, coastal erosion rates and future coastal erosion and flooding predictions need to be considered when designing coastal defence structures for Burrow Beach. Due to this, a large number of studies were undertaken to support decision making processes and find the best solution to Burrow Beach - these studies will be addressed in the following sections.

3.4. Coastal Erosion at Burrow Beach

Coastlines naturally undergo a constant cycle of erosion and accretion. Coastal erosion can result from natural causes and/or from human interference. Natural causes include the continual tendency towards a state of equilibrium between coasts and environmental forces, climatic change (particularly an increase in the frequency of storms or a shift in storm tracks), relative sea level rise and natural changes in the sediment supply. Human interference is usually associated with changes in the sediment budget, either directly, through the removal of beach or inshore sediment, or indirectly, by impeding or altering sediment movement. It is important to recognise that the process of coastal erosion is part of a natural tendency towards equilibrium. Natural shorelines attempt to absorb the energy entering the coastal zone by redistributing sediment (NPWS, 2013a).

Coastal erosion has always been seen as one of the main threats to Irish coastal habitats and is more pronounced on the soft, eastern coastline than on the western seaboard. The Fingal coast

is a soft coastline that is particularly susceptible to coastal erosion and is characterised by a series of dune complexes which act as a natural buffer between the land and the sea (Gault et al., 2007). Short term adjustment and realignment of the coast is typical where beach barrier complexes occur and can take place as part of an ongoing long-term coastal change (Mulrennan 1990).

Much of Ireland's soft coastline is low and susceptible to tidal surges and storm activity. A number of severe storms since the 1980s have accelerated the rates of erosion, to the extent that coastal zone management has become an issue that needed addressing in Ireland (Brady Shipman Martin, 1997). Coastal protection work carried out in the past involved the construction of relatively simple hard structures built in response to periodic emergencies without investigations of even the short term implications of such structures on the coastline as a whole. Many examples of small-scale coastal defence works exist around the county, which have been installed to prevent land losses in response to local erosion problems (Devoy, 2000; Ryle et al., 2009).

Before addressing the problem of the coastal erosion at Burrow Beach, a brief explanation about the general dynamics of saltmarshes and sand dunes systems is necessary, as well as, a brief explanation about the anthropogenic impacts on these environments.

3.4.1. Coastal Dynamics of Saltmarshes

Maintaining the favourable conservation condition of the saltmarsh habitats in Rogerstown Estuary in terms of its structure and functions depends on a range of attributes. The location, character and dynamic behaviour of saltmarshes are governed by sediment supply, tidal regime, wind-wave climate, and sea level change (NPWS, 2013a). The slope of the saltmarsh allows the development of several ecological gradients such as tidal submergence and salinity. Saltmarsh vegetation consists of a limited number of halophytic (salt-tolerant) species that are adapted to regular immersion by the tides. The regular ebb and flow of the tide brings salinity, nutrients, organic matter and sediment, which are central to the development, growth and survival of saltmarshes. Species in the lowest part of the saltmarsh require regular inundation, while those higher up on the marsh can only tolerate occasional inundation (NPWS, 2013a).

Accretion and erosion are natural elements of saltmarsh systems and maintaining the sediment supply is vital for its continued development and natural functioning (NPWS, 2013a). Interruption to the sediment circulation through physical structures can starve the system and

lead to accelerated erosion rates. The conservation target for Rogerstown Estuary SAC is to maintain a flooding regime whereby the lowest levels of the saltmarsh are flooded daily, while the upper levels are flooded occasionally (e.g. highest spring tides).

3.4.2. Coastal Dynamics of Dunes Systems

The location, character and dynamic behaviour of sand dunes are governed by a combination of geographic, climatic, edaphic and anthropogenic factors. Sand dunes are highly complex, dynamic systems, where the habitats occur in a complex and constantly evolving and changing mosaic. They function as systems in terms of geomorphology and hydrology and maintaining the favourable conservation condition of the habitats present depends on allowing these processes to continue unhindered (NPWS, 2013a).

Coastal sand dunes develop where there is an adequate supply of sand (sediment within the size range 0.2 to 2.0 mm) in the intertidal zone and where onshore winds are prevalent. Of critical importance is the presence of a sufficiently large beach plain, the surface of which dries out between high tides. The dry sand is then blown landwards and deposited above high water mark, where it is trapped by specialised dune-building grasses which grow up through successive layers of deposited sand. Sand accumulation which persists above the high tide line of normal tides may be colonised by the first perennial plants in dune succession to form the so-called "embryonic dunes". Embryonic dunes are low accumulations of sand that form above the strandline. They are sometimes referred to as foredunes, pioneer dunes or embryo dunes, as they can represent the primary stage of dune formation. They are characterised by the presence of the salt-tolerant dune grasses such as sand couch (*Elytrigia juncea*) and lyme grass (*Leymus arenarius*), which act as an impediment to airborne sand. Strandline species can remain a persistent element of the vegetation.

As embryonic dunes accumulate, the dune surface is raised above the level of normal tides and the sand, partly through washing by fresh rainwater, becomes less salty. In these conditions *Ammophila arenaria* (Marram grass) - the major dune building grass - is able to colonise initiating the transition to mobile dunes (shifting dunes along the shoreline with *Ammophila arenaria*). These unstable and mobile areas are sometimes referred to as "White Dunes or 'Yellow Dunes', owing to the areas of bare sand visible between the tussocks of marram. It is tall and robust (but flexible in the wind) and very effective at trapping sand by reducing the wind speed at the surface. Marram growth is actively stimulated by sand accumulation. This

environment is still too inhospitable for all but a very few plants and the dominant Marram is surrounded by large areas of bare ground. The so-called “Blowouts” on sand dune systems, is the removal of sand from a dune by the wind after protective dune vegetation has been lost (Ryle et al., 2009).

Further inland, where the vegetation has developed so that it forms a more or less complete cover of the substrate, the fixed dunes habitat forms. Fixed dunes are the more stabilised area of dune systems, generally located in the shelter of the mobile dune ridges, where the wind speed is reduced and the vegetation is removed from the influence of tidal inundation and salt spray. This leads to the development of a more or less closed or ‘fixed’ carpet of vegetation dominated by a range of sand-binding species (Gaynor, 2008). Mosses and lichens become more common as the grassland matures and it is because of the presence of lichens that the term ‘Grey Dunes’ is often applied to fixed dunes (Ryle et al, 2009). Where the sandy substrate is decalcified, fixed dunes may give way to dune heath. Wet hollows, or dune slacks, occur where the dunes have been eroded down to the level of the water-table (NPWS, 2013a).

All the dune habitats indicated above occur as a complex mosaic of constantly changing and evolving vegetation communities. They are inextricably linked in terms of their ecological functioning and should be regarded as single geomorphological units. As such, no dune habitat should be considered in isolation from the other dune habitats present at a site, or the adjoining semi-natural habitats with which they often form important transitional communities (NPWS, 2013a).

Dunes are naturally dynamic systems that require continuous supply and circulation of sand. Sediment supply is especially important in the embryonic dunes and mobile dunes, as well as the strandline communities where accumulation of organic matter in tidal litter is essential for trapping sand and initiating dune formation. The construction of physical barriers such as sea defences can interrupt longshore drift, leading to beach starvation and increased rates of erosion. Sediment circulation and erosion also have a role to play in the more stabilised dune habitats. Cycles of erosion and stabilisation are part of a naturally functioning dune system, where the creation of new bare areas allows pioneer species and vegetation communities to develop, increasing biodiversity. The construction of physical barriers can interfere with the sediment circulation by cutting the dunes off from the beach resulting in fossilisation or over-stabilisation of dunes (NPSW, 2013a). Maintaining dune systems natural dynamism is essential

to ensure that all of the habitats present at a site achieve favourable conservation conditions (NPWS, 2013a).

3.4.3. Anthropogenic Impacts Over Burrow Beach Coastal Systems

Coastal change due to erosion and accretion processes are part of a natural tendency towards beach equilibrium, however, human activities can disrupt this balance, especially where the coastal hinterland is of high economic, cultural or environmental value (ECOPRO, 1996; Gault et al., 2007). The demand for tourist facilities such as holiday homes, hotels, caravan parks, car parks, golf courses, etc., has resulted in large areas of Irish sand dunes having been lost or at least significantly altered (Gault et al., 2007; Ryle et al., 2009). On the east coast of Ireland, long stretches of the coastline are heavily urbanised, or are within easy reach of large numbers of people (Ryle et al., 2009). Lower population densities on the west coast, however, or the relative isolation of sites or agricultural management mean that some sites are less intensively impacted by recreational use (Ryle et al., 2009).

The main recreational activities affecting sand dunes in Ireland are trampling and general overuse of the dune system through social gathering, pedestrian damage, littering, horse-riding, motor vehicles including quad bikes that can compact the soil, lead to the creation of tracks and undermine the vegetation integrity, accelerating the damage to dune systems and favouring erosion processes (ECOPRO, 1996; Gault et al., 2007; Ryle et al., 2009). The degradation of dune vegetation is usually paralleled with the development of a network of paths and tracks usually originating from a central or main access route or car park and can cover an extensive area of the frontal dunes. Blowout formation due to vegetation degradation and aeolian erosion may eventually increase dune susceptibility to more intense marine erosion (Gault et al., 2007).

Burrow Beach at Portrane is a popular a resort during the summer. Bathing, walking, horse riding and birdwatching are very common activities throughout the year (Ryle et al., 2009). The remaining fixed dune within the site and associated saltmarsh are under severe recreational pressure mainly due activities associated with the holiday dwellings and ease of access to the site locally.

The dune systems at Portrane are subject to high recreational pressure as seen by the numerous tracks running through them and associated blowouts, as well as bonfires (Gault et al., 2007; Ryle et al., 2009). A number of pedestrian dune pathways run parallel to the beach and are extensively utilised by walkers. These pathways are not managed and as a result sometimes

"branch off" and cut through the dune face onto the beach. This can lead to the cutting up of the dune face into "sections" or "blocks" which tend to be more sensitive to marine, aeolian and further human induced erosion (Gault et al., 2007).

Caravans and holiday homes occupy 40ha of the fixed dune system, although these developments are outside of Rogerstown Estuary SAC (Ryle et al., 2009). Areas of the fixed dunes are mowed in front of the houses to provide extra "garden" area for residents and some infilling has been carried out by residents near the holiday chalets and houses next to the fixed dunes due to flooding during the storms and high tides (Ryle et al., 2009). The absence of a strandline habitat along the north and south edge of the beach is most likely a result of natural erosion and mechanical beach cleaning (Ryle et al., 2009). Mechanical beach cleaning tends to remove all tidal debris including seaweeds and plant remains, source of nutrients and seeds for the strandline vegetation development.

In 2007, Gault et al. identified that the main management issue at Burrow Beach involves problems with planning and development control – an issue still observed in the current days. Gault et al. (2007) identified that a number of dwellings were located close to the eroding dune face (some cases were found to be as close as 23m) and houses, mobile homes and caravans were scattered throughout the dune system due to an increase in the number of buildings and level of planning applications. This directly contributed to the degradation of the dune system. Gault et al. (2007) indicated that unmanaged access also contributed to dune erosion and vegetation degradation, since access paths cut through the dunes and onto the sandy beach.

Although sand dunes are considered natural barriers to the encroaching sea, they do not guarantee protection during high tides and storms. Therefore, many of the dwellings located on the dunes are at considerable risk to marine induced erosion and/or flooding. Gault et al. (2007) recommended that no additional permits should be granted to dwellings located in such close proximity to the sea.

A number of tracks are utilised by vehicles and lead directly on to the foreshore at Portrane. These are located at the southern and northern ends of Burrow Beach. The saltmarsh habitat at the northern end of Burrow Beach has formed the main car parking area during peak times/season and is currently in a state of decline as a result of human pressure (Gault et al., 2007). The dunes fronting the saltmarsh have been breached due to natural erosion

compounded by these human activities, and the saltmarsh has been covered with sand (NPWS, 2013a).

Cars drive along a track across the saltmarsh to gain access the dunes and holiday houses, existing cars park on the flat saltmarsh to access the strand, wheel ruts over many parts of the habitat, a sandy track along the western side of the saltmarsh that accesses the northern shoreline, and tracks from walkers and horse riders (McCorry, 2007).

The presence of horses and dogs along the beach is controlled during the summer period, but both animals are allowed at any time during the winter months. Within the SPA dogs should be kept on leads and horses should be controlled and ridden along permitted paths only, with the purpose of reducing the impacts of disturbance upon birds (NPWS, 2013b).

The general public are usually entitled to access public areas and amenities through prescribed "public rights of way". However, user access can be controlled and limited to particular areas (using bye-laws) if practices are detrimental to the resources (see Appendix – section 5.2). An effective management response to access problems requires site specific recommendations in order to account for the type and extent of detrimental usage (Gault et al., 2007).

A beach management plan was developed for Burrow Beach in 2007 (FCC, 2007). The beach is protected by bye-laws which prohibits vehicle access and horse riding over the environments, although cars do park in the saltmarsh (FCC, 2006; McCorry and Ryle, 2009). Locals stated that these bye-laws are ignored (Ryle et al., 2009). A variety of signage was observed and examined by Gault et al. (2007), some of which had been vandalised. Observed vehicular access to the beach and pedestrians tracks on the dunes system suggesting that beach and dune users do not adhere to the signage and that the signage may be degraded or outdated (Gault et al., 2007).

3.4.4. Coastal Erosion Assessments

The coastal erosion at Burrow Beach is a result of the combination of high wave activity and storm surges that occur on the occasion of south and southerly storms (RPS, 2013a). Storm surge is the difference between the observed water level and that which would have been expected at the same place in the absence of the storm (Harris, 1963). In other words, a storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide (NOAA, 2020). When a storm surge occurs in combination with an

astronomical high tide, then it is called “storm tide”. This abnormal rise in water level can cause extreme flooding in coastal areas particularly when storm surge coincides with high tide, posing a great threat to life and properties (NOAA, 2020).

Human activities, such as those described in the previous section, have been contributing to localised erosion and this is impeding the natural potential of the system to repair itself after storms (NPWS, 2013a).

In Portrane, storms with large surges that occur at times of high spring tides are particularly damaging with significant dune erosion occurring over a short period of time, whilst the volume of erosion is directly related to the height that seawater levels achieve during the storms (RPS, 2013a). Besides the severe impact of storm surges on the beach and dunes ecosystems located in the forefront of the peninsula, salt marshes located at the rear of the peninsula are also susceptible to abnormal flooding during these storm events (NPWS, 2013a).

Over time the dunes have the capacity to regenerate, although this can take several years in the case of damage resulting from a major storm event - particularly if there are significant areas of the dunes with steep exposed sand faces (RPS, 2013a). In a healthy dune system, dry sand from the upper beach is transferred to the dune system by onshore winds and during storm events the sand stored and retained in the dunes returns to feed the beach, maintaining the sediment balance. If dune vegetation cover is removed or damaged by storms or human activity, large quantities of sand may be blown away and lost from the coupled beach-dune system, leading to a critical coastal erosion process.

Historical photos indicated that erosion pressures already existed along the southern section of Burrow Beach at least since 1950 (RPS, 2020a). The structure is approximately 180m length of sheet piling buried by an accretion of sediment at this location (this structure will be further detailed at Section 3.6).

Many studies were commissioned by FCC in order to understand the coastal erosion scenario at Burrow Beach in Portrane. The earliest study found in this literature review was the publication “Environmental Survey of the Rogerstown Estuary”, authored by Kirk McClure Morton in 1992, followed by the study “Coastal Protection Schemes at Burrow Strand, Portrane, Preliminary report” authored by A. Russell Oliver in 1995. Both studies were mentioned by Gault et al. (2007) as reports not found.

In 1998 Kirk McClure Morton published the report "The Burrow Portrane Coastal Study Report for Fingal County Council". This report is widely cited by many publications reviewed by the current bibliographical research, such as Gault et al. (2007), NPWS (2013a) and RPS (2013a), however, the original publication was not found by this literature review. According to RPS (2013a), the study conducted by Morton (1998) searched for historical changes at Burrow Beach coastline assessed by reference to Ordnance Survey maps of 1842 and 1938, together with an aerial survey in 1971, and a 1997 beach survey. The study comparing the high water mark suggested that there was erosion at the southern end of Burrow Beach between 1843 and 1938 (Gault et al., 2007). The historical review made by Morton (1998) indicated that system was generally accreting from the 1970s until the early 1990s. Since the 1990s however the system appears to be eroding with a breach occurring in the northern end of the site. From the late 1990s a significant erosion of the foredunes to the south of Burrow Beach with a progradation of the spit in the northern extremity was verified. The dune line has retreated to almost the same line that existed in the 1970s. Overall the coastline has remained dynamically stable over the past 30 years.

In 2007, FCC commissioned a study to assess the condition and usage of sand dune systems at specific sites on the Fingal coast, Portmarnock, Portrane and Rush, and subsequently prepare dune management plans to address the issues prevalent at each site. This study (Gault et al., 2007) identified the main issues in these dunes systems as erosion and coastal change, public access, sea buckthorn invasion, vandalism and bonfires, lack of information and encroachment of development. The most pressing local issues identified in Portrane were housing development, either completed or proposed, and the proximity of this development to the eroding face of the dune system. See section 3.4.3 for information on the detrimental human activities identified in the dune systems.

The analysis suggested that comparatively limited development has taken place within Burrow Beach system over the 2000 – 2005 period, however, at least 24 dwellings were located within 60m of the eroding dune face. At that time, applications have been received to build a number of developments at Burrow Beach, but FCC were concerned that Burrow Beach system has far exceeded its capacity for holiday homes development and further development could only exacerbate existing usage. GIS analysis revealed that individual dwellings at Portrane were located as close as 22m to the erosional face of the foredune at a location that eroded up to 12m since 1935 (Gault et al., 2007).

In the study undertaken in 2007, Gault et al. verified a significant variation in the Portrane coastline position. The northern section of the coastline experienced significant erosion (240m) from 1935 to 2000. However, since 2000 significant foredune development took place and its associated accretion led to an increase of 50m during this period. Coastal change was less extreme in the southern sections over the 70 year period. The coast has been eroding since 2000 with a decrease of over 5m recorded from 2000 to 2005. According to Gault et al. (2007), it was unclear if current erosion at Portrane is either a relatively new phenomenon or an ongoing part of cyclic coastal change because of a lack of primary data. Gault et al. (2007) suggested that a monitoring scheme of coastal change should be implemented in an attempt to better understand the complexities of this system as this would provide decision makers with the baseline data required to make effective management decisions.

In 2013, the RPS consulting company was commissioned to further investigate the dynamics of coastline at Burrow Beach. Based upon the seminal work of Morton (1998), RPS undertook a further review of historical aerial ortho photographs from the Ordnance Survey Ireland. Aerial photographs taken in 1973, 1982, 1995, 2000, 2005, 2009 and 2011 provided a degree of insight into the evolution of the beach over the past 40 years (RPS, 2013a).

The results of the above mentioned study showed changes in the high water mark at Portrane indicating that there was erosion at the southern end of Burrow Beach between 1843 and 1938 and a substantial accretion at the northern end during the same period. Between 1938 and 1971 a considerable erosion at the north eastern end of Burrow Beach was noticed. The beach experienced episodes of erosion and accretion over the past 40 years, reflecting a dynamic beach system that moves in response to changes in prevailing weather conditions. While a movement of the dune line in both easterly and westerly directions was observed, it was notable that in almost all areas of the coastline, the 2013 vegetation line had not retreated any further west than that detected in the photos of previous years.

RPS (2013a) classified Burrow Beach in three distinct zones according to the dynamics of the dune system: Zone 1-North section; Zone 2-Middle section; Zone 3-South section (Figure 8). The RPS (2013a) evaluation to each zone is summarized below:

Zone 1 - North section: The study identified that the greatest changes occurred at the northernmost end of the beach (Zone 1), which was subject to net erosion in the years between 1973 and 2013. In 1973, the salt marsh habitat vegetated area extended approximately 80

metres further east than verified in 2013. In 1982, a fairly substantial sand spit has formed to the east of the sand dunes and salt marsh, presenting a tidal lagoon separating it from Burrow Beach. By 1995 the spit had gone, and the vegetation line of the salt marsh area was some 30 metres west of the 1973 extent. Further erosion took place between 1995 and 2000 and a large area bare of vegetation became evident in 2000 – an area described by McCorry and Ryle (2009) as a blow out. In the southern part of Zone 1, the dunes accreted eastward by a distance of up to 20 metres between 1973 and 1982, but subsequently significant amounts of erosion occurred between 1982-2000, with the dune line moving west by 35 metres from the 1982 position. Since 2000, the vegetation line in this area has remained relatively stable, with only a few metres of movement of the vegetation line occurring since then. The "blow out" area seen in 2000 was partially restored by 2005 and almost fully re-vegetated by 2009. In 2009 and 2013, a sand bank east of the salt marsh measuring around 230m by 40m that was above the normal high water mark and which was gradually increasing in vegetation cover was revealed, suggesting that there has been net accretion in this part of the beach since 2005. The RPS expectations were that if this area were to continue accretion and colonisation, it would bring the vegetation line close to where it was in 1973.

Zone 2 - Middle section: The study indicated that the vegetation line moved east indicating substantial dune accretion by up to 25 metres between 1973 and 1982. Following this, a significant erosion in the period 1982-1995 was observed, with the vegetation line moving westwards again by as much as 30 metres. In the period 1995-2000, there was another episode of accretion with the vegetation line moving east again by around 10 metres. Between 2000 and 2005 the vegetation line was relatively stable, with little change in its position. However, the 2000 image analysed showed sparse coverage of the vegetation, with a greater number of bare areas and erosion caused by pedestrian access paths. The cover appeared denser in 2005 and the paths were much more defined. A further period of erosion occurred between 2005 and 2009, with a retreat of around 15 metres, returning the dunes to approximately the same position as in 1995.

Zone 3 - South section: The vegetation line in 2013 was very similar to that in 1973, suggesting that the shoreline has not eroded any further west between these dates. There was a period of significant accretion in this zone from 1973, with the vegetation line moving up to 20 metres east by 1995. The vegetation line remained relatively static between 2000 and 2005. Some erosion occurred in the period between 2005 and 2009 represented by a westward movement

of the vegetation line in the order of 3-5 metres. More substantial rates of erosion occurred between 2009 and 2013 suggesting that up to 15 metres of the dune line has been eroded, particularly in the area just north of the main access to the bathing area, where sandbags were placed in 2013. This zone presented several permanent dwellings that are less than 50 metres behind the beach, bringing the biggest concern for erosion in this section of Burrow Beach.

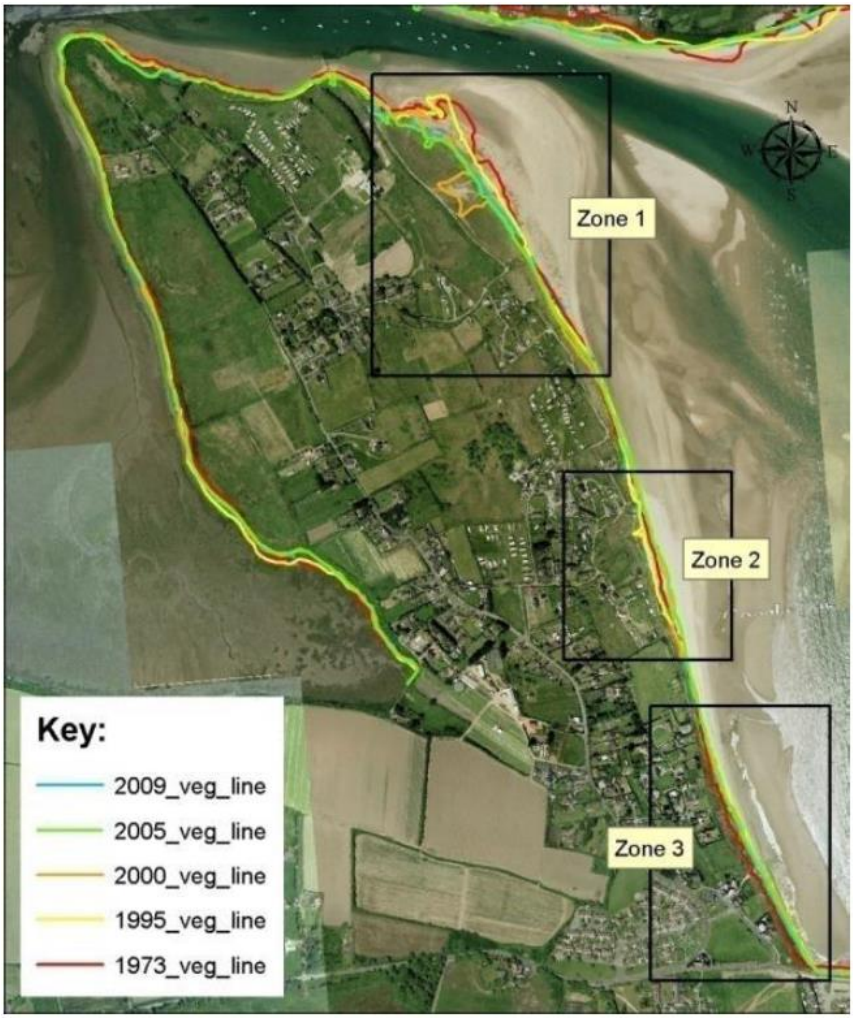


Figure 8: Zones of erosion/accretion on Burrow Beach (Source: RPS, 2013a).

A follow up analysis undertaken by RPS (2018b) after the Storm Emma (March 2018) episode indicated that the southern extent along Burrow Beach was significantly affected by coastal erosion and that the magnitude of erosion gradually decreased northwards. This pattern suggests that much of this recent erosion could be attributed directly to easterly and north easterly storm events. The report also noted that the coastline in this area has already retreated by approximately 10 metres since the last appraisal in 2013, which would be a halfway towards the erosion line projected for the mid-range climate change future scenario for 2100 (explained

in detail in the section 3.5). In some regions of Burrow Beach, the erosion exceeded 20 metres in 2018 (Figure 9).

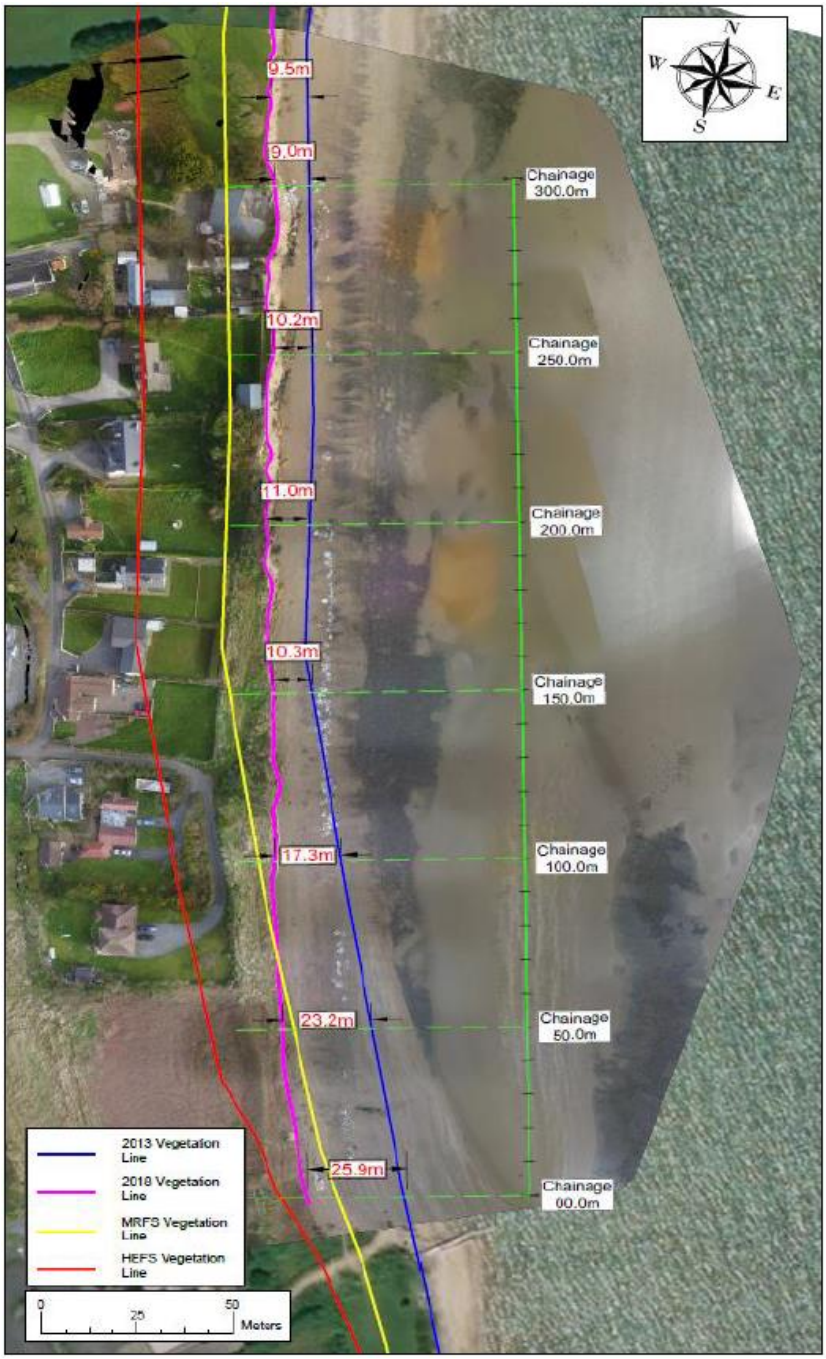


Figure 9: The 2018 and 2013 vegetation line in relation to the 2100 MRFS and HEFS vegetation line (Source: RPS, 2018b).

In 2020 RPS reviewed the erosion and flood risk assessments for Burrow Beach (RPS, 2020a). Based on the historical photographs from the 1950s, it is estimated that the current position of the shoreline is approximately 15 - 20m landward relative to the 1950s shoreline (RPS, 2020a).

Using geo-referenced shoreline datasets, RPS assessed the rate of coastal change across the study area between 1973 and 2019 (precisely: 1973, 1982, 1995, 2000, 2005, 2009, 2011, 2013, 2018, and 2019). In this recent assessment the beach was classified in 13 sections (Figure 10).

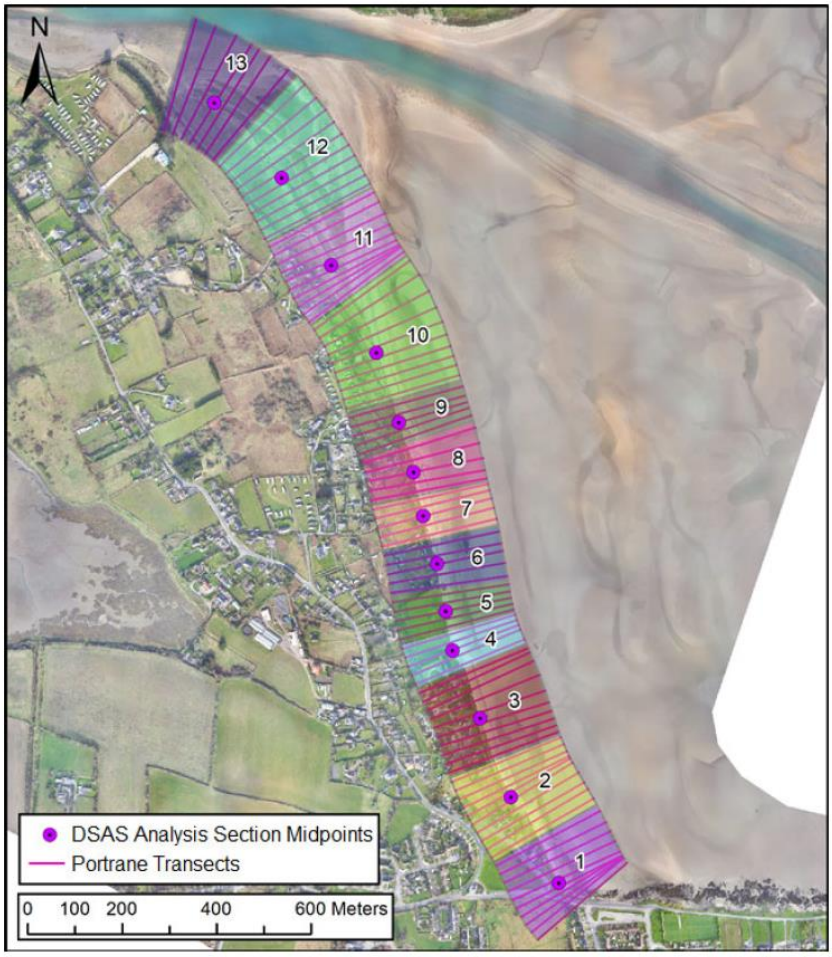


Figure 10: Burrow Beach split into sections for Digital Shoreline Analysis System (Source: RPS, 2020a).

The study found that between 1973 and 2000, the southern section of Burrow Beach advanced seaward by circa 20m. Following Storm Emma in 2018 and several other storms, sections of Burrow Beach retreated by more than 20m. The coastal retreat during this episode was so severe that a private residential property had to be demolished some months later (RPS, 2020a).

Since the installation of the interim coastal protection works in late 2018 (i.e. the concrete Seabee units – further explained in section 3.6.6), the study found that there has been little movement of the shoreline immediately behind the units, while erosion has continued to the north of these protection works (RPS, 2020a).

Burrow Beach was found to depend almost exclusively on sediment supply from the south east as the strong littoral currents coming from the Rogerstown estuary prevent the effective transfer of sediment between Burrow Beach and Rush beaches. The sediment transport regime along Burrow Beach is no longer in a dynamic state due to a deficit in the sediment supply. As the supply of sediment to the beach is no longer proportional to the volume of sand leaving the beach, there are now increased erosion pressures along this coastline. This shift has been attributed to the recent increase in the frequency and magnitude of storm events which have lowered beach levels and increased wave energy (RPS, 2020a).

RPS (2020a) quantified the change in bed levels and beach volumes across multiple areas of the Rogerstown Estuary. This assessment found that there has been a notable decrease in bed levels and sediment volumes within the estuary, i.e., a loss of approximately 66 thousand m^3. The elevation of the beaches along Burrow Beach have decreased approximately 1.64m since 2008 and over 697 thousand m^3 of sediment material has been removed from the intertidal region along Burrow Beach since 2008 (RPS, 2020a). The intertidal beach area at Rush south also lost approximately 0.50 million m^3 of material during the same period, indicating that sand is not moving between the two beaches but, instead, is being transported offshore and out of this sub cell. These findings are contrary to the conclusions of previous studies which found that the local sediment systems at Burrow Beach and Rush south were once closely interlinked with sediment being exchanged between the two beaches during both calm and storm conditions (RPS, 2020a). RPS attributes the changes in sediment dynamics to a significant change in bed levels across the two beaches which has in turn altered the prevailing wave climate and sediment transport processes within the Rogerstown estuary area, combined with climate change and an increase in the incident wave energy.

Owing to the low-lying nature of much of Portrane peninsula, it is believed that the current threat of coastal erosion presents a very significant flood risk to Burrow Beach if the dune system was to be breached (RPS, 2018a,b). Nevertheless, the increase of coastal erosion and flooding due to climate change not only presents an immediate structural risk to assets, infrastructures and properties, but also pose risks to the local biodiversity and ecosystems. It is recognised that many of the nesting sites have been lost through erosion (NPWS, 2013a). The Annex I species Little Tern (*Sterna albifrons*) occasionally bred on the shingle area at the outer sand spit; however, this area has been washed away as a result of erosion and no known nesting has been recorded since 1995 (Ryle et al., 2009; NPWS, 2013a).

3.5. Coastal Change and Flooding Predictions for Burrow Beach

For the purposes of the Catchment-based Flood Risk Assessment and Management Programme (CFRAM) – a programme developed to meet the requirements of the EU Floods Directive (2007/60/EC) and deliver on core components of the 2004 National Flood Policy (further explained in section 3.7.1 of the Appendix) –, the OPW recommended two indicative potential futures for flood risk assessment scenarios in face of climate change: the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). These scenarios provide potential futures that permit flood hazard and risk assessments to be undertaken to identify possible impacts of climate change on flooding, which, in turn, enables an assessment of the vulnerability of different communities and areas around the country to such possible changes. This informs how flood risk in communities should be managed now and into the future (OPW, 2019).

According to OPW (2019), these scenarios were selected to reflect a future in the latter part of the century that would be typical or near to the general average of the future climate projections (MRFS scenario), or a more extreme future based on the upper end of the range of projections of future climatic conditions and the impacts such changes would have on the drivers of flood risk (HEFS scenario). The Mid-range Future Scenario (MRFS) expects sea level to rise by 0.5 metre by 2100 and the High-End Future Scenario (HEFS) expects sea level to rise by 1.0 metre by 2100 (OPW, 2019).

Sea level rise should increase the energy of the wave climate approaching the dunes at Burrow Beach and further contribute to the coastal erosion. According to simulations performed by RPS in 2013 (RPS, 2013a), it was expected that for the MRFS the greatest changes would occur at the middle of the beach (Zone 2), with projected erosion of approximately 24 metres by 2100. For the HEFS, Zone 2 is likely to retreat west by 48 metres by 2100. It was expected that the foredune would erode and expose residential properties located in Burrow Beach, to both wave and tidal conditions. The amount of sand eroded from the receding dunes was relatively small in comparison to the area of the beach, so the RPS study in 2013 considered that there would be no significant change in the sediment regime of the area.

In regard to Zone 1, which currently is largely occupied by salt marsh habitat, the RPS study suggests that the vegetation line could retreat west by approximately 20 metres by 2100 in the MRFS. However, a sand bank that was developing east of this region might delay the erosion

in this area. It was expected that the dune was likely to move west by 40 metres by 2100 when considering the HEFS.

At the southern section of Zone 3 the erosion was expected to be slower than the erosion in Zones 1 and 2, with the dune face retreating by approximately 9 metres by 2100 when considering the MRFS. According to the analysis, this is because unlike Zones 1 and 2, the shoreline in this region is not directly exposed to wind and swell energy originating in the south and south east sectors, especially due the presence of a stony headland that protects the shoreline from erosion. Conversely, a further erosive process was expected to the northern section of Zone 3, probably at the same rate as Zone 2, with the dune retreating west by approximately 24 metres by 2100. Considering the HEFS, the simulations suggested that the vegetation line would move west by 18 metres by 2100 the southern section of Zone 3, whilst the dune would move west by approximately 48 metres by 2100 in the northern section of the same zone.

The 2013 RPS risk assessment (RPS, 2013a), evaluated that one residential property located approximately 19 metres behind the foredune in Zone 3 (section 3.1 in the border with Zone 2) was threatened from coastal erosion when considering the MRFS. Considering the HEFS scenario, 11 residential properties located in Zones 2 and 3 were identified as being at risk of significant structural failure.

Following Storm Emma and a succession of other severe storm events, a follow up report was commissioned by FCC in 2018 to assess the feasibility of a coastal defence scheme to reduce flood risk within the Rogerstown Outer Estuary area. This study conducted by RPS (2018b), assessed and quantified the morphological response of the dune system subject to a combination of extreme storm events that could be statistically expected to occur over a 100 year period. The results of this study indicated that the existing dune system could retreat by up to 8.5 metres and 12.2 metres during a 1 in 50 and 1 in 200 year joint probability event respectively and that the existing dune system could retreat landward at a rate greater than 0.86 metre per year. Based on this rate of retreat, the existing dune system could be expected to retreat more than 86 metres. Under a scenario which accounted for climate change by including a sea level rise of 0.75 metres, approximately more than 52 properties could be at immediate risk from coastal erosion and a further 23 properties could be at risk from coastal flooding if the main dune system was breached during a 1 in 200 year flooding event.

In 2020 RPS reviewed the erosion and flood risk prediction for Burrow Beach (2020a) and estimated that the future shoreline can retreat by 103, 36 and 32 metres by 2100 at sections 3, 7 and 10 respectively. The rate of coastal change was found to be greatest towards the southern section of Burrow Beach, with a maximum rate of coastal retreat of 1.29m/yr at section 4. At the northern extent of Burrow Beach, the rate of coastal change was less severe and more uniform at an almost constant rate of 0.45m/yr ±<0.01m. The average rate of coastal retreat along the entire beach was found to be 0.60m/yr ±0.92m (RPS, 2020a).

RPS rationalises that recent extreme events indicate a potential "turning point" in the coastal processes along Burrow Beach and that rates of coastal erosion could be significantly greater than those reported in this study (RPS, 2020a) since the erosion rates were estimated using all available shoreline data (from 1973 to 2019) and that the average erosion rates could be up to three times greater if historical data prior to 2013 was excluded. According to the consultancy, without sufficient long-term high-resolution data it is not possible to determine if these recent events are unique outliers or the beginning of a new long-term trend.

RPS produced a series of future coastal change maps that illustrated the projected position of the shoreline by 2050 and 2100 for the following scenarios:

i. Existing climate conditions and erosion rates.
ii. Medium Range Future Scenario (MRFS) climate conditions whereby sea levels are expected to rise by +0.50m by 2100.
iii. High End Future Scenario (HEFS) climate conditions whereby sea levels are expected to rise by +1.00m by 2100.

In order to produce these maps, RPS considered that by 2050 the coastline at Burrow Beach could retreat by 19m (existing climate scenario), 29m (MRFS), and 39m (HEFS), with confidence in trend analysis of ±14m (Figure 11). Based on these projections, from 6 to 15 properties along Burrow Beach are expected to be lost to coastal erosion by 2050. These buildings primarily comprise residential properties and a small number of private out-buildings and/or mobile homes. Several commercial and public buildings are also included in this total.

The projected coastal retreat across the study area by 2100 is 48m (existing climate scenario), 68m (MRFS), and 88m (HEFS scenario), with confidence in trend analysis of ±30m (Figure 12). From 19 to 46 buildings can be potentially lost to erosion by 2100 these projections.

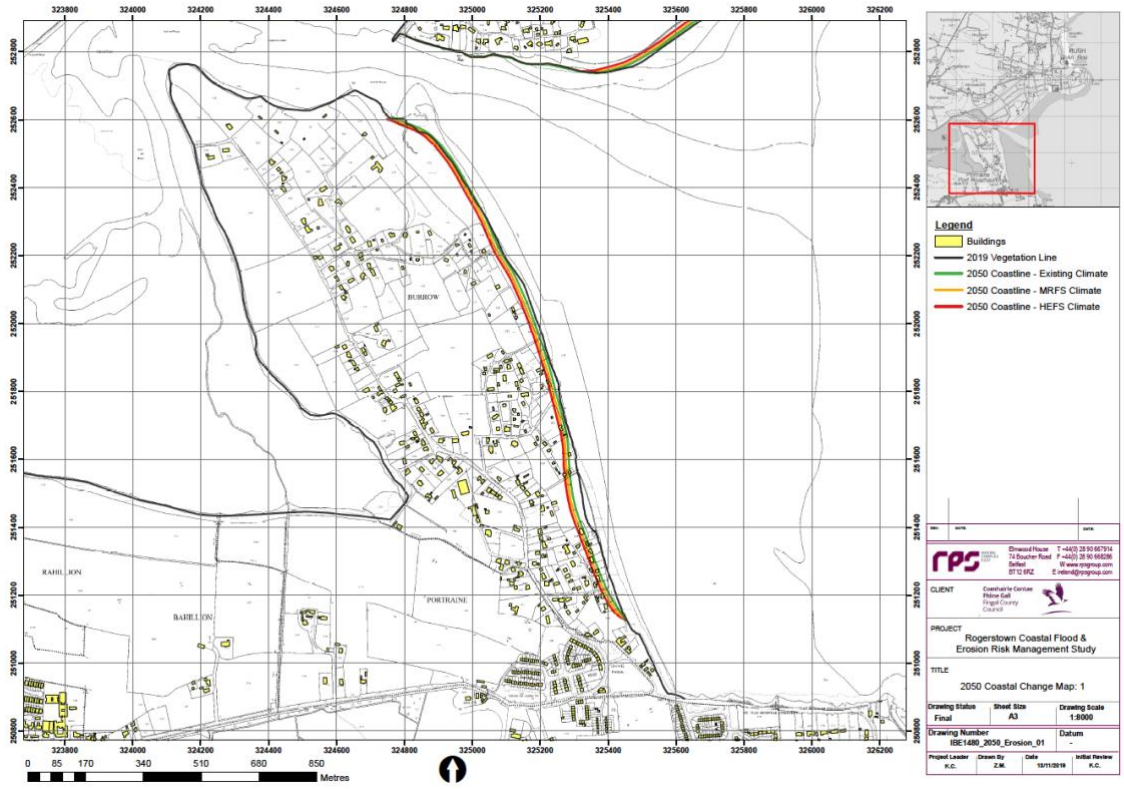


Figure 11: Projected coastal change at Burrow Beach by 2050 based on the following climate scenarios: Existing climate; MRFS Climate and HEFS Climate (Source: RPS, 2020a).

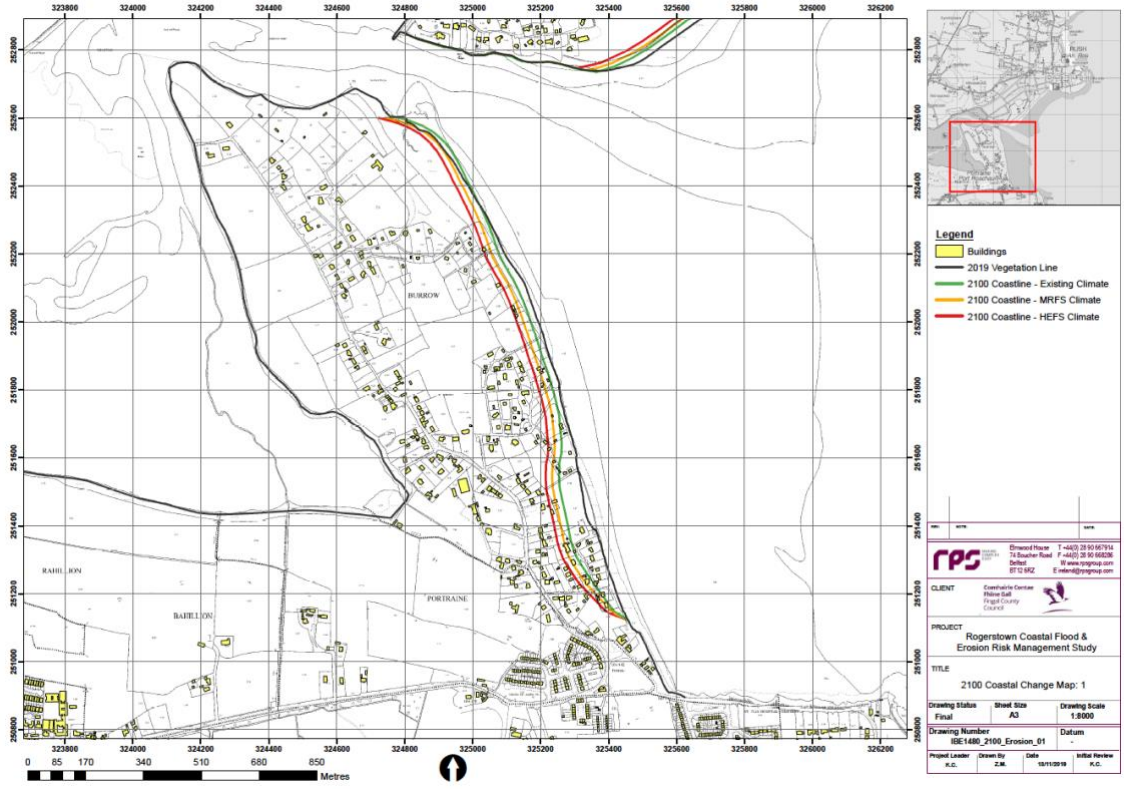


Figure 12: Projected coastal change at Burrow Beach by 2100 based on the following climate scenarios: Existing climate; MRFS Climate and HEFS Climate (Source: RPS, 2020a).

Considering the flood risk assessment, as the scope of RPS study (2020a) was to assess coastal flooding, i.e., flooding from combined tide and surge activity and wave overtopping, the potential impact of fluvial flooding has not been considered in this assessment. The fluvial flood risk extents remain unchanged for all the climate scenarios because RPS were provided only with the present-day scenario fluvial flood extents from the FEMFRAM study (RPS, 2020a). Using a baseline hydrodynamic model, RPS developed additional hydrodynamic models to represent the modified position of the coastline due to erosion at each study area by 2050 and 2100 for both the MRFS and HEFS future climate change scenarios. The flood risk analysis was based primarily on available bathymetric and topographic data together with various Annual Exceedance Probability (AEP) water levels events.

RPS (2020a) produced maps to illustrate the projected flood extents for five scenarios: Existing conditions (Figure 13); 2050 MRFS and HEFS (Figures 14 and 15); 2100 MRFS; and HEFS (Figures 16 and 17). The figures illustrate the flood extents for the 1 in 10 year (10% AEP), 1 in 200 year (0.5% AEP) and 1 in 1000 year (0.1% AEP) return period storm events.

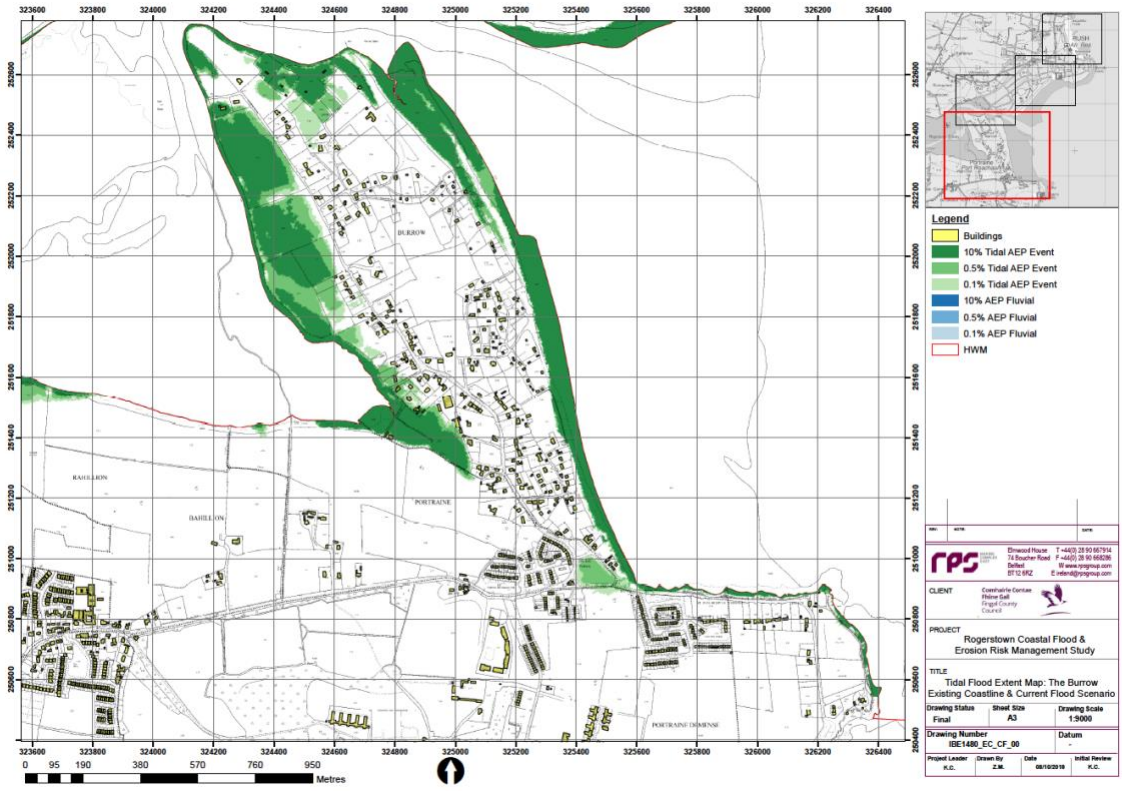


Figure 13: Tidal Flood Extent Map for the Present Day Conditions (i.e. no sea level rise or coastal change) (Source: RPS, 2020a).

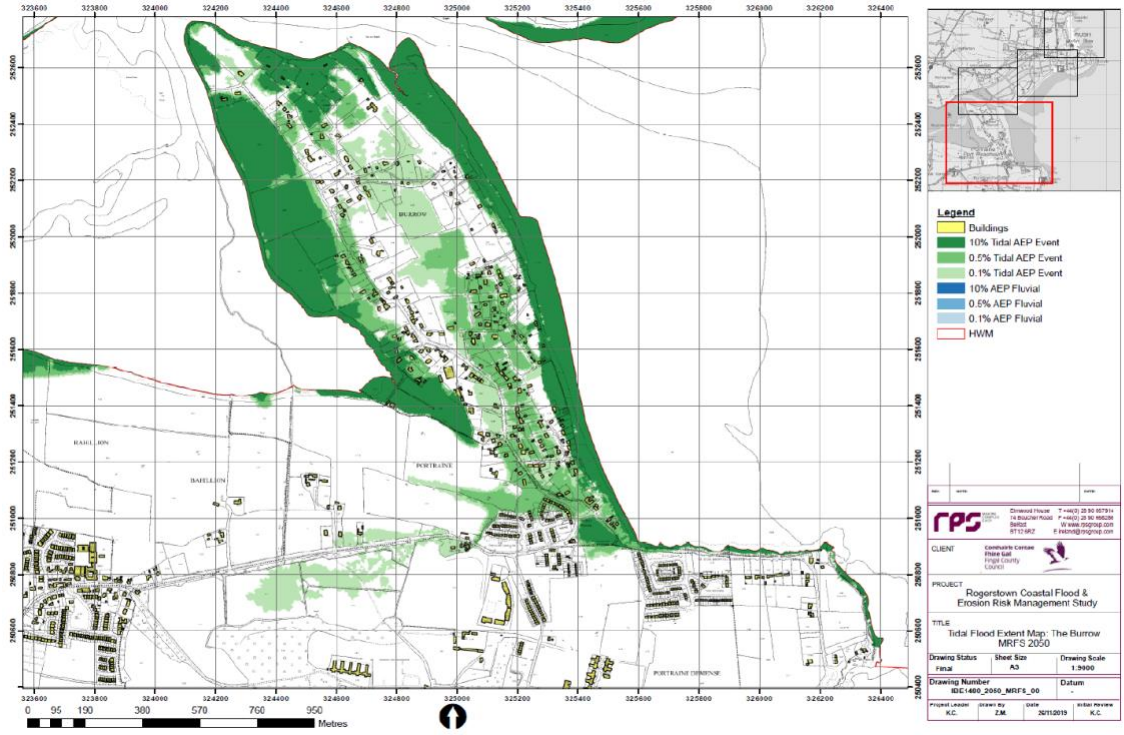


Figure 14: Tidal Flood Extent Map for the 2050 MRFS (+0.20m sea level rise and 29m of coastal retreat) (Source: RPS, 2020a).

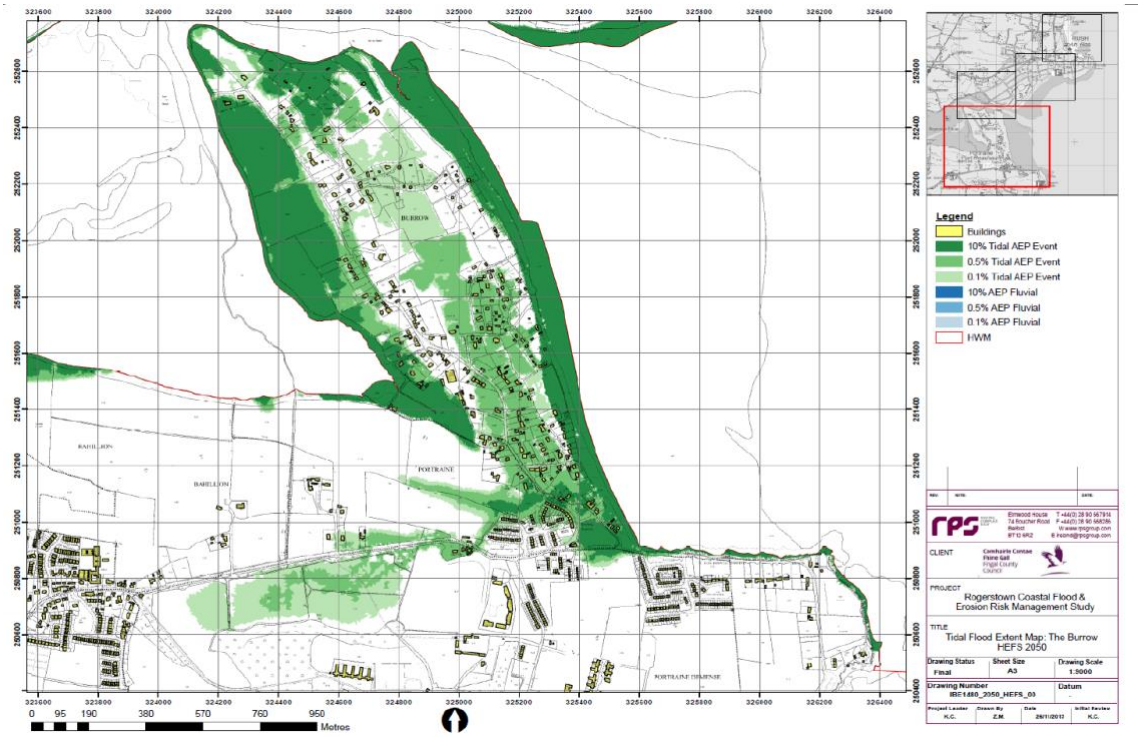


Figure 15: Tidal Flood Extent Map for the 2050 HEFS (+0.33m sea level rise and 39m of coastal retreat) (Source: RPS, 2020a).

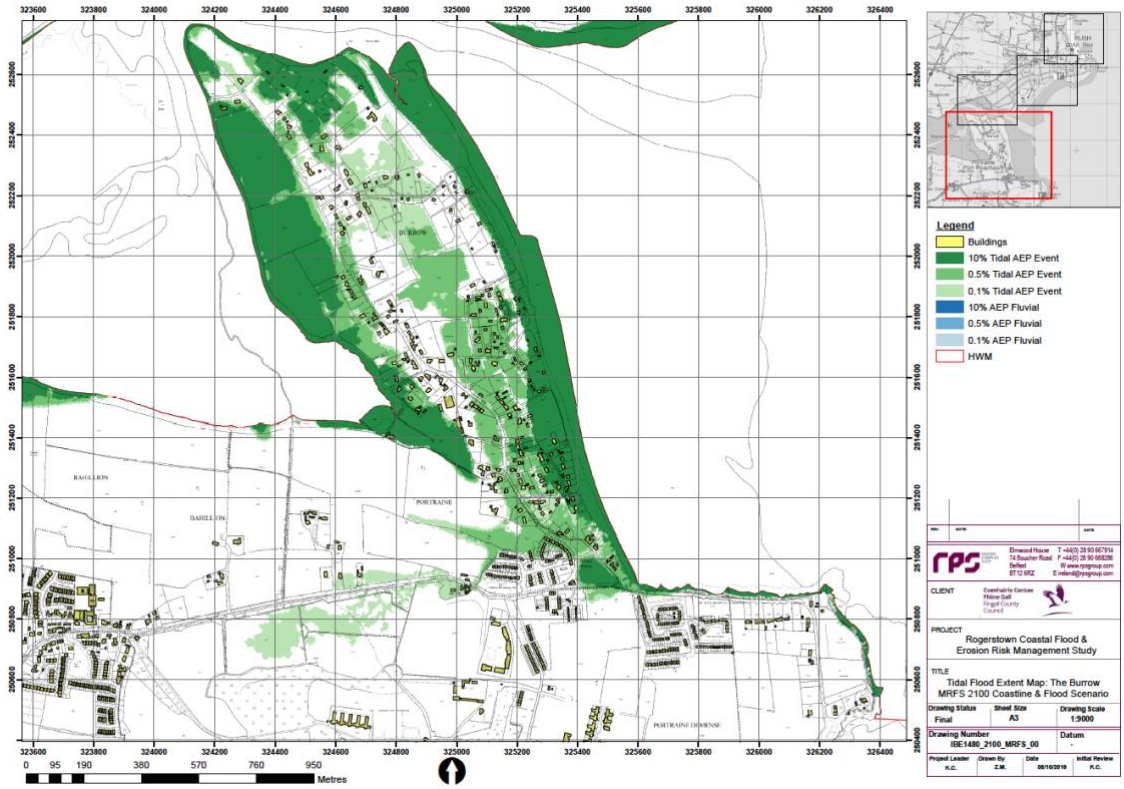


Figure 16: Tidal Flood Extent Map for the 2100 MRFS (+0.50m sea level rise and 68m of coastal retreat) (Source: RPS, 2020a).

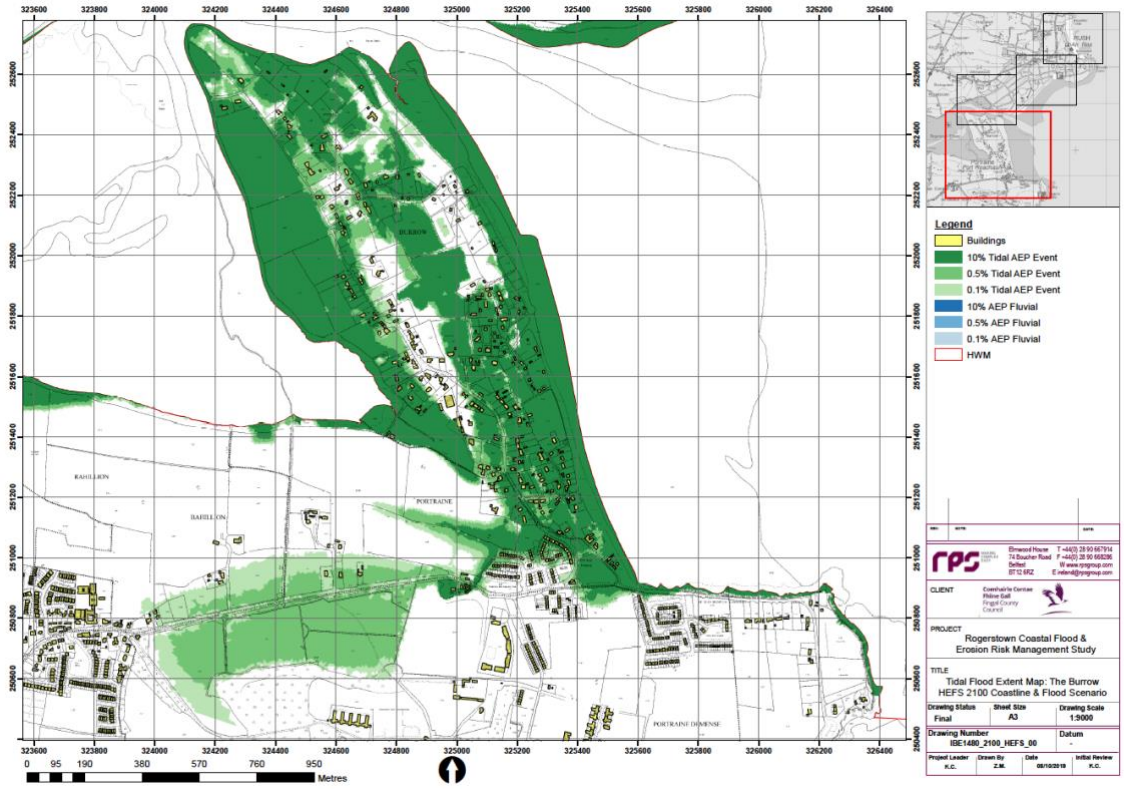


Figure 17: Tidal Flood Extent Map for the 2100 HEFS (+1.00m sea level rise and 88m of coastal retreat) (Source: RPS, 2020a).

Based on present day conditions, up to 48 buildings were found to be at risk from coastal flooding at Burrow Beach. Considering the 2050 MRFS and the 2050 HEFS scenarios, up to 208 and up to 215 buildings were found to be at risk from coastal flooding respectively. When considering the 2100 MRFS and the 2100 HEFS scenarios, up to 248 and 286 buildings were found to be at risk from coastal flooding, respectively (RPS, 2020a). It is important to note that erosion of the existing dune system along Burrow Beach significantly enhances the coastal flood risk by creating additional flood routes RPS (2020a).

The expected flood damage costs at Burrow Beach could range between €154k to €2.8m depending on the future climate scenario considered and the consequent rate of erosion (RPS, 2020b). Under the MRFS future climate scenario, the loss of land along Burrow Beach by 2100 is estimated at 17 hectares, which equates to €258,485 (RPS, 2020b).

We recommend additional reading on the quoted reports for a thorough understanding of the various methodological procedures conducted to investigate the coastal erosion and flooding considering the prospective climate change scenarios for Burrow Beach from the historical perspective cited in this section.

3.6. Solutions and Opportunities for Burrow Beach

As addressed within the previous sections, FCC has commissioned studies that go beyond the understanding of the nature of coastal erosion and flooding future predictions, it also aimed at identifying potential solutions that could be implemented to mitigate the flood and erosion risk in this area and evaluate their technical, ecological, and economic viability. These studies took into account initiatives aiming to restore the dunes system, reduce the anthropogenic impact on dunes using interim defence solutions and, ultimately, employ soft and hard engineering as defence options to protect the coast from erosion. Information about the studies that have been undertaken so far will be discussed in this section.

3.6.1. The 1950s sheet piling

The first evidence of a coastal defence structure at Burrow Beach is the existing sheet piling along the southern section of the beach. Photographs taken in the 1950s revealed the existence of this structure at that time. Based on anecdotal evidence it is believed that this sheet piling could have been installed in the 1950s to provide protection to several small coastal cottages that no longer exist (RPS, 2020a). The structure is approximately 180m long but only 100m is

exposed at the southern section of the beach, while the other 80 metres are buried in the sand (Figure 18). The sheet piling is estimated to be 3m deep and capped with concrete. RPS ground investigations found that the sheet piling is in relatively good condition. It should be noted that the installation of this defence so far back from the existing coastline indicates that the coastline was once approximately 10 - 15m behind its current position (RPS, 2020a). According to the studies undertaken by RPS in 2020, the sheet piling seems to be effectively preventing the shoreline from retreating beyond its present position at this part of Burrow Beach.



Figure 18: Evidence of the 1950s sheet pile located along the southern section of Burrow Beach.

3.6.2. Rock Armour Installation

In 1998 a survey commissioned by FCC conducted by Kirk McClure Morton recommended the "do nothing" approach at the central and southern beach sections; control and maintenance of beach access points; prohibit access of cars, caravans, motorbikes and cycles to beach; repair to the rear dune blowouts; use of wooden groynes, sand trapping fences and planting to allow the dunes to rebuild at the breached area (northern portion of Burrow Beach) and conserve the associated saltmarsh (Gault et al. 2007; Ryle et al., 2009).

The 1998 study suggested that the sand could be removed at the northern tip (where it is gathering) to deepen the channel and maintain tidal inundation of the saltmarsh by the sea and this sand could be placed in the groyne bays. The intention at that time was to help to protect the fixed dune and saltmarsh while at the same time indirectly protect the property that lies further landward of these habitats. This recommendation was not carried out. Instead, rock armour was installed in the breach and covered with sand and planted with marram, however, this has not stabilised the breach and the sand and planting were removed by winter storms in 2004 (Ryle et al., 2009). As it was not possible to find the original study, it is difficult to provide more details concerning this tentative solution.

3.6.3. Dune Protection Plan

In 2007 a study was commissioned by Fingal County Council to assess the current condition and usage of sand dune systems at specific sites on the Fingal coast, Portmarnock, Portrane and Rush, and subsequently prepare dune management plans to address the issues prevalent at each site. The study was conducted by Gault et al. (2007) when key issues were identified, such as coastal change and erosion, vandalism and bonfires, public access and lack of information, development encroachment, and sea buckthorn invasion (these problems are described in Sections 3.4; 3.4.3; and 3.4.4).

Gault et al. (2007) suggested that a monitoring scheme of coastal change should be implemented to better understand the complexities of this system as this would provide decision makers with the baseline data required to make effective management decisions. The study recommended guided actions to tackle the problems identified, as follows:

Coastal Change and Erosion: Invest in monitoring and modelling of coastal processes in Burrow Beach/Rogerstown area in order to determine why, and at what rate, erosion is taking a place; Whilst a monitoring scheme is being implemented a “do nothing” approach should be adopted. This period will provide the opportunity to assess the natural processes and then suggest the best solution in economic terms for this location. This may be a sensitive issue but the implementation of any short-term coastal protection schemes without relevant background data would be ill-advised; Inform the public of the retreating coastline and associated risk of coastal erosion in the area through signage and the media and advise the relevant authorities of the potential risk associated with granting planning for development in this area.

Vandalism and Fire Control: Remove flammable material (e.g. sticks and plastic) from the dunes and beach; Clear the remains of existing bonfire sites to prevent them being used as sites for future fires; Use informative signage to increase awareness of the potential hazards and environmental consequences of uncontrolled bonfires; Employ a beach warden to help with enforcement of existing bye-laws that the local authority has implemented under the Local Government Act 1994 (This individual could be employed on a seasonal basis at peak times (May – September) and could cover more than one coastal location. The warden's remit could include education, enforcement and monitoring as well as raising awareness); Provide support for the warden by establishing a hotline for users to report detrimental usage of the amenity and ask the local Gardai to help to curtail anti-social behaviour.

Access and Provision of Information (Signage): Remove or replace all signs that are in a poor state of repair or that have become obsolete; Provide information on the evolution of the coastline possibly to highlight the natural processes occurring and their influence on this section of Fingal coastline; Construct a gate or concrete bollards to further restrict vehicular access to the northern section of Burrow Beach; Direct traffic towards the car park at the southern end of Portrane; Formalise existing path (running north – south) within dunes to decrease erosion and usage of alternative paths; Provide signage to dunes and caravan park entry points illustrating the important role that inhabitants/users have in dune conservation and reaffirming the need to keep to the designated routes; Install informative signage describing the nature and reason behind any monitoring programme.

Development Encroachment: Land use restrictions can have a profound environmental impact. The adoption of a setback line can allow the natural development of the coastal ecosystem that may lead to the establishment of wider beach profiles. Monitoring should determine the required setback distance in a particular area and this estimate should also take into account climate change scenarios. A minimum set back distance of 50m is recommended for soft coasts such as that found at Portrane. Further restrictions on development could be enforced through the Planning and Development Act (2000) and the relevant bodies should be made aware of the particular physical attributes of this site and their implications for potential development.

Sea Buckthorn Removal: Completely remove established sea buckthorn stands in a 3-4 day period and prevent further spread to neighbouring dune areas: Use power tools (Chainsaws, clearing saws and brushcutters) to manually remove established plants; and, hand pull (including roots) suckers in surrounding foredune area and monitor subsequent results.

3.6.4. Methodology for Coastal Monitoring

In 2009 FCC commissioned a report aiming at developing a methodology for a community-based coastal monitoring programme for the Fingal coast at Burrow Beach and Rush. An extensive Methodology for Coastal Monitoring Programme at Portrane and Rush Beaches was prepared by Kozachenko and Gault (2009). This study consists of a complete guide with accessible monitoring techniques and methods to support the community to undertake the monitoring by themselves and suggested implementation plans for such monitoring programmes.

There are three main processes that this monitoring programme helps to measure: (1) Record lateral changes of the coastline (cliff line; high water mark) position due to erosion/accretion processes; (2) Record vertical changes in beach profiles (e.g. due to tidal currents and waves); (3) Map sediment movement patterns in the near shore and intertidal area (e.g. due to tidal and river currents).

In order to support the implementation of a community-based monitoring programme, the overall recommendations of the Kozachenko and Gault (2009) study were: Collect and analyse the baseline data available, including existing aerial photographs, historical maps, plans and charts, bathymetrical, LIDAR, meteorological, tide, wave and current data. Based on these analyses a detailed implementation plan for the monitoring programme should be developed taking into account recommendations provided. Each of the monitoring techniques described above should be first undertaken on a pilot basis before applying them to the whole study domain. Following successful completion of the pilot exercises, a full monitoring programme should be strategically implemented. For all monitoring techniques it is important to keep up regular measurements at consistent scheduled time intervals. Finally, in order to stimulate the involvement of the local community it was suggested to disseminate monitoring results on an ongoing basis through a webGIS interface.

3.6.5. Dune Management Scheme

According to the RPS report (2013a), although the dunes along the northern section of Portrane beach had presented reasonably good vegetation cover, the middle and southern sections of Portrane beach had areas where there is exposed sand along the dune face. This study recommended a dune management system including dune re-profiling, matting and planting in conjunction with sand fencing along the eroded part of the central and southern sections of the

Portrane dunes where significant erosion had occurred (RPS, 2013a). This solution was believed to greatly assist the natural post storm regeneration of the dunes in these areas.

FCC commissioned then another study aiming at verifying the feasibility of that proposed solution. In 2015 RPS published an analysis comprising a search for an appropriate sand source and the quality of the material; a Marram grass source and planting strategy; and an economic assessment of the strategy, including a benefit cost ratio analysis.

The RPS (2015) study found that the dredging of the Boyne Bar by Drogheda Port is a viable source of suitable marine sand for the proposed dune rebuilding at Portrane, taking into account all the necessary permissions and consents in place for the extraction of the material at source (RPS, 2015). Marine transport of material from the Boyne Bar to the lower beach at Portrane was considered feasible, however, placement of this material at the dune face would require plant operation on the intertidal area to recover the sand (RPS, 2015). This procedure may not be acceptable to NPWS due to the impact on the designated sites. Further, this operation would require a Foreshore Licence and a Dumping at Sea permit.

According to the study, the dune habitat at Burrow Beach was not considered a suitable source for donor Marram grass material or other stabilising grasses. To preserve the source of the Marram grass at the site, it was recommended that seed could be harvested from the dunes at Burrow Beach and grown on at a remote site, however, there was considerable uncertainty as to whether sufficient viable seed could be harvested from the site in a single season (RPS, 2015).

Based on the economic assessment of the dune management scheme involving the dredging and transportation of sand from the Boyne Bar to Portrane, stabilising the dune by planting Marram grass, and then constructing sand fencing, a cost of approximately €668k was estimated.

The study concluded that the proposed Dune Management Scheme at Burrow Beach was not economically viable in terms of being eligible for central government funding.

3.6.6. Seabees – an Interim Solution

Except for the structure built in the 1950s, no hard engineering measures have been yet implemented to mitigate the threat of coastal erosion along Burrow Beach due to the potential of such measures impacting the future interests of the Rogerstown Estuary's Natura 2000 sites.

Therefore, FCC commissioned a study to analyse an interim solution aimed to attenuate the incident wave until a conclusive solution is implemented.

RPS conducted an analysis searching for interim coastal protection measures and identified that the most viable option involved the use of precast concrete Seabee units to "trip" the incident waves before they interact with the dune, thus reducing the wave energy available to erode the coastline along Burrow Beach. This option was brought forward for further assessment (RPS, 2018a).

RPS collaborated with Queen's University and undertook scaled hydraulic testing of these units. The test found that an array consisting of three staggered rows of Seabee units measuring approximately 1.7m wide and 1.4m high could successfully reduce the energy of incident waves during a 1 in 50 year return period sea state by 70%. It was proposed to place three rows of these units along a 260m long section of the top of the existing beach. No units were required further south of the proposed line because the existing pilling sheet is effective to prevent further erosion at this location (RPS, 2018a).

The study evaluated the likely interaction of the Seabee units in the Rogerstown Estuary SAC and SPA. The results found that the Seabee units will not be located within Rogerstown Estuary SPA, but they will be located entirely within Rogerstown Estuary SAC in a supratidal area of the beach at a distance varying between 9m and 25m up the beach from the mean spring high water line (RPS, 2018a). According to this report, the evaluation and analysis has revealed that there are no likely significant detrimental effects upon reaching, achieving or delaying the conservation objective targets for any of the qualifying interests of sites generally, or Rogerstown Estuary SAC or Rogerstown Estuary SPA in particular.

The study also assessed how the Seabee units would affect the pattern of the winds which might affect the transport of sediment from the beach to the dune systems. Based on the model developed as part of the Coastal Risk Assessment for Portrane, the amount of sand coming off the dunes due to storm erosion is only 1.6 percentage of the quantity of sand moving around the beach during a storm event ($26m^3/m$ from the dunes compared with $1620m^3/m$ transport on the beach (RPS, 2018a). As the Seabee units were to be spaced 70cm apart, the study considered this spacing sufficiently large to allow the wind to blow through the units and transport sand through the unit array (RPS, 2018a).

The screening study concluded that the proposed development was not directly connected with or necessary to the management of any European site; would not give rise to potential significant effects on the Qualifying Interests or Special Conservation Interests of any European site; and would not give rise to potential in-combination or cumulative effects with the other projects considered.

The installation of the Seabees units started in late 2018. The wave attenuation array consisted of circa 355 individual precast Seabee units, weighing approximately 4.2T each, and placed along the foreshore region in three individual rows (RPS 2020a). According to this latest RPS report, these interim measures have performed as anticipated having reduced erosion rates in the area immediately behind the units in the period since installation. The Seabee units have created a perched beach effect whereby sand is trapped on the lee (landward) side of the units which in turn has raised beach levels further reducing potential wave energy breaking onto the dunes (RPS 2020a).



Figure 19: Seabees installed at the southern section of Burrow Beach.

A survey on the southern section of Burrow Beach undertaken in February 2020 by RPS found that erosion rates behind the Seabee units were generally nearly 60% less than those observed much further north (RPS, 2020a). It was also noted that the effectiveness of the Seabee units had decreased towards the northern extent of the array. This was because beach levels have

continued to drop in this area which in turn decreased the relative crest level and, thus, the wave attenuation properties of the interim measures (RPS 2020a).

3.6.7. Coastal Risk Management Studies and Optioneering Reports

Since 2013 RPS consultancy has prepared studies aimed at understanding the coastal hydrodynamics and morphodynamics processes occurring at Burrow Beach and supporting FCC in taking decisions based on the best information available. RPS coastal erosion risk management and climate change studies and accompanying coastal defence optioneering reports were published in 2013, 2015, 2018 and 2020.

The published coastal defence optioneering reports encompassed an extensive analysis regarding the likely strategic defence options for Burrow Beach and its associated costs. The options screened were based on coastal management practices around the world (Ballinger and Dodds, 2017; Esteves and Williams, 2017; Haigh et al., 2020; Pontee et al., 2005; Pranzini et al., 2015; Williams et al., 2018), including "No Active Intervention" (or "Do Nothing"), "Hold the Line", "Advance the Line", "Managed re-alignment", and "Managed Retreat". These options are indicated by the "Minor Flood Mitigation Works and Coastal Protection Scheme" (OPW, 2009 - further explained in section 4), except for the "Managed Retreat" option. These options are described below:

- No Active Intervention or "Do Nothing": this is a policy decision not to invest in providing or maintaining any defences. Where there are presently no defences, this policy means that the shoreline will continue to evolve naturally. This policy can also apply to areas that currently have coastal defences. In a "Do Nothing" approach these defences will not be maintained and these areas will evolve naturally.
- Hold the Line: This policy involves improving or maintaining the standard of protection provided by the existing defence line. Renewed defences refer to the construction of new, more robust defences. There may be some residual risk in holding the line as foreshore steepening and loss of beach width, factors that could make this policy unsustainable sooner than anticipated. The aim of this policy is to retain the existing character and form of the coast with minimal disruption, whilst maintaining all existing assets.

- Advance the Line: This policy involves building new defences on the seaward side of the original defences in order to reclaim land and improve the standard of protection that was provided by the original defences.
- Managed Re-alignment: When a coastline is protected with hard or soft defences, this option involves allowing the coastline to move backwards (or forwards) from its present position by realigning the position of existing defences and creating a new line of protection. In terms of coastal erosion, this usually involves creating a setback area (buffer zone) where no development is permitted (no build zone). For coastal flooding, it will state a minimum elevation above mean sea level for development. Although similar in many respects, the key point that differentiates "Managed Retreat" from "Managed Realignment" is that the latter involves realigning existing defences, so if no coastal defences are present, then this option cannot take place.
- Managed Retreat: This policy is applicable when a coastline is not protected by coastal defences and similar to the option of Managed Realignment this policy involves creating a sacrificial buffer zone whereby no further development is permitted (no build zone). In respect to the properties located in the buffer zone, several options are usually considered including the relocation of properties, compensation schemes for landowners, or the long-term abandonment of the area amongst others.

Given the uncertainty of climate change impacts at Burrow Beach coast at that time, the reports published in 2013 recommended the "Do Nothing" approach and the "Dune stabilization, management and maintenance" techniques, while keeping a monitoring of the likely changing conditions (RPS, 2013a,b). RPS stated that assuming no human interference in terms of the installation of coastal protection works then with increasing sea levels the shoreline will naturally tend to recede to re-establish the equilibrium between the water depth and wave climate that currently exists along the dune frontage (RPS, 2013a). Also, the 2013 analysis considered that Rogerstown estuary SAC and SPA designated sites include shifting and fixed dunes, the Dune Management systems must be in line with the conservation objectives for the Natura 2000 designated sites, and structures that might interfere in natural processes are extremely unlikely to comply with the conservation requirements (RPS, 2013a).

In regard to this conclusion, it is important to underline that while management structures aimed at halting coastal erosion and flooding can interfere negatively on the specially

designated areas, “Do Nothing” can also affect ecosystems’ balance and contribute to habitat and biodiversity loss, further magnifying the future effects of climate change.

In 2018, RPS was commissioned by FCC to assess the feasibility of a coastal defence scheme to reduce flood risk within the Rogerstown Outer Estuary area (RPS, 2018b). Following Storm Emma and a succession of other severe storm events, the scope of the study was expanded to ensure that the proposed scheme also mitigated the risk of future coastal erosion. The report published in 2018, examined the impacts of Storm Emma on Burrow Beach and diagnosed that a massive erosional process occurred due to this extreme event (this erosional process is detailed in Section 3.4.4). The report indicated two hard defence options that would be feasible to implement given the current scenario: (1) Hold the Line with the use of revetment structure; (2) Hold the Line with the use of fishtail groynes and renourishment. The first option (Revetments) would infer a cost between €3m and €4m, while the second option was expected to raise this cost up to €5.5m, plus €1m for frequent beach renourishment campaigns. Option 2 was considered to be the most technically and cost effective solution, however, with a high potential impact to interfere with the conservation objectives and qualifying features of the nearby environmentally designated SPA and SAC habitats (RPS, 2018b). While no solution was being implemented, RPS conducted a study to verify the feasibility of implementing the interim solution (Seabees), as described above (RPS, 2018a).

RPS published the largest analysis ever undertaken on Burrow Beach area in 2020. The “Coastal Flooding and Erosion Risk Management” (CFERM) plan for the Rogerstown Estuary area consisted of an extensive screening process to review the technical feasibility and economic justification of several coastal management policies. This study included an initial appraisal, a multi-criteria assessment and an economic assessment of potential options, aiming to identify a preferred management plan for each site (RPS, 2020b). In accordance with guidance of the Catchment Flood Risk Assessment Study conducted by OPW and the Flood and Coastal Erosion Risk Management Appraisal Guidance published by UK Environmental Agency, and consultation with FCC, this study aimed at developing an appropriate management plan for the short, medium, and long term epochs defined as: from Present day to 2025, from 2025 to 2050 and from 2050 to 2100.

Past the initial screening of high-level policies, the option “Advance the Line” was screened out of further analysis due to the lack of benefits relative to the high probability of environmental impacts associated with this policy (RPS, 2020b).

Considering the alternative “Managed Retreat”, the strategy for Burrow Beach would be the gradual abandonment. A long-term planned abandonment can follow the “Do Nothing” approach in which buildings are regarded as having a fixed life span and when these are at imminent risk of coastal erosion or flooding, no attempt is made to protect them (RPS, 2020b). The most pressing constraint with this policy is that from an Irish perspective, there is no national strategic policy to facilitate implementing a policy managed realignment.

Considering the option “Holding the Line”, many strategies associated to this policy were described in detail in the RPS report (2020b), such as seawalls, revetments, groynes, detached breakwaters, embankment, beach nourishment, perched beach, sand motor and dunes stabilization. The detailing included a description of each technique, an initial appraisal, and an assumption about the feasibility to implement these at Burrow Beach, considering its potential to solve the problems of coastal erosion and flooding, whilst conserving the Natura 2000 designated sites.

All these CFERM options were assessed through a preliminary options appraisal and as a result the options “managed realignment”, “detached breakwaters”, “sand motor”, and “perched beach” were excluded from further consideration.

In regard to the option “Managed Realignment” it was excluded from the screening process because this option refers to the realignment of existing coastal defences and at sites like Burrow Beach (which is practically undefended), this policy is not applicable.

Considering the exclusion of the “Detached Breakwaters”, the report indicated that without a detailed assessment including a physical model testing it was difficult to assess the performance and the likely environmental impacts of this technique. Some reasons listed to exclude this option were related to the likely high installation cost (not calculated though), uncertainty on how these structures will perform at the site, and to the fact that they do not mitigate coastal flooding during storm surge activities. However, groynes are also linked to a high cost and the disadvantage of obstructing the access along the beach. Detached breakwaters are widely used to prevent coastal erosion around the world as they provide shelter from waves and decrease the sediment drift behind the structures, which in turn will support tombolos formation (accumulation of sand between the breakwater and coastline), allowing the beach restoration. The biggest problem verified at Burrow Beach is a deficit in the sediment supply due to waves swell that approach from the south east sector combined with the longshore

sediment drift in the northward direction resulting in the bulk of sediment being intercepted by the strong tidal jet of the Rogerstown Estuary that ejects it out of the mini sub cell (RPS, 2020a). Therefore, the exclusion of the "detached breakwaters" from an in-depth analysis may be considered as a premature decision.

The resultant CFERM options were then analysed according to a Multi-Criteria Analysis (MCA), which considered social, economic, environmental and technical criteria. The highest scoring option from the MCA was, respectively, embankments followed by revetments, beach nourishment, seawalls, managed retreat, groynes, and lastly, dune stabilisation. Based on this assessment embankments could be considered the best option to mitigate the flood risk, however, they would need to be combined with another option to mitigate the threat of erosion (RPS, 2020b). Despite being considered, Managed Retreat would be expected to do little to minimise the risk to human health and properties across Burrow Beach, followed by a significant detrimental impact on the local economy (RPS, 2020b).

Based on these results, RPS developed three different schemes for Burrow Beach:

Option 1 - Embankments, Seawalls and Revetment: This option would include for the provision of approximately 1,250m rock revetment along the toe of the existing dune system to prevent future coastal erosion; the construction of nearly 100m of seawall at Marsh Lane to mitigate flood risk and the construction of a nearly 135m wall along a section of Burrow Beach and Quay roads to reduce wave overtopping. To reduce the risk of flooding from the estuary side of Burrow Beach, this option also considers the construction of strategically placed embankments across Burrow Beach which would total approximately 1,430m in length.

Option 2 – Managed Retreat: This option would involve creating a dynamic setback line through a series of rolling easements. Based on the assumption that a compensation scheme could be established for affected stakeholders, this option could require about 13 properties being purchased at average market value over the short term. Over the longer term (by 2100 considering the MRFS scenario), up to an additional 34 properties could have to be purchased to allow future retreat. This number would depend on several factors including the rate of future climate change and coastal erosion. This is a dynamic option that requires continuous monitoring and reviewing.

Option 3 – Groynes, Beach Nourishment, Embankments and Walls: This option would consider installing specially designed Y shaped groynes structures complemented by a beach

re-nourishment scheme. These groynes structures would help control the longshore and cross-shore transport elements of the prevailing littoral drift across Burrow Beach. Each groyne would extend seaward by approximately 70m at a spacing of around 175m between one another to create 7 sediment sub-cells along Burrow Beach. The total footprint of the proposed groynes would equate to circa 0.4 hectares. In order to restore beach levels, it would be necessary to fill each sub-cell with beach nourishment material. In total it is expected that approximately 175,000m^3 of sand material would need to be placed over an area of circa 9.2 hectares in order to achieve suitable beach levels. The concept of this option is that the re-nourished beach profile will reduce incident wave energy along the coastline by limiting the prevailing water depth and thus mitigating the threat of erosion. The groynes are an important element of this option as they will regulate the movement of sand across the beach and prevent the sand being stripped from the beach during a single storm event. The embankments and walls structures proposed at Option 1 are also considered to be placed in conjunction with the groynes.

Beach nourishment often requires a long-term maintenance effort, so the success of a re-nourishment scheme can be enhanced with the construction of hard defences to limit the loss of sand. A limitation of beach nourishment is that Ireland does not have an established offshore dredging industry, as a result, sourcing suitable material and obtaining the relevant permissions could be problematic which would likely be reflected in costs (RPS, 2020b).

Considering the economic assessment, regardless of the future climate scenario adopted, all options for Burrow Beach were considered economically viable under the Benefit Cost Ratio (BCR) analysis. Based on the BCR testing, the study found that Option 3 is economically robust and would deliver a positive net present value (BCR > 1.0) with only 15 properties being lost to erosion. This is significantly less than the 36 – 46 properties that were found to be at risk by 2100 under the MRFS and HEFS respectively (RPS, 2020b). This option would cost between €15m and €16m to be implemented with an additional beach recharge cost of approximately €8.5k per year.

Option 1 was found to cost approximately €11m to be implemented with an additional beach recharge cost of approximately €8.5k per year and Option 2 would cost up to €3.8m to compensate properties loss over the short term scenario and up to €9.8m over the long term scenario (RPS, 2020b).

The Optioneering Process has demonstrated that finding a preferred option for Burrow Beach is complex because each option considered has its own advantages and disadvantages when considered in the context of sustainable development. The study concluded that Option 3 was therefore considered the preferred CFERM plan for Burrow Beach over the short to long term (i.e. present day to 2100), since it can reduce the social impact of coastal flooding and erosion whilst minimising the environmental impact on the nearby environmental designated habitat.

RPS prepared a report to inform Screening for Appropriate Assessment in respect of the emerging preferred solution to Burrow Beach. The report aims to inform FCC's Appropriate Assessment (AA) screening which is required in respect of the proposed preferred flood defence works. Based on objective scientific information, the screening study concluded that the project, either individually or in combination with other projects and plans, is likely to have a significant effect on any European designated sites and, therefore, an AA is required (RPS, 2020b).

An Environmental Impact Assessment Screening study was prepared by RPS in order to inform FCC in relation to the requirement for an Environmental Impact Assessment Report (EIAR) for the works at Burrow Beach. The study concluded that the proposed development meets the mandatory EIA requirements and is deemed to screen in for an EIA. Hence, an EIAR should be prepared as a statutory requirement of the planning process (RPS, 2020b).

4. Coastal Climate Adaptation Frameworks in Ireland

Climate Change severity has been recognised by the Houses of Oireachtas through the declaration of a Climate Emergency by Dáil Éireann in May 2019. However, the Government of Ireland has for a number of years been working on a series of strategies, guidelines and plans focused on addressing climate change and its first legal basis for climate action was published in 2015 and amended in 2021.

The European Commission (EC) focused policy effort on climate change adaptation in 2009, with the publication of the White Paper on this topic (EC, 2009). This was followed by the publication of the first European Adaptation Strategy in April 2013, which aimed at contributing to a more climate-resilient Europe. The EC undertook a review of the Strategy with a view to assessing how effective this statement has been in facilitating the progress on

adaptation in European Member States. A revised version of the European Adaptation Strategy on Climate Change was published in February 2021, and it is focused on four objectives: to make adaptation smarter; faster; more systemic; and, to step up international action for climate resilience (EC, 2021a).

Climate change adaptation has implications for many economic sectors and environments, such as on biodiversity, agriculture, fisheries, transport, and infrastructure. Since this report is focused on coastal erosion and flooding, further attention is paid to the role of coastal management for climate adaptation. Academic and practitioner-based literature both recommend that the planning and management of coastal areas adopt an integrated, participatory, and ecosystem-based approach, widely known as Integrated Coastal Zone Management (ICZM). ICZM is a continuous and dynamic planning process that should address social, economic, environmental and governance issues within coastal areas, aiming to improve the quality of life of coastal communities by considering the maintenance of biological diversity and ecosystem services (GESAMP, 1996). ICZM encourages a participatory approach which involves a broad environmental assessment, considering history, culture, traditions, the use of the territory and associated conflicts (Cicin-Sain, 1993).

The topic of ICZM and related challenges have long been discussed in the European context and since the 1990s a move towards more integrated approaches has taken place (EC, 1992; EC, 1994; EC, 2000), resulting in the EC Recommendation on ICZM published in 2002 (EC, 2002). This recommendation was developed in recognition of the declining status of coastal areas across Europe, e.g., depletion of resources, over development, habitat loss, vulnerability to climate change, coupled with an awareness of the benefits of adopting an integrated approach to coastal management practices. However, Europe still lacks a legal instrument (e.g., a Directive) that would require its Member States to implement an ICZM framework.

The debate around the need of an ICZM framework in Ireland initiated in the 1960s when An Foras Forbartha (the Planning Institute) and Bord Fáilte (the Tourist Board) commissioned the first study of the entire coastline which was performed in 1972 (Cummins et al., 2004a; O'Mahony et al., 2014). This debate evolved during the 1990s following international Conventions' recommendations (prominent at the United Nations Conference on Environment and Development/Rio de Janeiro, 1992) and with the advance of the Sustainable Development's international agenda advocating for more integrated forms of management. Two important documents concerning a strategic and integrated model to support coastal

planning and management in Ireland were published during this period: *Towards a Marine Policy for Ireland – Proceedings of the Consultative Process* (Marine Institute, 1991); and *Coastal Zone Management: A Draft Policy for Ireland* (Brady Shipman Martin, 1997). The latter included recommendations for integrated coastal management in order to overcome the sectoral approach and the conventional dissociation between marine and terrestrial planning frameworks, however, the Draft policy recommendations were never officially adopted (O'Mahony et al., 2014).

Since then, successive government department strategies have signalled intentions to implement an ICZM framework. For instance, in 2001 the former Department of the Marine and Natural Resources (DMNR) published the report '*Making the Most of Ireland's Marine and Natural Resources Strategy Statement (2001 – 2003)*' stating as one of the key priorities to develop an integrated legislative and planning framework for coastal zone and natural resources management in Ireland under the principles of ICZM. The document recognised that the growing development pressures in the marine coastal zone underlined the need for a comprehensive integrated framework for the sustainable management and development in the coastal area. It had as one of its main strategies "*to develop and adopt, in the context of the elaboration of coastal zone management policy, and taking account of the likely effects of climate change, an overall strategy for targeted coast protection*" (DMNR, 2001).

According to CMRC (2004) the subsequent DMNR's Strategy Statement (2003 - 2005) went a step further, by making pledges on protocols on cooperation and coordination in respect of ICZM to be agreed by December 2003, that a Coastal Zone Management Bill should be published in 2004, and for the preparation of an assessment and a strategy in accordance with the timeframes specified in the EC Recommendation. However, these goals have never been achieved in practice.

Despite the lack of a legal ICZM framework in Ireland and the absence of an EU ICZM Directive, other European Directives that exert influence on coastal areas are implemented in Ireland through national legislation. These Directives include the Birds Directive (Directive 2009/147/EC), the Habitats Directive (Directive 92/43/EEC), the Environmental Impact Assessment Directive (Directive 2011/92/EU), the Water Framework Directive (Directive 2000/60/EC), the Marine Strategy Framework Directive (Directive 2008/56/EC), the Maritime Spatial Planning Directive (Directive 2014/89/EU), among others.

A thorough examination of the key strategic aims and objectives of legislation, policies and plans published at national, regional, and local levels addressing issues of coastal management, development and planning, and climate change adaptation (including biodiversity) relevant to underpin the discussions about the management of coastal erosion and flooding in the Portrane area (Fingal County/Great Dublin Region) was undertaken (Figure 20). All Irish legislation (the Acts and Statutory Instruments) are currently in force, including amendments, since their first publication were examined. Regarding policies and plans, this study only examined the most recent ones (from 2000 onwards) to the present day (August 2021).

A dynamic timeline (Figure 21) and a visual communication of this analysis were organised using the online platforms *TimeGraphics* and *ArcGIS StoryMaps*, and can be accessed using the following link: http://www.ccatproject.eu/coastal-climate-adaptation-Ireland/

The Coastal Climate Adaptation frameworks are summarised in the following subsection and comprehensively presented in the Appendix. For a comprehensive understanding, this subsection must be read in conjunction with the Appendix[2].

National Coastal Zone Management Legislation, Policies and Plans [Appendix - Section 1]

Section 1 of the Appendix presents national legislation, policies and plans relevant to Coastal Zone Management. Ireland has a limited number of legal instruments that deal directly and solely to coastal areas. The primary piece of relevant legislation is the Foreshore Act, 1933. The principal act has been amended four times since then, primarily to take account of obligations deriving from EU law. The Coast Protection Act, 1963 is used in specific circumstances only. Both these legal instruments focus mainly on regulating the construction of structures and do not provide an integrated approach to the planning and management of the coastal zone, as recommended by the ICZM approach. The **Foreshore Acts, 1933 - 2011** [section 1.1] require that leases and licences are obtained from the appropriate Minister for the carrying out of works (including sea defence works) on the State-owned foreshore. The foreshore is defined as the shore and the seabed, below the line of high water of ordinary or medium tides to the 12 nautical miles of the sea, including tidal river/estuaries, channels, creeks, and bays. The **Coast Protection Act, 1963** [section 1.2] provides the basis for the

[2] References to Appendix sections are enclosed in square brackets to differentiate them from references to sections presented in the body of the report.

implementation of coastal protection schemes in cases of encroachment by the sea. The Act provides the legal basis for the Office of Public Works (OPW) and Local Authorities (LAs) to jointly implement coastal protection works and clarifies competencies between the interested governmental institutions.

In order to structure and update the procedures provided by the Coast Protection Act, the Irish government through the OPW, published the guidelines **Minor Flood Mitigation Works and Coastal Protection Scheme** in 2009 [section 1.3]. The scheme provides funding to LAs to support the installation of minor flood mitigation and coastal protection works and/or to studies addressing localised problems. The guidelines provide for the technical requirements for the applications. This is the only policy in Ireland which mentions that appropriate alternative options and measures to best manage the risks associated with coastal erosion and accretion, including the 'Do Nothing', 'Do minimum', 'Hold the Line', 'Advance the Line', and 'Managed re-alignment', should be indicated in the proposal.

From 2003 – 2013 the OPW commissioned the **Irish Coastal Protection Strategy Study (**ICPSS) [section 1.4] with the objective of providing information to support decision making about how best to manage risks associated with coastal flooding and coastal erosion in Ireland. The Study completed in 2013 provided strategic current scenario and future scenario (up to 2100) coastal flood hazard maps and strategic coastal erosion maps for the national coastline. In 2020 the national government established the **National Coastal Change Management Strategy Steering Group** [section 1.5] with the purpose to examine and to provide a framework for key decisions to be taken on how Ireland can best manage its coastline in light of the risks from rising sea levels and more frequent extreme storm surge events and coastal erosion.

In 2021 the Government of Ireland published its first **National Marine Planning Framework** (NMPF) [section 1.6] to meet the requirements of the EU Maritime Spatial Planning Directive. The NMPF gathered for the first time in a unique framework all marine-based human activities, outlining the government's vision, objectives, and policies for each marine activity, detailing how these marine uses and activities should interact with each other in order to ensure the sustainable use of the marine resources up to 2040. The marine plan covers 490,000 km^2 of the Irish maritime area, which extends from the mean high water mark at the coast, up to 200 nautical miles. Therefore, the NMPF does not provide for an integration of the maritime area with the coast. This framework will rely on enactment of new legislation, the **Maritime Area**

Planning Bill, to operationalise the planning and management of the maritime area, including a system of spatial designation through ocean zoning and an integrated consent system to enable the occupation of Ireland's maritime area. The Bill proposes the creation of a nearshore area, a zone that would have a maximum extent of three nautical miles from the shore and where "*Coastal Planning Authorities*" would assume certain responsibilities, including examining applications for certain developments, granting of development consent, and enforcement and compliance. The current version of the Bill (August 2021) does not provide for integrated management or coastal erosion and flooding management.

National Planning and Development Legislation, Policies and Plans [Appendix - Section 2]

Section 2 of the Appendix presents national planning and development legislation, policies and plans. Following a chronological sequence, the section starts presenting the **Local Government Acts, 1925 - 2019** [section 2.1] which define structures, powers, functions, and duties of local governments in the topics of, inter alia, planning (of the land area); housing; economic and community development; environment (including waste, noise, and air pollution). The Acts also provide powers to LAs to pass local regulations known as bye-laws. These can be used, among other things, to promote environmental protection of coastal environments which may in turn support climate mitigation and adaptation.

The **Planning and Development Acts, 2000 - 2021** [section 2.2] form the basis for contemporary development planning in Ireland and cover a wide range of matters. The Acts provide the framework of the development management by setting out details of development plans at national level (such as the National Planning Framework), regional planning guidelines (such as the Regional Spatial and Economic Strategy), and local area plans. In particular, the Acts stipulate as mandatory the preparation of Development Plans, by local planning authorities, which should include objectives for the conservation and protection of archaeological and natural heritage and the conservation and protection of designated European sites. The Acts also call attention to the need of regulating, restricting, and controlling development in areas at risk of erosion and other natural hazards; and of carrying out flood risk assessment for the purpose of regulating, restricting, and controlling development in areas at risk of flooding (whether inland or coastal).

Regarding the National Development Strategies, the **National Spatial Strategy (2002 - 2020)** (NSS) [section 2.3.1] originated from the commitment stated in the National Development Plan

(2000 - 2006) to prepare a spatial strategy to plan at national level for the country's future spatial development. The NSS was the predecessor of the current **National Planning Framework - Project Ireland 2040** (NPF) [section 2.3.2]. The NPF sets out a process by which more detailed planning documents must follow, including spatial planning, infrastructure planning, social and economic planning, and outlines principles that these plans should be based on, such as sustainability, creativity, and community. This framework places the United Nations Sustainable Development Goals (SDGs) at the heart of long-term planning, including the sustainable management of water, waste, and other environmental resources, and encourages tackling climate change by a series of climate actions aligned with the National Mitigation Plan and the National Adaptation Framework. It recognises that as a result of climate change, sea levels and patterns of accretion and erosion are key issues for planning and flood risk assessment, especially in managing the ongoing development of cities and towns.

The first National Development Plan presented in the Appendix is the **National Development Plan (2007 - 2013)** (NDP) [section 2.4.1], which proposed an investment of some €184bn in economic and social infrastructure. Aligned with the NSS it had the objective to integrate strategic development frameworks for regional development, for rural communities, for all-island co-operation, and for protection of the environment with common economic and social goals. The NDP projected over €23m to fund protection schemes to protect the coastline from erosion and flooding, and support for the completion of the ICPSS.

The subsequent and current NDP in operation, the **National Development Plan (2018 - 2027)** [section 2.4.2], aims to drive Ireland's long term economic, environmental, and social progress and sets out the investment priorities that should underpin the successful implementation of the current NPF. The NDP demonstrates the government's commitment to meeting Ireland's infrastructure and investment needs over the next ten years, through a total investment estimated at €116bn over the period. Transition to a Low-Carbon and Climate- Resilient Society has been identified as a strategic investment priority and circa €21.8bn should be allocated to accomplish this National Strategic Outcome. The current NDP designates investment actions on Flood Risk Management and highlights the importance of flood relief schemes to minimise the impacts of river and coastal flooding on society, however, it does not explicitly present investments for coastal erosion alone.

The Section 3 of the Appendix presents the National Climate Change Legislation, Policies and Plans. The Government of Ireland published in 2014 the document **National Policy Position on Climate Action and Low Carbon Development** [section 3.1], aiming to provide a high-level policy direction for the adoption and implementation by government of plans to enable the State to move to a low carbon economy by 2050. This long-term vision is based on a reduction in carbon dioxide (CO_2) emissions of at least 80% (compared to 1990 levels) by 2050 across the electricity generation, built environment and transport sectors; and in parallel, an approach to carbon neutrality in the agriculture and land-use sector. This document stated that the evolution of climate policy in Ireland should be an iterative process, based on the adoption by the government of a series of national plans over the period, including mitigation and adaptation frameworks.

In the following year, 2015, the Government of Ireland enacted its first Climate Action and Low Carbon Development Act and in July 2021, enacted the Climate Action and Low Carbon Development (Amendment) Act, intended to significantly strengthen the legal framework for climate action. The **Climate Action and Low Carbon Development Acts, 2015 - 2021** [section 3.2] state that the national climate objective is to "*to reduce the extent of further global warming, pursue and achieve, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy*". The Acts sets out the definitions and the legal basis for the making of the National Mitigation Plan, the National Adaptation Framework, the Sectoral Adaptation Plans, the requirements for the development of a National Long Term Climate Action Strategy, and the obligation for LAs to prepare Local Climate Action Plans comprising mitigation and adaptation measures. The Acts provide for the creation of the Climate Change Advisory Council and seeks to ensure citizen participation in the making of the above-mentioned plans. The 2015 Act define "Adaptation" as "*any adjustment to any system designed or operated by human beings (including an economic, agricultural or technological system), or any naturally occurring system, including an ecosystem, that is intended to counteract the effects (whether actual or anticipated) of climatic stimuli, prevent or moderate environmental damage resulting from climate change or confer environmental benefits*".

Ireland has published two National Climate Change Adaptation Frameworks so far. The first one, the **National Climate Change Adaptation Framework** (NCCAF) [section 3.3.1], was published in 2012 and provided the basis for the second one, the **National Adaptation**

Framework (NAF) [section 3.3.2] published in 2018 and which upscaled its predecessor. The NCCAF mirrored the approach proposed by the EU White Paper on Adaptation and recommended a two-phased approach to adaptation in Ireland. The first phase was aimed at identifying national vulnerability to climate change, based on potential impacts relative to current adaptive capacity. The second phase was aimed at addressing the development and implementation of sectoral and local adaptation action plans as part of the comprehensive national response to the impacts of climate change. The NACCF also recognised the Local Development Plans as the mechanism for the delivery of local climate adaptation actions.

The NAF sets out the international policy context of the time and incorporated key drivers, such as the Agenda 2030 for Sustainable Development and the Sendai Framework for Disaster Risk Reduction, and brought the latest visions for a low carbon, climate resilient and sustainable development in Ireland after the enactment of the Climate Action and Low Carbon Development Act in 2015. In terms of implementation the NAF does not identify specific locations or propose adaptation measures or projects in relation to the sectors but proposes that adaptation measures should be developed across sectors and local governments, in accordance with the specifications in this framework, respecting the principle of subsidiarity.

The **Climate Action Plan** (2019) [section 3.4], formally declared a "*Climate and Biodiversity Emergency*" in Ireland. It consists of a government roadmap composed of a set of policy actions committed to achieving by 2030 "*net zero carbon energy systems objective for Irish society and in the process, create a resilient, vibrant and sustainable country*". The Plan outlines the current state of climate breakdown across different sectors (such as Electricity, Built Environment, Transport, Agriculture, Enterprise and Services, and Waste and the Circular Economy) by identifying the nature and scale of the challenges. It sets out the new governance structures necessary to implement changes, including the creation of a Climate Action Delivery Board and a Climate Action Council. The report recognises the imminent climate change impacts to Ireland's coastal zone and highlights the need for adaptation measures to help the country cope with the effects of climate change.

The first **Local Authority Adaptation Strategy Development Guidelines** [section 3.5] was published in 2016, following the recommendations of the NCCAF 2012. In 2018, it was updated to incorporate the new recommendations specified in the Climate Action and Low Carbon Development Act, 2015 and in the NAF 2018. The Guidelines were created to assist LAs to develop their own adaptation strategies and ensure that they will complement the

Sectoral Adaptation Plans to be prepared under the NAF by providing a coherent and consistent step-by-step approach to adaptation planning. It recognises that LAs are the level of government closest to local communities and the first responders in many emergencies, so are critical to implement positive adaptation actions on the ground. LAs count on the support of the four Climate Action Regional Offices (CAROs), established in 2018, to develop and implement their strategies.

The **Sectoral Planning Guidelines for Climate Change Adaptation** [section 3.6] published in 2018, have been developed to assist the government departments to prepare statutory Sectoral Adaptation Plans in relation to the priority area they are responsible for and aims to ensure that a coherent and consistent approach to adaptation planning is adopted by the key sectors in Ireland. According to these Guidelines, adaptation strategies can be classified as Soft, Green, or Grey and may range from simple solutions to large scale transformational projects. Sectors are required to prepare their plans in line with the six step planning cycle described in the Guidelines while also being aware of the overall requirements regarding the development of sectoral adaptation plans in the Climate Action and Low Carbon Development Acts and in the NAF.

Following the methodology proposed by the Sectoral Planning Guidelines, seven Irish government departments prepared 12 Sectoral Adaptation Plans, grouped as follows: Agriculture, Forest and Seafood; Built and Archaeological Heritage; Transport; Electricity and Gas Networks; Communications networks; Water Quality and Water Services Infrastructure; Health; Flood Risk Management; and Biodiversity. The last two Sectoral Adaptation Plans are particularly relevant to discuss adaptation solutions for coastal erosion and flooding, so these are thoroughly described in the Appendix together with their corresponding legislation, policies and plans.

The first **Climate Change Sectoral Adaptation Plan for Flood Risk Management** [section 3.7] was produced by the OPW in 2015 under the mandate of the NCCAF 2012 and the second Plan was prepared by the OPW in 2019 under the mandate of the NAF 2018. The 2019 Plan (currently in operation), updates its predecessor by considering novel information available on climate change and its potential impacts on flood risk management, including progress made on the actions set out in the non-statutory adaptation plan, particularly in the areas of research, assessment (such as the information generated through the Catchment Flood Risk Assessment and Management "CFRAM" Programme), and planning, design and implementation of flood

relief schemes (OPW, 2019). The **CFRAM Programme** [section 3.7.1] was a large flood risk study carried out by the OPW, in consultation with LAs and published in 2018. It consisted of a detailed engineering assessment of 300 areas or communities believed to be at significant risk of future flooding, which 90 are located in coastal areas. This was completed through six CFRAM Projects covering 29 River Basins, and other location-specific projects. Flood maps were developed for current conditions and for two future scenarios for the end of the century the Mid-Range Future Scenario (MRFS) and the High-End Future Scenario (HEFS). The Flood Risk Management Sectoral Plan acknowledges climate change will increase the flood risk associated to the continued sea level rise, more severe Atlantic storms which could generate more significant storm surges and extreme waves, increase in the number of heavy rainfall days each year, and wetter winters. The Plan sets out a long-term goal for flood risk management adaptation, along with a set of objectives and actions, in order to ensure effective and sustainable management of flood risk into the future.

The **Biodiversity Climate Change Sectoral Adaptation Plan** [section 3.8] published in 2019 reinforces that Irish biodiversity is vulnerable to the impacts of climate change, which is a major and growing driver of biodiversity loss. The Plan also emphasises the importance of biodiversity and ecosystem functions and services for human well-being and recognises that, on the other hand, biodiversity plays a key role in building resilience (adaptive capacity to climate change) and in contributing to mitigation and disaster risk reduction. Actions within the Sectoral Plan were built on the foundations of the **National Biodiversity Action Plan (2017 - 2021)** (NBAP) [section 3.8.2], which captures objectives, targets and actions that should be undertaken to achieve the Ireland's Vision for Biodiversity: "*That biodiversity and ecosystems in Ireland are conserved and restored, delivering benefits essential for all sectors of society and that Ireland contributes to efforts to halt the loss of biodiversity and the degradation of ecosystems in the EU and globally*". The Biodiversity Sectoral Adaptation Plan and the NBAP, are the means to operationalise some of the prerogatives provided by the **Wildlife Acts, 1976 - 2012** [section 3.8.1]. The Sectoral Plan recognises coastal habitats as one of the most vulnerable to climate change due to the impact of the changing temperature combined with the additional threat of sea level rise and sets out the objective to "*develop an integrated coastal management strategy which includes ecosystem-based adaptation actions to manage climate risk and build resilience to climate change*".

Regional Coastal, Planning, and Climate Legislation, Policies and Plans [Appendix - Section 4]

The Section 4 of the Appendix presents the Regional Coastal, Planning, and Climate Legislation, Policies and Plans for the Greater Dublin Area and the Eastern and Midland Region. First, the **Regional Planning Guidelines for the Greater Dublin Area (2010 - 2022)** (RGP-GDA) is presented [section 4.1]. It sets out the planned direction for growth within the Greater Dublin Area up to 2022 and works to implement the strategic planning framework provided by the NSS. The RPG-GDA informs and directs the City and County Development Plans of each of the Councils in the Greater Dublin Area, providing the links between national policies and LAs planning policies and decisions, and supporting regionally important infrastructure and the investment priorities of the NDP. It sets out new approaches to environmental and social policy which incorporates themes of green infrastructure development, climate change, flood risk management and social inclusion. The RPG-GDA proposes a regional approach to ICZM as a mean to sustainably manage the development of the coastal zone and proposes a collaborative preparation of Coastal Zone Management Plans with LAs, state bodies and communities together. The RGP-GDA recommends that precautionary approaches should be taken to restrict development within areas of high risk of erosion and flooding.

The **Regional Spatial and Economic Strategy for the Eastern and Midland Region (2019 - 2031)** (RSES-EMR) [section 4.2] is a strategic plan which identifies regional assets, opportunities and pressures and provides appropriate policy responses in the form of Regional Policy Objectives. It provides a framework for investment to better manage spatial planning and economic development to sustainably grow to 2031. The RSES is required under the Planning and Development Acts and its principal statutory purpose is to support the implementation of the NPF. Some of the Regional Strategic Outcomes include, inter alia, to conserve and enhance the biodiversity, heritage, and ecosystem services; to build climate resilience; and to support the transition to a low carbon economy by 2050. Portrane (Fingal, Co. Dublin) was identified as a primary area of potential coastal erosion risk for the region. The Strategy recommends the use of an ICZM approach to enable collaborative and stakeholder engagement approaches to the management and protection of coastal resources against coastal erosion, flooding, and other threats.

Fingal Coastal, Planning, and Climate Legislation Policies and Plans [Appendix - Section 5]

The Section 5 of the Appendix presents the local Coastal, Planning, and Climate Legislation Policies and Plans of Fingal County. First, the last three **Fingal County Development Plans** (FCDP) are presented [section 5.1]: FCDP (2005 - 2011); FCDP (2011 - 2017); and FCDP (2017 - 2023). These Plans were built according to the instructions provided by the Planning and Development Acts and consistent with the authority provided by the Local Government Acts. It was possible to observe progress in the way the county addresses the problem of coastal erosion and flooding and proposes climate adaptation strategies over time, synchronously with the progress made on climate adaptation at the national level.

The **FCDP (2005 - 2011)** [section 5.1.1] already recognised the impacts of predicted sea level rise due to climate change, including coastal erosion and flooding, and encouraged the development of an ICZM approach to manage and develop the coast in a way which protects and enhances its natural heritage and landscape. However, this plan offered few propositions related to coastal management when compared to the succeeding plans. These included the rehabilitation of the sand-dune systems, control the access of motor vehicles on the beach, and assess all coastal defence plans and projects for their environmental impact. Specifically for Portrane, the Plan recommended to ensure the protection of sensitive coastal-estuarine areas and to prohibit the replacement of chalets/holiday huts by permanent dwellings, encouraging the removal of existing chalets and huts at Burrow Beach.

The **FCDP (2011 - 2017)** [section 5.1.2] built its policies and objectives based on the previous plan and many statements were kept the same, however, proposed policies for coastal areas increased in number. The 2011 Plan introduced concepts such as “Soft Engineering Approach” and “Hard Engineering Approach”, demonstrating a greater concern in relation to the problem of coastal erosion and flooding. It introduced the requirement for developments to consider the need of coastal protection from the outset and stated the developments are subject to prohibition where they pose threat to coastal habitats, alter patterns of erosion/deposition, and are proposed in areas prone to flooding. It also recommended that a “Coastal Zone” should be designated during the lifetime of the Plan to provide for the proper planning and sustainable development of the coast. The objectives for Portrane area remained the same as proposed by the preceding Plan but it included the requirement of a Habitats Directive Assessment screening to any proposed development over sensitive areas of Burrow Beach.

The most recent and currently in operation, the **FCDP (2017 - 2023)** [section 5.1.3], advances the county's planning objectives and policies stated in the previous plans and includes the requirement to prepare a 'core strategy' for the County, which must be consistent with National and Regional development objectives set out in the NSS and in the RPG-GDA. This is the most extensive of the development plans, consisting of an extensive Written Statement with 502 pages, Maps and Appendices. Amongst its 11 aims, the most significant to this study is to "*Incorporate sustainable development, climate change mitigation and adaptation, social inclusion, high quality design and resilience as fundamental principles, cross cutting and underpinning the Development Plan*". In order to deliver its aims, some strategies are placed, such as "*Ensure new developments have regard to the requirements of the Planning System and Flood Risk Management Guidelines*"; and "*Minimise the County's contribution to climate change, and adapt to the effects of climate change, with particular reference to the areas of land use, energy, transport, water resources, flooding, waste management and biodiversity, and maximising the provision of green infrastructure including the provision of trees and soft landscaping solutions*". The Plan incorporates a greater number of specific objectives addressing coastal flooding, biodiversity and natural heritage, and coastal protection and, overall, states that new developments will only be permitted if it does not require coastal defence works over the lifetime of the development and where the likelihood of coastal erosion is minimal. Regarding the specific objectives for Portrane, the Plan sustains the objectives to protect the sensitive coastal estuarine area of Burrow Beach and the restrictions over the occupation of chalets and holiday huts. It further includes the objective to "*Prepare a study to decide on the optimal future development of lands in the Burrow area, having regard to the local issues of coastal erosion, flooding, drainage and the significant landscape and biodiversity sensitivities in the area*".

In order to regulate a variety of issues concerned to beach management, FCC passed the **Fingal County Council Beach & Foreshore Bye-Laws in 2006** [section 5.2]. These bye-laws provide for control of: nuisance (includes litter, fires, motor vehicles, etc.); dune damage; animal control (including dogs and horses); amongst other uses and activities. Any person who infringes these bye-laws are considered guilty of an offence and are liable on summary conviction to a fine. While many of the stipulations in the bye-laws aim to prevent damage to coastal systems, these only produce indirect results for climate change adaptation and/or mitigation and do not provide solutions to the problem of coastal erosion and flooding.

With the objective of producing a beach management plan for Burrow Beach, FCC commissioned a consultative process in 2006, resulting in the publication of the **Beach Management Plan for the Burrow Beach (2007)** [section 5.3]. The Plan aims to provide directions for FCC and the local community to implement effective beach and dune management practices for Burrow Beach in order to ensure the preservation of these areas, maintenance of natural biodiversity and preservation of the character of the beach while allowing for recreational use and enjoyment by present and future generations. This publication is an action plan based on partnership, setting out a range of practical actions in the short, medium, and long term. The actions proposed aimed at improving four main issues: coastal environment protection and coastal erosion prevention; amenities improvements (including tourism and accesses); quality of life ameliorations (including waste management); and public awareness improvement (including information and education).

In 2016, aiming to respond to the increasing concern in relation to erosion and flooding in the Fingal coastal areas, FCC established the **Fingal Coastal Liaison Group** [section 5.4]. The Group aims to form coherent structured response to address these issues and improve communication between stakeholders; and provide a forum for discussion of approaches to planning for and dealing with the problems of coastal erosion and flooding. The Group is made up of County Councillors, Council Officials, and community members from the three areas affected by these issues: Rush, Portrane, and Sutton, and meets on a regular basis.

In 2019, following the requirements of the Climate Action and Low Carbon Development Acts and, according with the guidance provided in the Local Authority Adaptation Strategy Development Guidelines, FCC published its first **Fingal County Council Climate Change Action Plan (2019 - 2024)** [section 5.5]. The Plan aims to set out targets to improve energy efficiency and reduce greenhouse gases in the County while making Fingal a more resilient region, with engaged and informed citizens. In order to achieve the proposed targets, the Plan sets out the current and future climate change impacts and greenhouse gas emission levels in the County, through the development of mitigation and adaptation baselines. Regarding the adaptation baseline, it recognises that the effects of climate change are already impacting the area at a significant rate and are very likely to increase in frequency and intensity. Sea level appears to be rising by twice the global average in the last 20 years and the amount of extreme flooding events has risen in the last 10 years. Impacts of sea level rise and flooding were identified in five areas: Critical Infrastructure and the Built Environment; Transport;

Biodiversity; Waste Management; and Water Resources. The Plan recommends adaptation actions to be implemented by the LA in order to reduce and address the current and future effects of sea level rise and flooding, some of those include, inter alia, coastal ecosystems rehabilitation and restoration; nature-based solutions; grey solutions (i.e. engineering); control and management of new developments in areas at risk; flood forecasting and monitoring systems to forecast coastal surges. The plan highlights Portrane as an important case study and declares that FCC is considering several options to defend the coast, such as groynes associated with beach supplementation, seawalls, and even considering managed retreat.

Challenges and Opportunities for a Coastal Climate Adaptation Governance System

The legislation, policies and plans examined, have the overall aim to promote sustainable development across the country while meeting local community needs, enhancing environmental quality, and promoting the sustainable use of ecosystems goods and services including the conservation and restoration of habitats and biodiversity, and proposed actions to adapt to climate change. These documents also aim to meet Ireland's international responsibilities and commitments regarding nature conservation and climate change in order to preserve the integrity of natural resources for future generations.

According to the governance structure examined, LAs are responsible for planning and managing land territory above the high-water mark (stated by the Local Government Acts and by the Planning and Development Acts) whilst the State is responsible for managing the sea territory below the high water mark (stated by the Foreshore Acts, the Coastal Protection Act, and by the recently published National Marine Planning Framework). Therefore, a divide between marine and terrestrial planning frameworks is noticed. In the case of issues or developments overlapping in the high-water mark, or which incorporate an onshore element, the existing governance system can lead to a duplication of efforts (O'Mahony et al., 2014). Nevertheless, the Planning and Development Acts gave LAs jurisdiction as planning authorities over development on the foreshore that adjoins the functional area of the planning authority, however, any development on the foreshore still requires a foreshore licence/lease as well as planning permission from the appropriate planning authority.

In addition to the coastal frameworks discussed above, many other national, regional, and local frameworks analysed herein have demonstrated to impact directly coastal areas and comprise relevant baseline documentation to scale up a legal ICZM framework in Ireland and support

coastal climate adaptation, such as the planning frameworks and the suite of climate adaptation frameworks. A number of typologies for climate adaptation solutions were identified, these are:

- Grey Adaptation (related to hard engineering solutions): NPF-Project Ireland 2040 (2018); Sectoral Planning Guidelines (2018); Fingal County Climate Change Action Plan (2019 - 2024);
- Hard engineering and Soft Engineering: National Development Plan (2007 - 2013); Fingal County Development Plan (2017 - 2023); Biodiversity Climate Change Sectoral Adaptation Plan (2019);
- Nature-based Solutions (NbS) and or Ecosystem-based Solutions (EbS): Biodiversity Climate Change Sectoral Adaptation Plan (2019); Fingal County Climate Change Action Plan (2019 - 2024);
- Green Adaptation (related to NbS): NPF-Project Ireland 2040 (2018); Sectoral Planning Guidelines (2018); Fingal County Climate Change Action Plan (2019 - 2024);
- Green infrastructure (related to NbS): Regional Planning Guidelines for the Greater Dublin Area (2010 - 2022); Fingal County Development Plan (2017 - 2023); Fingal County Climate Change Action Plan (2019 - 2024);
- Soft Adaptation (related to alteration in behaviour, regulations, or systems of management): Sectoral Planning Guidelines (2018);
- 'Do nothing', 'Do minimum', 'Hold the line', 'Advance the line', and 'Managed re-alignment': Minor Flood Mitigation Works and Coastal Protection Scheme (OPW guidelines - 2009).

It should be highlighted that these typologies are applied to different environments (not exclusive to the coastal zone) and that disparities in the terminology adopted were observed. Also, the solution 'Managed Retreat' was not found in any one of the documents examined. An update, organisation and harmonization of terminologies addressing coastal climate adaptation in Ireland is recommended in order to support local governments in dealing with the reality of future climate impacts on the coast.

Even though Ireland still lacks a dedicated legal ICZM framework to guide planning, management, and the application of climate adaptation solutions specific to the coastal zone, the documents examined herein are relevant to form the basis of the debate on coastal climate adaptation and provide support for a planning that considers sea level rise predictions and

proposes actions to minimise imminent risks for coastal communities. The development and implementation of an integrated, participatory, and ecosystem-based national framework would provide technical solutions, legal instruments, and the desired governance system necessary to fulfil this gap. The legislations, policies and plans compiled in the Appendix provide the basis for this discussion.

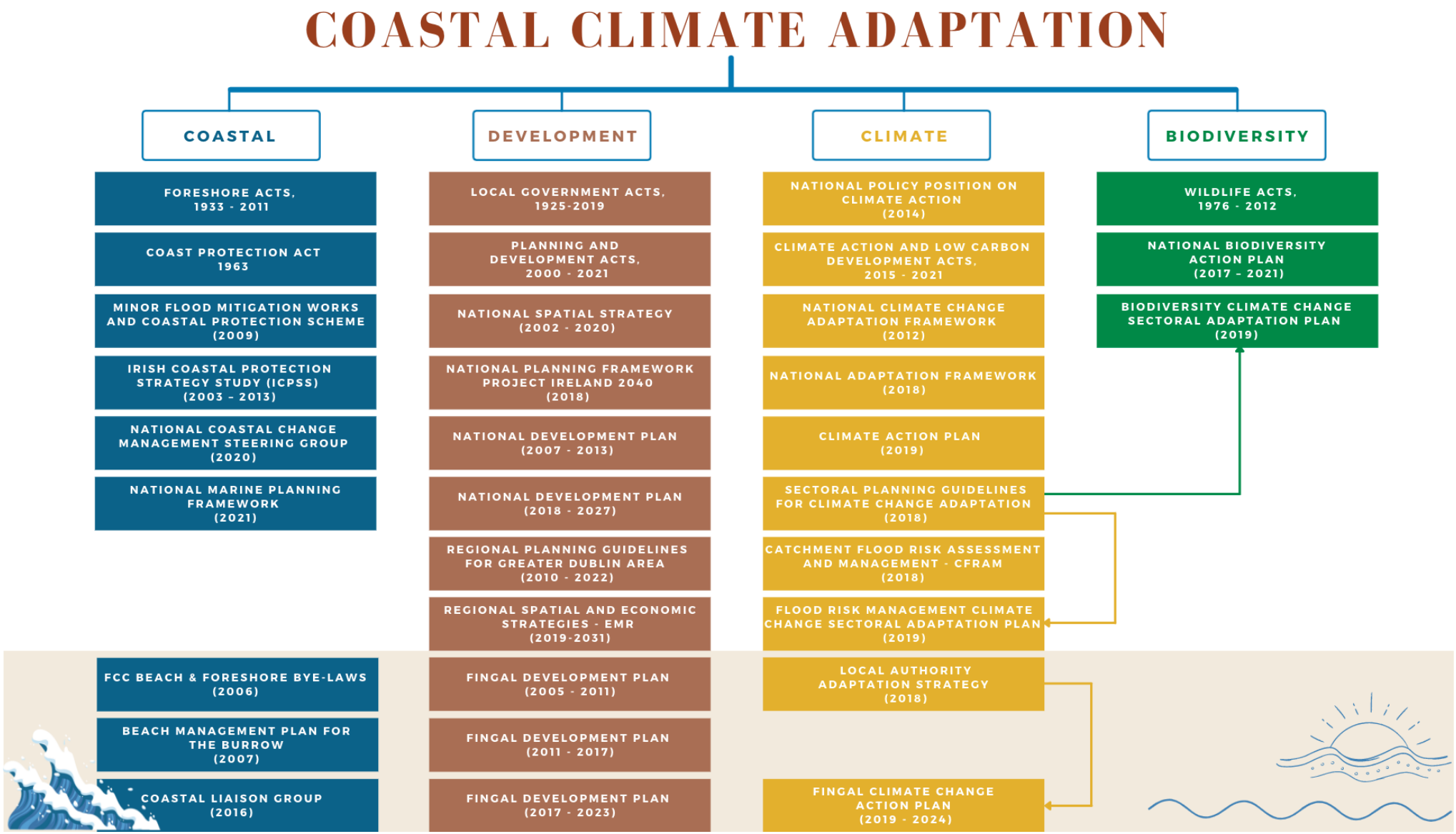


Figure 20: Legislation, policies and plans, at national, regional and local levels, addressing coastal management, planning and development, climate change adaptation (including biodiversity).

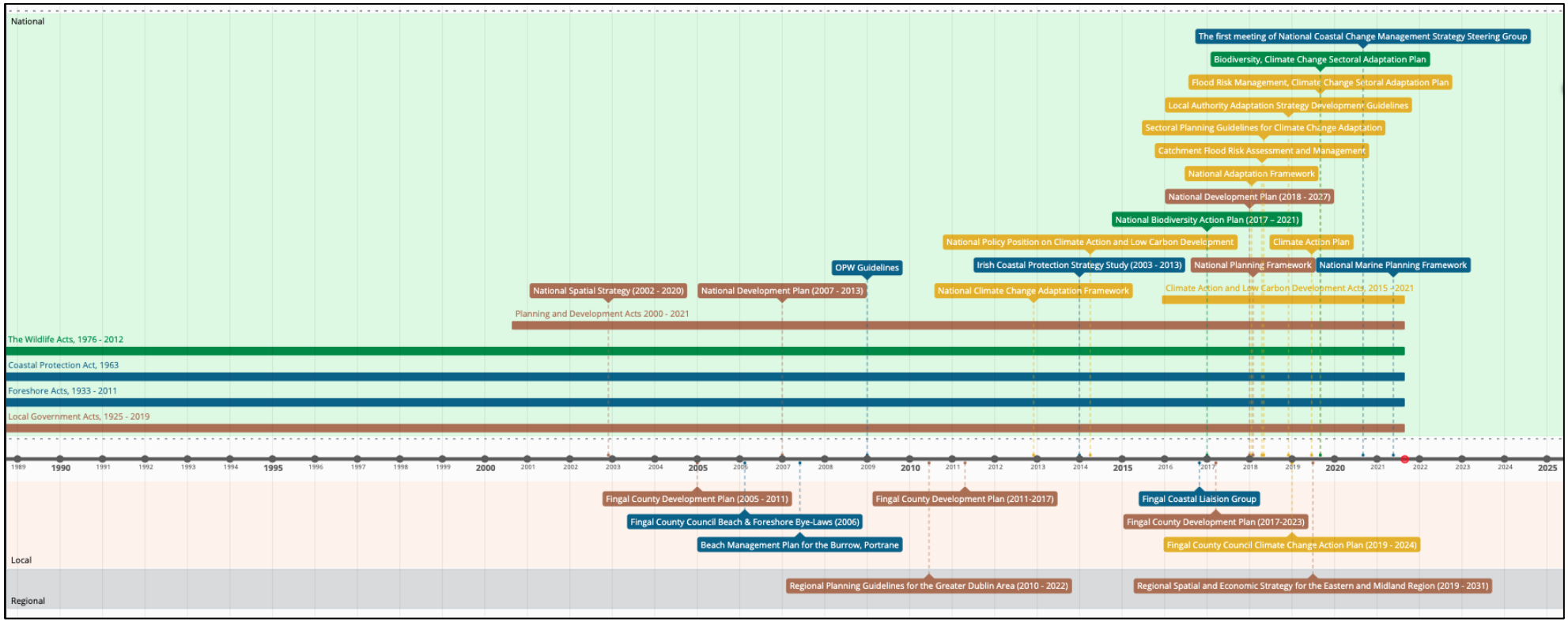


Figure 21: Dynamic timeline containing all the national, regional and local legislation, policies and plans presented in this section and examined further in the Appendix. This timeline was organised on the TimeGraphics application and can be accessed at: https://time.graphics/line/532018

5. Coastal Climate Adaptation Perspectives in Ireland

As detailed in the previous chapters, Rogerstown Estuary and Burrow Beach host sensitive coastal ecosystems with high biodiversity, important historical structures, and human settlements, all currently experiencing coastal erosion, vulnerable to coastal flooding, and threatened by projected impacts of climate change. According to the studies reviewed in this report, storms have become more frequent and intense in recent years, and the dune system of Burrow Beach is losing its capacity to serve as a natural buffer against episodes of high wave energy, especially when storm events are combined with high tides, the so-called "storm-surges". Since the beach level at Portrane has been significantly lowered due to the wash-out of sediments combined with its dissipative beach characteristics (i.e., a high energy beach with a low-sloping and wide beach face consisting of fine sand), even a minor storm event occurring during standard high tide has the potential to cause notable impact along Burrow Beach. Furthermore, observed disturbances caused by human activities, such as trampling, motor vehicle trails, and the removal of circa 40 hectares of native dune vegetation to make way for caravan parks and holiday homes, has reduced the capacity of the dune system to trap and retain sand, and has contributed to the loss of sediment in this natural system, thus, reducing its ecological resilience.

Integrated Coastal Zone Management (ICZM) has been recommended by the European Commission (EC, 2021b) as a critical approach to preserve dune strength, maintain beach width, allow retreat of shoreline in a controllable way, as well as elaborate coastal management plans. However, as evident from Section 4, Ireland still lacks a national legislative and administrative framework to support the implementation of ICZM practices with coordinated and effective solutions to coastal erosion and flooding. The legislation examined (especially those concerning coastal management aspects such as the Foreshore Acts, 1933 - 2011 and the Coastal Protection Act, 1963), that could provide a meaningful way to tackle those problems, do not address how to deal with the contemporary problems and future threats posed by climate change in Irish coastal areas. Beach bye-laws implemented by LAs, despite being capable of regulating certain beach uses and activities, have not been shown to be effective in dealing with coastal erosion or coastal defence management (MacLeod et al., 2000; O'Mahony et al., 2012). Furthermore, the current governance divide between the terrestrial and the marine management systems still poses a challenge to implement faster adaptation solutions. Ongoing work to reform marine planning and management through the anticipated Maritime Area Planning Bill

2021, proposes the creation of a new nearshore area in law where coastal local authorities would assume certain responsibilities. However, the current version of the Bill does not provide for integrated management or indeed erosion management. It is essential to develop a policy that encourages the integration of watershed management with coastal-marine management in order to consider hydrodynamics and the sediment balance to deal with coastal erosion and flooding issues.

Coastal Erosion and Flooding Impacts and Practices

In a comprehensive assessment of the risks posed by climate change on diverse Irish sectors, based on the published Sectoral Adaptation Plans and workshops with key stakeholders, Flood et al. (2020) reported that coastal erosion and coastal flooding may lead to and increase the impacts on the following sectors:

1) *Natural and cultural capital*: by impacting on coastal tourism businesses, damaging coastal habitats and leading to loss of biodiversity, and damaging historical built heritage;
2) *Critical infrastructure*: by damaging roads, buildings and infrastructure, resulting in transport disruption and increasing the costs of repair and maintenance, and leading to the need to relocate underground power cables and gas distribution pipelines;
3) *Water resources and flood risk management*: by increasing the loss of coastal land and the frequency of landslides, causing temporary submersion of low-lying coastal sites, leading to potential damage to domestic wastewater treatment systems and pollution of water, and leading to the disruption of water treatment plants and impacting the water supply;
4) *Public health and well-being*: by increasing office closures and loss of essential services to the community at times when the demand for these services is acute because of severe weather impacts, and general increase in the level of public health and safety impacts.

Despite the severity of the matter, studies have shown that the problem of coastal erosion and coastal flooding in Ireland has been historically managed in a reactive and localised manner, with little national co-ordination (Cronin et al., 2017, Murphy, 2017).

A study was conducted to determine the scale of the coastal erosion problem in Ireland, existing LAs policies on coastal erosion, and local practices in dealing with the problem in order to suggest the most appropriate approach to coastal erosion management (Cronin et al., 2017). In

this study, 19 LAs were consulted and information on properties and infrastructure at risk from erosion were gathered[3]. The study found out that the national policy dealing with coastal erosion is less developed than those dealing with other coastal hazards (such as flooding) and that the approach to this problem tended to be reactive rather than proactive. Also, it identified contrasts between LAs with regards to the methods used to assess coastal erosion, staff resources, erosion control options considered, approaches to deal with private property damage, level of coastal protection per county, and available funding.

Cronin et al. (2017) proposed that coastal erosion should be a higher priority nationally and central government fund should be established in order to provide the means to invest in protection measures. The authors also recommended consultation with stakeholders at local and national levels; clarification on the responsibilities of LAs and private landowners in relation to damage to private properties; and education and training to provide clarity to parties on their respective responsibilities. The results of the survey showed that, overall, LAs are favourable towards the development of a national coastal erosion policy, including the publication of a set of national best practice guidelines to assess coastal erosion.

Cronin et al. (2017) recommended that a national coastal erosion policy should have two principal components: 1) a strategy framework, led by the Department of Communications, Climate Action and Environment; and 2) a structured programme delivered by local agencies. It should be the result of close collaboration between all relevant government levels and agencies, for example, LAs, the OPW, and the NPWS, and should clearly define the roles and responsibilities of all parties involved. The development of a national coastal strategy (Step 1) would deal with other coastal hazards, such as flooding and erosion in a holistic manner (Cronin et al., 2017). Funding for both proactive and reactive coastal management should be budgeted and provided by the central government. The national coastal strategy should address whether to implement erosion control options (such as "hold-the-line" and "advance the line"), decide about the responsibility for protecting the private properties, and support the work of LAs (Cronin et al., 2017).

[3] A WebGIS system containing supplementary data for consultation was developed: http://ucc.maps.arcgis.com/apps/View/index.html?appid=2d9bfd557e2f4d19810c0a6efc653e0c

Profile of Local Government Climate Actions

While a national coastal strategy does not yet exist, LAs apply County Development Plans (under the Planning and Development Acts, 2000 - 2020), Local Area Plans (LAPs) (under the Planning and Development Act, 2000), and Climate Change Action Plans (under the Climate Action and Low Carbon Development Acts, 2015 - 2021; the Local Authority Adaptation Strategy Development Guidelines 2018; and the Climate Action Plan 2019), to address coastal problems and climate adaptation locally. Also, the CAROs established in 2018 provide advice to LAs to deal with coastal climate hazards.

LAs play a key role in responding directly to the impacts of climate change since they are the primary actor with responsibility for coordinating and managing extreme weather events when they arise (Clarke and O'Donoghue-Hynes, 2020; Dekker, 2020) and can respond faster and more effectively to local climate events than other government agencies given their close relationship with communities and their knowledge of the natural and built environment (DCCAE, 2019).

A study was undertaken in order to assist the local government sector in quantifying the role LAs play in delivering a wide range of climate actions, such as mitigation, adaptation and emergency response (Clarke and O'Donoghue-Hynes, 2020). The research found that local government has been proactive in many of the areas assessed, including critical infrastructure, flood risk management, water resources, nature-based solutions, and public engagement - each of which have delivered positive climate actions. The findings showed that LAs prioritise different needs and therefore implement different climate actions based on prevailing climate change risks in their jurisdictions (Clarke and O'Donoghue-Hynes, 2020).

Regarding coastal erosion, Clarke and O'Donoghue-Hynes (2020) revealed that some LAs are gathering data for the first time in order to develop their strategies for climate adaptation. This observation corroborates with the reactive character of LAs to deal with coastal erosion (Cronin et al., 2017; Murphy, 2017).

Regarding flood risk management and water resources, the study showed that LAs collaborated with the OPW on 21 major flood defence schemes and delivered a further 228 smaller flood defence schemes between 2014 and 2018. Approximately €173.5m was invested in major flood defences and Minor Flood Mitigation Works and Coastal Protection Schemes by the OPW and LAs; of this investment, LAs contributed approximately €12.4m towards these flood defences.

LAs also spent approximately €101m in responding to emergencies following extreme weather events between 2014 and 2018 when the impacts of extreme weather events arose (Clarke and O'Donoghue-Hynes, 2020).

An imbalance in the importance given between coastal erosion and flooding could also be noticed in the report published by Clarke and O'Donoghue-Hynes (2020), especially when exploring the answers obtained in this survey. Despite the investment in coastal protection being mentioned jointly with the flood defence schemes, the higher relevance of the latter for the LAs is noticeable in the results presented and from the many examples of flooding schemes given. Further studies could investigate how much the lack of a national coastal management strategy is impacting the effective and swift delivery of coastal adaptation solutions.

Coastal Management Practices

Despite the policy vacuum on a national ICZM approach, studies have shown that coastal management in Ireland has been progressing through local project-based initiatives. Those studies demonstrated that coastal stakeholders in Ireland (community groups, LAs, research and education organisations, state agencies, and NGOs) have delivered good practice experiences and, therefore, a body of practitioners are in place to share experience and develop capacity that could support the implementation of a national coastal strategy (Cummins et al., 2004b; O'Hagan and Ballinger, 2010; O'Mahony et al., 2014).

The general approach to community-based coastal management is characterised by action-centred programmes dependent on highly motivated individuals, with a genuine desire to achieve sustainable development and promote awareness of the coastal environment (Cummins et al., 2004b). However, the potential for influencing policy is reduced due to limitations on participation in the decision-making process at regional, national, and local levels (Cummins et al., 2004b) and by Ireland's top-down approach to decision making (Cummins et al., 2004a).

The current coastal governance structure examined in Section 4, despite being extensive and diverse, favours a sectoral and fragmented approach in opposition to the integrated and ecosystem-based approach recommended by ICZM frameworks and by the EU. Coastal management for coastal climate adaptation relies on the convergence of diverse sources of knowledge and subjects, such as climatology, oceanography, geology, ecology, economy, sociology, governance, etc. so as to reflect the dynamics and range of interests occurring in coastal areas. A lack of coherency in coastal management in Ireland is observed since land and

marine issues are managed on a sectoral basis and governed by a wide range of agencies and authorities at different governance levels, ignoring the complexity of land-sea interactions.

According to Cummins et al. (2004a) there appears to be a lack of motivation or commitment to developing an ICZM policy for Ireland whilst the focus is primarily on the implementation of EU Directives, such as the Habitats Directive, the Birds Directive, and the Water Framework Directive, with implications for the protection and management of the coastal environment. More recently, the Government has prepared plans to meet the requirements of the EU Marine Strategy Framework Directive and the EU Maritime Spatial Planning Directive, but these are limited to the objectives of those instruments and do not fully address the need for integrated coastal management.

O'Mahony et al. (2014) highlighted the importance of an ICZM approach to support the implementation of EU Directives with implications for the protection and management of the coastal environment and recommended a series of actions to enable delivery of successful ICZM for Ireland's coasts and marine waters. These frameworks are in line with the adoption of climate change mitigation and adaptation strategies, such as the implementation of nature-based solutions, aimed at achieving coastal sustainability and resilience.

Coastal Climate Adaptation Perspectives

Climate change legislation, policies, and plans seem to be advancing in the absence of a coastal management framework and are guiding the management of coastal climate hazards in Ireland. However, challenges with respect to a coastal climate adaptation governance system persists.

A study published in 2013 that aimed to assess the specific demands of coastal climate adaptation in Ireland, identified that the key barriers to effective coastal climate governance were the fragmentation of institutions and administrative functions; ill-defined responsibilities among the actors and institutions involved; short-term planning and top-down management; and lack of experience of cross-sectoral cooperation and stakeholder involvement (Falaleeva et al., 2013).

Falaleeva et al. (2013) stated that integrating coastal climate adaptation into existing and future planning would require substantial capacity-building at the local level, by equipping LAs and coastal communities with the adequate methods, tools and resources that might be useful to implement effective adaptation at the local scale. However, LAs often lack resources in terms

of staff and time to implement programmes and actions that support responses to climate change (Dekker, 2020).

The establishment of CAROs in 2018, despite their lack of statutory authority, were envisioned as a bridge between LAs and national government in order to support LAs in the development and implementation of their climate action plans. According to Dekker (2020), each CARO was endowed with a budget of €500k per year to cover staff and administrative costs – an amount that may limit the desired performance of the agency and disregard regional particularities to tackle climate hazards. "Whilst lack of resources in terms of staff and finances are a challenge for the CAROs, as they are for LAs, the networks that they provide can be used to highlight the commitment of LAs to respond to climate change" (Dekker, 2020).

According to an analysis of the policy implementation network formed to carry out the Climate Action Plan 2019, Wagner et al. (2021) exposed that national level actors dominate climate policy, making it more difficult for the network's administrative organization (the Department of the Taoiseach) to gain support from local-level actors. This governance structure gives disproportionately less power to local actors, distances those responsible for action from local communities, makes it more difficult for those geographically distant from the centre of power to hold those in charge accountable and is less likely to be able to address the heterogeneous preferences of citizens (Wagner et al., 2021). Therefore, a major challenge for Ireland's future climate policies is to rethink the current governance structure in order to provide more autonomy to the LAs and CAROs, while maintaining steady central coordination.

New and emerging natural resource management approaches, such as adaptive co-management, has the potential to support climate adaptation decision-making in Ireland and build resilience of coastal communities under conditions of uncertainty and complexity (Falaleeva et al., 2013). According to these authors, the efficacy of adaptive actions will be largely dependent upon the ability of LAs to integrate climate adaptation considerations into economic and development planning, addressing uncertainty and maintaining coherence between local, regional, and national planning.

6. Final Remarks and Recommendations

This report presented the case of Portrane, Co. Dublin in relation to the problems of coastal erosion and coastal flooding, particularly at Burrow Beach from the late 1990s to present day. The case of Portrane exemplifies how the impacts of past human disturbances on coastal ecosystems, such as damage to dune systems, replacement of natural ecosystems by houses and gardens, and the anthropogenic impacts on the estuarine ecosystems by altering the flow of water and sediment along the watershed, can lead to coastal problems. The problems observed in Portrane are likely to be exacerbated due to climate change, specifically future sea level rise and the likely increase in the frequency and intensity of storms. In addition to the reported impacts of coastal erosion and flooding on various Irish sectors, further social impacts on community cohesion may occur.

The erosion and flooding predictions for Burrow Beach are of great concern and solutions are urgently required. The preferred solution recommended by the studies commissioned by FCC to date would be to install a series of groynes combined with a beach re-nourishment scheme and flood embankments. Alternative schemes, such as rock armour and embankments would have a lower cost; however, are likely to have a significant detrimental impact on the nearby dunes and beach habitats. Another solution would be to gradually remove the houses from the dunes and let the ecosystem naturally find its balance, the so-called "Managed Retreat". Despite being a difficult decision to implement, managed retreat is under consideration by FCC. Despite being encouraged in other coastal areas globally, guidance on managed retreat is not provided in any of the coastal climate frameworks evaluated. Nevertheless, in Portrane, the existing coastal ecosystems protected by a number of statutory designations provide opportunity to implement nature-based solutions that will deliver both mitigation and adaptation climate change.

FCC must base its decisions on the available legislation. However, despite the extensive available information on coastal erosion and future impacts of climate change, the current governance system has failed to respond to past and current coastal changes in Burrow Beach, demonstrating a lack of capacity to deal with the problem. This is due to the centralized characteristics of the Irish governance system while a fragmented and sectoral approach to deal with coastal planning and management issues is observed. In recent years, Ireland has progressed the governance basis for Climate Adaptation; however, priority is given to the management of general flooding issues. Coastal erosion remains a problem for many coastal

areas and local governments have often through necessity approached the problem on a reactive basis instead of a preventive basis due to the lack of clear guidance, policy, and integrated legal provisions from central government. A National Coastal Management Framework would deal with the current and future risks of coastal erosion and flooding and support the implementation of sustainable adaptation solutions in coastal areas.

Recommendations to advance Coastal Climate Adaptation in Ireland and in Portrane, Fingal

Arising from the legislation and policies examined, the literature reviewed, and further interpreted from this study, the following statements abridges some of the principal recommendations for advancing a coastal climate adaptation framework in Ireland:

1. A statutory National Coastal Management Framework should be instituted in Ireland, based on integrated, participatory, and ecosystem-based approaches, which includes climate adaptation strategies and coastal protection solutions as cross cutting themes interlinked to other coastal matters, such as biodiversity conservation; watershed management; urban development, housing and land ownership; tourism and leisure; and others. This holistic framework could be built by reframing existing legal instruments, policy objectives and government bodies.

2. A national funding scheme should be established and provide with clear guidance, administrative structures and technical oversight to support the implementation of coastal adaptation solutions. This scheme should address the responsibilities in assessing coastal erosion and adaptation solutions, clear guidance on financial responsibilities, the approach on private owned lands, funding support for LAs, and other matters as required;

3. This framework should adopt a participatory and adaptive multi-level governance system in order to address the imbalances in stakeholders' participation and reverse the current low level of local participation and top-down approach. This multi-level governance system should consist of (1) a central body at the national level with responsibility for coordinating the implementation of the framework (this appropriate department should be designated by the national government); (2) a national multi-stakeholder advisory committee (consisted of governmental bodies, sectoral representatives, local government representatives, and community representatives)

with a formal commitment to cooperate and provide advice on the implementation of the framework; (3) a network of coastal LAs and CAROs aimed at sharing knowledge on practical experiences on coastal management and climate adaptation and support each other in applying the framework on the ground; and (4) coastal stakeholders networks at the local level (involving local communities representatives, local sectoral representatives and local government departments) with the aim to foster participation in this adaptive co-management process by sharing experiences and exchanging knowledge, engaging local communities in the formulation of coastal policies, supporting the preparation and implementation of preparedness and response systems, and finding suitable coastal climate adaptation solutions;

4. Define the perimeter of the "Coastal Zone" by integrating the terrestrial (including watersheds) and marine territories, and its related institutions in order to delineate the geographic space of management, overcome the current land-sea divide and solve the existing gap in coastal-marine governance, including coastal climate adaptation;

5. Government bodies, especially LAs, should be empowered to adopt a proactive approach to decision making, with the participation of coastal communities, that is responsive to the uncertainty of climate change and coastal processes, and based on international experience, up-to-date scientific evidence, and climate predictions. A national investment in strategic coastal monitoring programmes is recommended;

6. Coastal adaptation guidelines should be developed and encourage a hands-on approach towards coastal climate adaptation based on the knowledge acquired through co-creation processes involving local communities, governments and the academic sector, i.e., based on best practices of integrated coastal management;

7. Dialogue on coastal climate adaptation in Ireland should be fostered and guidance developed in order to increase the capacity of LAs and local communities in dealing with coastal erosion and flooding at the local level; and

8. The impact of climate change in coastal areas should be widely communicated across all audiences and generations, including use of the media, and promote awareness raising initiatives to co-develop coastal climate adaptation solutions and build social-ecological resilience.

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APPENDIX

Coastal Climate Adaptation Frameworks

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    3.7. Flood Risk Management, Climate Change Sectoral Adaptation Plan (2019)
        3.7.1. Catchment Flood Risk Assessment and Management - CFRAM (2018)

[4] All legislation examined herein (primary and secondary) is available at http://www.irishstatutebook.ie/

3.7.2. Flood Risk Management, Climate Change Sectoral Adaptation Plan (2019)

3.8. Biodiversity Climate Change Sectoral Adaptation (2019)

3.8.1. The Wildlife Acts, 1976 - 2012

3.8.2. National Biodiversity Action Plan (2017 - 2021)

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5.1. Fingal County Development Plans

5.1.1. Fingal County Development Plan (2005 - 2011)

5.1.2. Fingal County Development Plan (2011 - 2017)

5.1.3. Fingal County Development Plan (2017 - 2023)

5.2. Fingal County Council Beach & Foreshore Bye-Laws, 2006

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5.4. Coastal Liaison Group (2016)

5.5. Fingal County Council Climate Change Action Plan (2019 - 2024)

1. National Coastal Zone Management Legislation, Policies and Plans

1.1. The Foreshore Acts, 1933 – 2011

The Foreshore Acts, as amended, requires that leases and licences are obtained from the relevant Minister for the carrying out of works (including sea defence works) or placing structures or material on, or for the occupation of or removal of material from the State-owned foreshore and to amend generally the law relating to foreshore and the seashore (Government of Ireland, 1933-2011). By "sea defence work" the Act means any wall, pier, groyne, stakes, bank, or other work constructed for the purpose of protecting any land, building, or other structure from injury by the sea or the waves or tides.

The foreshore comprises the shore and the seabed, below the line of high water of ordinary or medium tides (shown HWM on Ordnance Survey maps) to the 12 nautical miles of the sea and every tidal river/estuary, channel, creek, and bay. The seashore is defined as the foreshore and every beach, bank, and cliff contiguous to it and includes all sands and rocks contiguous to the foreshore.

All the foreshore of Ireland is presumed State-owned by the State Property Act, 1954, unless a valid alternative title is provided. Permissions for works must be obtained from the Minister for Housing, Local Government and Heritage for both State-owned and privately owned foreshore.

The Acts provide powers for the Minister to prohibit removal of beach material from an area of foreshore or seashore when it is likely to prejudicially affect any public rights or to cause injury to any land or to any building, wall, pier, or other structure. The removal of any beach material from the foreshore or seashore in contravention of a prohibitory order shall be guilty of an offence.

The Act provides that no person shall erect on any tidal lands not belonging to the State any building, pier, wall, or other permanent structure otherwise than in accordance with maps, plans, and specifications approved of by the appropriate Minister. The appropriate Minister shall not refuse to approve of any maps, plans, and specifications on any ground save that a structure erected in accordance with such maps, plans, and specifications would be or would cause or be likely to cause (directly or indirectly) an obstruction to navigation or to fishing or would have or be likely to have significant adverse effects on the environment.

The appropriate Minister shall ensure that, before a decision on an application is given, projects likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location are made subject to an environmental impact assessment. The Minister shall take all reasonable steps to ensure that a developer complies with any environmental condition.

Other provisions given by the Foreshore Act and amendments should be consulted on the Irish Statute Book website (http://www.irishstatutebook.ie/). A consolidated version of this Act with its amendments up to 25 March 2021 can be accessed on the Law Reform Commission website (https://revisedacts.lawreform.ie/eli/1933/act/12/revised/en/html).

1.2. Coast Protection Act, 1963

The Coast Protection Act, 1963 provides the basis for the implementation of coastal protection schemes in cases of encroachment by the sea (Government of Ireland, 1963). The Act provides the legal basis for the Office of Public Works (OPW) and Local Authorities (LAs) to jointly implement coastal protection works and clarifies competencies between the interested governmental institutions.

The Act states that a county council may investigate, when appropriate, proposals for coast protection works within the county. In this case, the council should prepare a report to be submitted on the location and extent of the relevant encroachment of the sea, the extent of the land and other property being damaged or endangered, the works necessary to prevent the continuance of the encroachment and the estimated cost of the works. The LA may recognise that the promotion of a coast protection scheme is necessary when land within a region is being progressively damaged by the continuing encroachment of the sea and putting in danger the safety of a harbour, the buildings or amenities of a residential area or other valuable property.

The LA should contact the OPW and follow the most up to date guidance for the installation of minor flood mitigation and coastal protection works and for studies to address localised problems provided by the OPW's "Minor Flood Mitigation Works and Coastal Protection Scheme" (OPW, 2009) – as explained in the following section.

The OPW have many functions and responsibilities in relation to coastal protection and flooding, including:

- Undertaking risk assessments associated with coastal flooding and coastal erosion at coastal sites by making use of up-to-date technologies and methodologies;

- Provision of an advisory service in relation to coastal erosion and flooding to support the preparation of annual coastal protection funding programmes, the Catchment Flood Risk Assessment and Management (CFRAM) programme, and inform broader policy development; and
- Maintenance of coastal protection schemes constructed under the Coast Protection Act, 1963.

Further provisions given by the Coast Protection Act should be consulted on the Irish Statute Book website (http://www.irishstatutebook.ie/). This Act has not been amended until the publication of this report.

1.3. Minor Flood Mitigation Works and Coastal Protection Scheme (2009)

The OPW initiated the "Minor Flood Mitigation Works and Coastal Protection Scheme" in 2009. This scheme provides funding to LAs to support the installation of minor flood mitigation and coastal protection works and/or studies to address localised problems (OPW, 2009). Funding of up to 90% is considered for projects that cost no more than €750k.

Proposals and funding applications for structural measures to prevent or mitigate erosion should be done in conjunction with an appropriate coastal erosion risk management study and the OPW provides detailed guidelines that should be followed to deliver these studies. The coastal erosion risk management study should investigate and develop a plan to manage the risks identified to human health and life, the environment, cultural heritage, and economic activity and to further assess and investigate the best available options and measures to the problem.

The study should consider an historic and current assessment of the problem; identify existing information gaps; undertake an inspection of existing structures; carry out modelling studies for current and future scenarios (MRFS and HEFS) for factor such as wind, wave, tide and sediment transport; produce maps on existing and future coastal erosion and accretion; prepare a risk assessment for the MRFS and HEFS scenarios for the 2050 and 2100 timescales; undertake a preliminary environmental assessment for the area and identify the need for any further environmental assessments or impact statements (such as SEA; EIA; AA); undertake consultation with relevant stakeholders; investigate and indicate the appropriate and alternative option and measures to best manage the risks associated with coastal erosion and accretion,

including the ‘Do Nothing’, ‘Do minimum’, ‘Hold the Line’, ‘Advance the Line’, and ‘Managed re-alignment’, and assess those option through an Multi-Criteria Analysis (MCA); prepare an appropriate coastal erosion risk management plan by identifying the preferred options and measures to best manage the risks identified; and finally, undertake an assessment of the economic benefits associated with the preferred options and measures.

Exceptions to the requirement of a coastal erosion risk management study will be consider when short structures (not exceeding 75m of coastline) are proposed in non-sensitive environmental locations; when short structures are necessary to replace an existing structure that has recently collapsed/failed or is at immediate risk of collapse; and, where exists an imminent and substantial risk to human life or health. In the cases above, the proposed erosion management measures and works will be required to present a simplified benefits assessment and needs to have been designed by a Chartered Engineer.

For further information consult:

OPW / Office of Public Works. 2009. Minor Flood Mitigation Works and Coastal Protection Scheme. Available on: https://www.gov.ie/en/publication/0e3b3d-minor-flood-mitigation-works-and-coastal-protection-scheme/

1.4. Irish Coastal Protection Strategy Study (2003 - 2013)

The Irish Coastal Protection Strategy Study (ICPSS) was commissioned by the Office of Public Works (OPW) in 2003 with the objective of providing information to support decision making about how best to manage risks associated with coastal flooding and coastal erosion in Ireland (Government of Ireland, 2020a). The Study completed in 2013 provided strategic current scenario and future scenario (up to 2100) coastal flood hazard maps and strategic coastal erosion maps for the national coastline. This major study intended to provide the information required to inform policy in this area, particularly for local authorities in relation to the proper planning and development of coastal areas.

The Phase 1 of the study, concluded in 2004, involved a general overview of coastal protection in Ireland. The subsequent reports comprised (1) an assessment of extreme coastal water levels and flood hazard at a strategic level, (2) a strategic level assessment of the coastal erosion hazard and potential risks, and (3) a future scenario strategic level assessments of extreme coastal water levels and flood hazard associated with projected future changes in climate and

glacial isostatic adjustment. For the last assessment, two future scenarios were considered representing a Mid Range Future Scenario (MRFS) and High End Future Scenario (HEFS), reflecting allowances for mean sea level rise of + 500 mm and + 1000 mm (up to 2100) respectively. A series of predicted coastal flood extent and flood depth maps for the coastline of Ireland, and erosion hazard maps were produced.

The reports were organised for each sector of the Irish coast, accordingly: North East Coast; South East Coast; South Coast; South West Coast; West Coast; and, North West Coast. Results for the coast of Fingal are presented in the North East Coast report (OPW, 2010). The section from Portrane to Malahide was classified as a primary area of potential coastal flood risk.

According to the Government of Ireland (2020a), "The strategic coastal flood and erosion hazard maps produced in this study will be of particular interest to local authority planners in considering such potential coastal flood and erosion hazard associated with future proposed development (both strategic and non-strategic) at the planning stage. These maps will also be of assistance to local authorities and emergency services generally in respect of the management of such hazards and their likely social, economic and environmental impacts".

For further information consult:

Government of Ireland. 2020 (a). Irish Coastal Protection Strategy Study (ICPSS). Available on: https://www.gov.ie/en/publication/eed0fb-irish-coastal-protection-strategy-study-icpss/

OPW / Office of Public Works. 2010. Irish Coastal Protection Strategy Study - Phase 3. North East Coast. Technical Report. Available on: https://www.gov.ie/en/collection/d52a5e-irish-coastal-protection-strategy-study-phase-3-north-east-coast/#main-technical-report

1.5. National Coastal Change Management Strategy Steering Group (2020)

In September 2020 the Government of Ireland launched the National Coastal Change Management Strategy Steering Group (Government of Ireland, 2020b). The work of the group will build upon preliminary risk analysis by the OPW, existing climate adaptation plans, the National Planning Framework and the National Marine Planning Framework, to provide a framework for key decisions to be taken on how Ireland can best manage its coastline in light of the risks from rising sea levels and more frequent extreme sea level events and coastal erosion.

The group is jointly chaired by the Department for Housing, Local Government and Heritage and the Office of Public Works (OPW) and is comprised of senior officials from the Department of Communications, Climate Action and the Environment, the Department of Transport, Tourism and Sport, the Department of Public Expenditure and Reform, the Department of Agriculture, Food and the Marine, Met Éireann, and the County and City Management Association.

According to the Minister Darragh O'Brien "For those living in coastal communities, such as Portrane in North Co. Dublin, coastal erosion is already having a profound impact. Around Ireland, it's projected that by 2050, the impact of coastal erosion could potentially affect up to 2 million people who live within 5 kilometres of the coast, all the major cities, and much of the country's industry and infrastructure and utilities, including transport, electricity and water supplies" (Government of Ireland, 2020b).

For further information consult:

Government of Ireland. 2020 (b). National Coastal Change Management Strategy Steering Group meets for first time. Available on: https://www.gov.ie/en/press-release/7b418-national-coastal-change-management-strategy-steering-group-meets-for-first-time/

1.6. National Marine Planning Framework (2021)

The National Marine Planning Framework (NMPF) of Ireland was approved on March 2021 and is a requirement deriving from the EU Maritime Spatial Planning Directive (2014/89/EU), which obliges all coastal Member States to establish Maritime Spatial Plans (MSP) at a national level. The EU Directive recommends that MSP should consider economic, social, and environmental aspects to support sustainable development and growth in the maritime sector, applying an ecosystem-based approach, and promoting the coexistence of relevant activities and uses.

According to the NMPF, MSP "*is a process that brings together multiple users of the ocean to make informed and coordinated decisions about how to use marine resources sustainably. It is a process by which the relevant public authorities analyse and organise human activities in maritime areas to achieve ecological, economic and social objectives*". The Irish NMPF is therefore the outcome of this process.

Ireland has transposed the EU MSP Directive through the Planning and Development (Amendment) Act 2018, establishing a legal basis for Ireland to implement MSP through the development of a maritime spatial plan on a 10-year cycle. The Minister for Housing, Local Government and Heritage was designated as the competent authority in this matter. The 2018 Act sets out Public Body functions relevant to use of the NMPF, including the authorisations (approval/awarding of consents, licences, certificates, and other documents) for proposed developments or activities on the marine area. Therefore, Public Bodies involved in authorising marine development and activities, are now obliged to consider this Framework.

The NMPF gathered for the first time in a unique framework all marine-based human activities, outlining the government's vision, objectives, and policies for each marine activity, detailing how these marine uses and activities should interact with each other in order to ensure the sustainable use of the marine resources up to 2040 (DHLGH, 2021a), consisting of a corresponding document to the National Planning Framework (detailed in Section 2.3.2).

The NMPF has been informed by existing sectoral plans and provides a framework in which those sectoral policies and objectives can be realised. One of the main objectives of the plan is to provide a more integrated governance structure to coordinate all these specific sectoral areas into an overall strategy.

The marine plan covers Ireland's maritime area comprising approximately 490,000 km^2, which extends from the mean high water mark at the coast seaward up to 200 nautical miles, i.e., including internal waters, territorial seas, exclusive economic zone (EEZ) and continental shelf – as stated by the Law of the Sea Convention (UN, 1982). The NMPF consists of a single plan for the entire maritime area, however, regional plans are expected to be made in the future.

The NMPF is part of the suite of marine planning reform measures identified in the Marine Planning Policy Statement (MPPS) (DHPLG, 2019), a document that provides for the preparation, adoption, and review of statutory marine planning policy statements on six-yearly cycles. The Statement's vision for marine planning is: "A marine planning system with clear forward planning, development management and enforcement elements that promotes and sustains ocean health, and supports the sustainable (recreational) enjoyment, management and use of Ireland's marine resource."

The NMPF provides guidance for marine management by clarifying objectives and priorities, and directing decision makers, users, and stakeholders towards more strategic and efficient use

of marine resources. It creates the overarching framework for decision making that is consistent, evidence-based and secures a sustainable future for the maritime area through continued public involvement including a broad range of marine stakeholders such as coastal community groups, environmental NGOs, public sector bodies, port authorities, local authorities, sports and recreation organisations, sea fisheries organisations, the renewable energy sector, the tourism sector, higher education bodies, amongst others.

The NMPF acknowledges the importance of integrating and co-ordinating the land planning at national, regional, and local levels into the Framework and has considered land-sea interactions in relation to diverse activities. Consideration has included linkages between land, coastal and marine management measures, however, little attention is given to coastal-marine issues related to coastal erosion and flooding and there are no policies to manage this problem.

Interactions of the marine realm with climate policies are mentioned in many parts of the Framework, but they especially refer to the potential of marine resources to mitigate climate change, such as with the delivery of offshore renewable energy, carbon capture and sequestration. Attention is given to climate adaptation in Section 5.8, where the framework states that proposals should demonstrate that they have considered and are resilient to the effects of climate change for the lifetime of the project. The Section comprises two policies: Policy number 1 recommends strategies to avoid, minimise and mitigate the likely impact of proposed developments on marine environment by the clarification on how these proposals will:

- Avoid contribution to adverse changes to physical features of the coast;
- Enhance, restore, or recreate habitats that provide flood defence or carbon sequestration ecosystem services where possible.

Policy number 2 indicates that the following should be demonstrated for the lifetime of the proposal (but not limited to):

- The likely impact upon sea level rise;
- Measures incorporated to enable adaptation climate change effects;
- The likely impact upon climate change adaptation measures adopted in the coastal area relevant to the proposal and/or adaptation measures adopted by adjacent activities; and
- Where likely impact upon climate change adaptation measures in the coastal area relevant to the proposal and/or adaptation measures adopted by adjacent activities is identified, these impacts must be avoided, minimised, and mitigated.

The NMPF also states that it is vital to protect coastal habitats and species given the increasing pressure on these resources, which is likely to be exacerbated by climate change (special consideration to biodiversity and protected marine sites is given in Section 5.1). The Framework determines that proposals must demonstrate that any significant adverse impacts on habitats that provide ecosystem services (such as flood defence and/or carbon sequestration), will be avoided, minimised, or mitigated.

The government is developing new legislation to modernise elements of the marine planning, management and enforcement systems, the Maritime Area Planning Bill (MAP) (DHLGH, 2021b). The new Bill will recast the provisions relating to MSP currently contained in the 2018 Act but will also include a system of spatial designation, i.e., the zoning of marine areas for specified purposes (e.g., protection or use by certain activity types). It will also introduce a single State consent system to enable the occupation of Ireland's maritime area with a binding condition to apply for development consent to An Bord Pleanála for projects under LAs' jurisdiction. The Bill will establish the "Maritime Area Regulatory Authority" (MARA), a maritime agency that will be responsible to, inter alia, assess and grant Maritime Area Consents, license certain activities, and deliver enforcement and compliance. Foreshore Consents should be replaced in the majority of circumstances by a more focused and streamlined Maritime Area Consent regime, with developments subject to a single comprehensive environmental assessment. The Bill proposes the creation of a nearshore zone, an area that would have a maximum extent of three nautical miles from the shore and where "*Coastal Planning Authorities*" (CPA) would assume certain responsibilities, including examining application for developments that do not require Environmental Impact Assessments and Appropriate Assessments, granting of development consent, and enforcement and compliance. The current version of the Bill (August 2021) does not provide for integrated management or coastal erosion and flooding management.

For further information consult:

DHPLG / Department for Housing, Planning and Local Government. 2019. Marine Planning Policy Statement. 18 p. Available on: https://www.gov.ie/en/publication/3e262-marine-planning-policy-statement/

DHLGH / Department of Housing, Local Government and Heritage. 2021a. National Marine Planning Framework. 210p. https://www.gov.ie/en/publication/60e57-national-marine-planning-framework/

DHLGH / Department of Housing, Local Government and Heritage. 2021b. Maritime Area Planning Bill. Available on: https://www.oireachtas.ie/en/bills/bill/2021/104/

2. National Planning and Development Legislation, Policies and Plans

2.1. Local Government Acts, 1925 – 2019

The Local Government Act, enacted by the Oireachtas on 26 March 1925, was the first Irish legislation with relation to the local government (Government of Ireland, 1925). The Irish Constitution provides the basis to it by affirming "The State recognises the role of local government in providing a forum for the democratic representation of local communities, in exercising and performing at local level powers and functions conferred by law and in promoting by its initiatives the interests of such communities". The Constitution also assures that direct elections for local governments should be held every five years.

The operation of the local government system is overseen by the Department of Housing, Local Government and Heritage which provides the policy framework to the work of the local authorities. Currently, there are 31 Local Authorities (LAs) in Ireland, distributed in 26 county councils, 3 city councils, and 2 city and county councils. Local governments are composed of a chief executive and the elected council.

The Acts define structures, powers, functions, and duties of local governments, nevertheless, a variety of other legislation regarding specific services that affects the operation of LAs should be jointly consulted. There is a broad range of specific services that LAs are responsible for, such as planning; housing; economic and community development; environment (including waste, noise and air pollution); recreation, and amenity services; roads and traffic; libraries; fire services; and register of electors.

LAs make decisions about policies by passing 'resolutions' (which are the councillors' reserved functions) and can pass certain types of laws, called 'bye-laws', which can be made under a variety of legislation related to matters which are not covered by any other legislation.

Bye-laws are often used to regulate parking zones, control litter pollution, and provide for animal control (dogs and horses) and may stipulate enforcement and associated fines. Many of these bye-laws can be used to promote environmental protection on coastal environments (beaches, dune systems and salt-marshes) and may support climate mitigation and adaptation.

Other provisions contained in the Local Government Acts and a list of legislative changes/amendments to this Act, and to statutory instruments, should be consulted on the Irish Statute Book website (http://www.irishstatutebook.ie/). A consolidated version of this Act with its amendments up to 16 April 2019 can be accessed on the Law Reform Commission website (https://revisedacts.lawreform.ie/eli/2001/act/37/front/revised/en/html).

2.2. Planning and Development Acts, 2000 – 2021

The Planning and Development Acts (as amended) (Government of Ireland, 2000) form the basis for contemporary development planning in Ireland and cover a wide range of matters. The 2000 Act replaced and modernised all planning legislation from 1963 to 1999. The Act has been amended several times since 2000.

The Acts provide the framework of the development management by setting out details of development plans at national level (such as the National Planning Framework), regional planning guidelines (such as the Regional Spatial and Economic Strategy), and local area plans. According to the Acts the development plans should set out an overall strategy for the appropriate planning and sustainable development of the area and should consist of a written statement and a plan or plans indicating the development objectives for the area in question. These development plans should address the necessity of adaptation to climate change.

It explains the Ministerial Guidelines that may be issued to planning authorities and defines the functions of the An Bord Pleanála as a national independent planning body that decides appeals on planning decisions made by local authorities and by direct applications. This legislation sets out a consent system by describing the process and the requirements for applying and obtaining planning permissions and providing particularities for its exemption. The Acts also provide for enforcement measures.

The Acts contain special requirements for protected structures, conservation areas and areas of special planning control by providing the statutory basis for protecting natural and architectural heritage. The Acts stipulate as mandatory for Development Plans to include objectives for the

conservation and protection of archaeological and natural heritage and the conservation and protection of designated European sites. It describes the Strategic Development Zones and the carrying out of Environmental Impact Assessment and Appropriate Assessment. Developments exempted from planning permission mostly loses its exempted status if an appropriate assessment or environmental impact assessment is required.

The Acts also brings attention to the need of regulating, restricting, and controlling development in areas at risk of erosion and other natural hazards; and of carrying out flood risk assessment for the purpose of regulating, restricting, and controlling development in areas at risk of flooding (whether inland or coastal).

Other provisions given by the Planning and Development Acts and a list of legislative changes/amendments to this Act, and to statutory instruments, should be consulted on the Irish Statute Book website (http://www.irishstatutebook.ie/). A consolidated version of this Act with its amendments up to 30 April 2021 can be accessed on the Law Reform Commission website (https://revisedacts.lawreform.ie/eli/2000/act/30/revised/en/html).

2.3. National Development Strategies

2.3.1. The National Spatial Strategy (2002 - 2020)

The 'National Spatial Strategy (2002 - 2020)' originated from the commitment stated at the National Development Plan (2000 - 2006) to prepare a spatial strategy to plan at national level for the country's future spatial development. The National Spatial Strategy for Ireland (NSS) was a twenty-year planning framework designed to achieve a better balance of social, economic, physical development and population growth across Ireland, through a coherent and more effective planning policy (Government of Ireland, 2002). The NSS states that its focus is on people, on places and on building communities. Through closer matching of where people live with where they work, the NSS aimed at supporting that different parts of Ireland be able to sustain a better quality of life for people, a strong and competitive economic position, and an environment of the highest quality.

The NSS encouraged the sustainable development of the marine and natural resources sector, recognizing its key role in supporting and advancing the economic well-being of rural and coastal areas and its importance for peripheral coastal communities. The following spatial issues were identified:

- Coastal infrastructure commensurate with the needs of the seafood and marine leisure sectors, at strategic ports and other key locations of particular importance for local economies must be developed. An appropriate balance must be struck between the wide range of economic, leisure and amenity activities and uses in coastal and island areas.
- Access infrastructure appropriate to the requirements of these sectors and the areas in which they operate is needed.
- Inland fisheries resources must be supported through effective catchment management and planning, embracing all key factors and with effective integration of inland fisheries considerations and land use planning.

Yet, coastal areas were identified in the NSS as experiencing development pressures arising from the growing trend of building second homes and developing holiday home accommodation. A process being driven by the increasing affluence of Irish people, the needs of the domestic tourism industry and the increasing levels of leisure time available.

Coastal areas were also identified as potential areas for revitalisation and the NSS called for the wise management of all environmental resources in the form of landscape policies, settlement policies, biodiversity and conservation of the cultural heritage. According to the NSS, coastal areas provide a scenically attractive environment that is biologically highly productive and diverse. At the same time, this environment accommodates a wide range of economic activities and recreational uses. The Strategy acknowledged the ICZM as a holistic approach to the interactions between sectors, agencies and legal codes. The document stated that an articulation of an ICZM strategy should be taken forward by the government departments concerned, "*drawing on EU recommendations on the implementation of ICZM and national and international ICZM research and experience*" (Government of Ireland, 2002).

Fingal was included in the NSS as part of the Dublin and Mid East regions (the Greater Dublin Area). These regions were considered jointly in the NSS because of their strong functional interrelationship. The NSS planned to enhance the competitiveness of the Greater Dublin Area, so that it continues to perform at the international level as a driver of national development, as well as develop the hinterland of the metropolitan area. Portrane's neighbouring town of Rush, was identified in the NSS as "Urban Strengthening Opportunity", due to its location close to one of the main transport corridors radiating from Dublin (the Dublin-Belfast Economic Corridor).

The National Development Plan 2007 - 2013 (see section 2.4.1) aligned the NSS centrally within it through a specific horizontal chapter on balanced regional development in order to establish the NSS as a practical policy measure to encourage balanced regional development and placing the NSS at the heart of national capital infrastructure decisions during its lifetime.

The NSS 2002 - 2020 was the predecessor of the current National Planning Framework - Project Ireland 2040, detailed in the next section.

For further information consult:

Government of Ireland. 2002. The National Spatial Strategy 2002 - 2020. Available on: http://www.housing.old.gov.ie/planning/national-spatial-strategy/national-spatial-strategy

2.3.2. National Planning Framework - Project Ireland 2040 (2018)

The National Planning Framework (NPF) - Project Ireland 2040 (Government of Ireland, 2018a), is the current government's high-level strategic plan for shaping the future growth and development of Ireland to the year 2040. It is a framework to guide public and private investment, to create and promote opportunities for the people, and to protect and enhance the environment. This document sets a process by which more detailed planning documents must follow: spatial planning, infrastructure planning, social and economic planning, and outlines principles that these plans should be based on, such as sustainability, creativity and community. The NPF stated ten National Strategic Outcomes: 1. Compact Growth; 2. Enhanced Regional Accessibility; 3. Strengthened Rural Economies and Communities; 4. Sustainable Mobility; 5. A Strong Economy supported by Enterprise, Innovation and Skills; 6. High-Quality International Connectivity; 7. Enhanced Amenity and Heritage; 8. Transition to a Low Carbon and Climate Resilient Society; 9. Sustainable Management of Water, Waste and other Environmental Resources; and, 10. Access to Quality Childcare, Education and Health Services.

This framework is more emphatic than the previous one in regard of the importance of strengthening a more environmentally focused planning at the local level and places the United Nations Sustainable Development Goals at the heart of long-term planning. It highlights the importance of a sustainable management of water, waste and other environmental resources, and encourages tackling climate change by a series of climate actions. The framework recognises that it is necessary to address the long-term causes of climate change through

reducing our greenhouse gas emissions, while adapting to its effects over the short, medium and longer terms.

The document states that the National Climate Policy Position (see section 3.1.) should shape investment choices over the coming decades in line with the National Mitigation Plan and the National Adaptation Framework. New energy systems and transmission grids are considered necessary for a more distributed, renewables-focused energy generation system, harnessing both the considerable on-shore and off-shore potential from energy sources such as wind, wave and solar and connecting the richest sources of that energy to the major sources of demand. These objectives relate to the following NPF objectives:

- National Policy Objective 54 – Reduce our carbon footprint by integrating climate action into the planning system in support of national targets for climate policy mitigation and adaptation objectives, as well as targets for greenhouse gas emissions reductions.
- National Policy Objective 55 – Promote renewable energy use and generation at appropriate locations within the built and natural environment to meet national objectives towards achieving a low carbon economy by 2050.

The NPF also introduces an integrated planning process to manage the marine areas and land-sea interface more effectively in order to double the economic value we gain from the ocean wealth by 2030, and beyond. The NPF recognises Ireland's coastline as a remarkable but fragile resource that needs to be managed carefully to sustain its character and attributes in physical, environmental quality and biodiversity terms. It recognises that as a result of climate change, sea levels and patterns of accretion and erosion are key issues for planning and flood risk assessment, especially in managing the ongoing development of cities and towns. It encourages responding to climate change and its impacts such as sea level change, more frequent and sustained rainfall events, and greater vulnerability of low-lying areas to flooding. The plan states that in the long term, to 2040 and beyond, climate change adaptation responses may entail the consideration of barrage or similar technologies to prevent inundation of lower-lying city centre areas during extreme weather events. The NPF considers of particular importance the potential future flood risk in the area of planning and development management, and the planning and design of infrastructure and advises on avoiding inappropriate development in areas at risk of flooding. The plan brings the following objectives to address coastal flooding and erosion problems:

- National Policy Objective 41a – Ensure that Ireland's coastal resource is managed to sustain its physical character and environmental quality.
- National Policy Objective 41b – In line with the collective aims of national policy regarding climate adaptation, to address the effects of sea level changes and coastal flooding and erosion and to support the implementation of adaptation responses in vulnerable areas.
- National Policy Objective 57 – Enhance water quality and resource management by: Ensuring flood risk management informs place-making by avoiding inappropriate development in areas at risk of flooding in accordance with The Planning System and Flood Risk Management Guidelines for Planning Authorities; Ensuring that River Basin Management Plan objectives are fully considered throughout the physical planning process; and, Integrating sustainable water management solutions, such as Sustainable Urban Drainage, non-porous surfacing and green roofs, to create safe places.

Overall, the climate component under the NPF considers:

- Integrating climate considerations into statutory plans and guidelines in order to reduce vulnerability to negative effects and avoid inappropriate forms of development in vulnerable areas.
- More energy efficient development through the location of housing and employment along public transport corridors, where people can choose to use less energy intensive public transport, rather than being dependent on the car.
- The roll-out of renewables and protection and enhancement of carbon pools such as forests, peatlands and permanent grasslands. It is necessary to ensure that climate change continues to be taken into account as a matter of course in planning-related decision making processes.
- The development of sustainable supply chains in the bio economy.
- Grey adaptation which typically involves technical or engineering-oriented responses to climatic impacts, such as the construction of sea walls in response to a sea level rise.
- Green adaptation which seeks to use ecological properties to enhance the resilience of human and natural systems in the face of climate change, such as creation of green spaces and parks to enable better management of urban micro-climates.

The NPF acknowledges the importance of conserving biodiversity and natural heritage sites. It recognises the role of Natura 2000 network (which incorporates Special Areas of Conservation and Special Protection Areas), the Habitats Directive, the Birds Directive and the Environmental Impact Assessment Directive in order to protect habitats and species inside or outside the legally protected areas. It also recognises natural heritage areas, national parks and nature reserves as part of national natural assets and cultural heritage and its importance to the tourism industry and for their contribution to quality of life and the attractiveness of places for economic investment. In regard to these, the NPF sets the following objectives:

- National Policy Objective 59 – Enhance the conservation status and improve the management of protected areas and protected species by: Implementing relevant EU Directives to protect Ireland's environment and wildlife; Integrating policies and objectives for the protection and restoration of biodiversity in statutory development plans; Developing and utilising licensing and consent systems to facilitate sustainable activities within Natura 2000 sites; Continued research, survey programmes and monitoring of habitats and species.
- National Policy Objective 60 – Conserve and enhance the rich qualities of natural and cultural heritage of Ireland in a manner appropriate to their significance.

As part of the preparation of the NPF, a number of environmental assessments have been carried out. These include a Strategic Environmental Assessment (SEA), an Appropriate Assessment (AA), and a Strategic Flood Risk Appraisal (SFRA). These assessments have been undertaken so that the high-level impact of the proposed National Policy Objectives and National Strategic Outcomes on the environment can be evaluated and used to inform the direction of the NPF. This is to ensure that the growth strategy and national objectives and outcomes respond to the sensitivities and requirements of the wider natural environment i.e., the likely environmental consequences of decisions regarding the future accommodation of growth and development and how negative effects can be reduced, offset, or avoided. These objectives relate to the following objective:

- National Policy Objective 75 – Ensure that all plans, projects and activities requiring consent arising from the NPF are subject to the relevant environmental assessment requirements including SEA, EIA and AA as appropriate.

The NPF was published together with a 10-year national investment plan as one vision – Project Ireland 2040, meaning that implementation of the Framework will be fully supported by the government's investment strategy for public capital investment and investment by the State sector in general. This investment is outlined in the companion of the document National Development Plan (2018 - 2027) (see section 2.4.2).

For further information consult:

Government of Ireland. 2018 (a). National Planning Framework - Project Ireland 2040. Available on: https://npf.ie/wp-content/uploads/Project-Ireland-2040-NPF.pdf

2.4. National Development Plans

2.4.1. National Development Plan (2007 - 2013)

The National Development Plan (NDP) "*Transforming Ireland — A Better Quality of Life for All*" aimed at setting out a roadmap to Ireland's future for a period of seven years (2007 - 2013) and proposed an investment of some €184bn in the economic and social infrastructure (Government of Ireland, 2007). The document stated that the NDP should integrate strategic development frameworks for regional development, for rural communities, for all-island co-operation, and for protection of the environment with common economic and social goals. Some of the objectives of the NDP 2007-2013 relevant to this report were:

- Integrate regional development within the NSS framework of Gateway cities and Hub towns to achieve the goals of economic growth in the regions and provide for major investment in the rural economy;
- Invest in long-term environmental sustainability to achieve the national goal of preserving the integrity of the natural environment for future generations as well as meeting international responsibilities and Climate Change obligations; this also involves a more balanced, efficient and sustainable use of land resources.

The NDP provided for a direct investment of over €25bn in Environmental Sustainability Programmes. This investment would be complemented by the strategy for balanced regional development and land use as envisaged in the NDP, based on the NSS model for compact and sustainable urban development. This robust framework aimed at accommodating the anticipated rapid growth in Ireland's population and concomitant economic growth while

maintaining the quality of the natural environment. Measures such as promoting the switch from car to public transport would be expected to have a substantial impact on environmental sustainability over the longer term and the potential to meet international commitments relating to climate change.

Other areas in which the NDP aimed at benefiting the environment, whether in terms of reducing damage to the environment by curtailing harmful emissions or discharges or in the protection of the environmental heritage for future generations, included the investment priorities for: Environment Services (water and wastewater services and waste management infrastructure); Climate Change Strategy (through investment in public transport); Promotion of renewable energy (a 15% commitment to use of renewables in electricity production by 2010); Agriculture; Tourism; Built and Natural Heritage preservation; and Environmental Research (including the energy, transport, agriculture and marine sectors).

The NDP recognised that the Irish coastline contains a wealth of resources, of economic, social, cultural, environmental and nature conservation value and that many of these areas face problems of coastal erosion and flooding. A sub-programme within the "Marine and Coastal Communities Programme" has been set with responsibility over maintaining and supporting Ireland's eroding coastlines and over €23m was expected to be spent to protect the coastline from erosion and manage the problem of coastal flooding to minimise its impact on the commercial and social activities of coastal communities. The overall goal of the Coastal Protection Sub-Programme was to ensure the sustainable development and management of the marine coastal zone by addressing priority coast protection requirements.

The planned investment under the NDP would be a mix of risk evaluation, development of procedures and guidance for scheme selection, Planning and Development assistance and capital projects of both a hard and soft engineering nature. The Plan stated that in areas where protection is not provided, the establishment of surge forecasting and warning systems could help to significantly mitigate flood damage.

The NDP stated that funding would be provided for the completion of the National Coastal Protection Strategy Study. This would identify areas at risk from erosion and flooding and quantify probable damages. The situation, with or without global warming induced sea level rise, would be examined. In areas of the necessity for protection schemes, funding would be provided to the relevant LA by means of a grant payment. Funding would be on a 75%

contribution by the Department of Communications, Marine and Natural Resources and 25% contribution from the LA.

For further information consult:

Government of Ireland. 2007. National Development Plan (NDP) "Transforming Ireland - A Better Quality of Life for All" (2007-2013). Available on: http://www.socialinclusion.ie/documents/NationalDevelopmentPlan2007-2013.pdf

2.4.2. National Development Plan (2018 - 2027)

The National Development Plan (NDP) 2018-2027 (Government of Ireland, 2018b) aims to drive Ireland's long term economic, environmental, and social progress across all parts of the country over the next decade. The plan is integrated with the spatial planning approach, setting out the investment priorities that should underpin the successful implementation of the current NPF (section 2.3.2). The NDP demonstrates the government's commitment to meeting Ireland's infrastructure and investment needs over the next ten years, through a total investment estimated at €116bn over the period to accomplish the ten National Strategic Outcomes stated by the NPF.

Transition to a Low-Carbon and Climate- Resilient Society has been identified as a strategic investment priority by the NDP and circa €21.8bn should be allocated to accomplish this National Strategic Outcome. Climate action should be taken to position Ireland to harness significant benefits from realising a low-carbon economy, including the creation of sustainable green jobs, sustainable food production, deepening energy security, and creating a healthier environment. The plan states that delaying climate action will put these potential benefits at risk, undermine the green reputation of exports, compromise national capacity to attract foreign direct investment, and make achieving the transition more costly. Some major national infrastructure projects in this regard are: the Climate Action Fund (allocation of €500m under the Department of Communications Climate Action and Environment); New Renewable Electricity Support Scheme; Investments in energy efficiency of existing commercial and public building stock; Enhanced electricity interconnection, including the Celtic Interconnector to France and further interconnection to the UK; Conversion of Moneypoint electricity generation plant to end the burning of coal; Cork City Flood Relief Scheme.

The new NDP designates investment actions on Flood Risk Management and highlights the importance of flood relief schemes to minimise the impacts of river and coastal flooding on society, however, it does not present investments for coastal erosion explicitly. The plan highlights that an investment of €350m since 1995 has already delivered 42 major flood relief schemes around the country, providing protection to 9,500 properties and an economic benefit to the State in damage and losses avoided estimated at 1.9bn. It states that €430m has been allocated for flood mitigation initiatives over the period 2016 to 2021 to protect threatened communities from river and coastal flood risk. This funding is supporting the development and implementation of a significant existing flood relief investment programme which includes eight major flood relief schemes under construction and 26 schemes under design and at planning to protect 11,200 properties.

The government is committed to the policy objective of delivering further capital works/flood relief schemes to minimise the impacts of river and coastal flooding on society through the roll-out of the 29 Flood Risk Management Plans developed by the Catchment Flood Risk Assessment and Management Programme "CFRAM" (see section 3.7.1). Delivery of this capital works programme will be underpinned by a total investment of up to €940m over the lifetime of the NDP. The 29 plans include proposed flood relief schemes which will need to be prioritised on a regional basis. The schemes will range from very large schemes costing in excess of €15m each to smaller schemes that can be progressed by the LA with funding available from the OPW.

For further information consult:

Government of Ireland. 2018 (b). National Development Plan (2018 - 2027). Available on: https://assets.gov.ie/19240/62af938dce404ed68380e268d7e9a5bb.pdf

3. National Climate Change Legislation, Policies and Plans

3.1. National Policy Position on Climate Action and Low Carbon Development (2014)

The National Policy Position on Climate Action and Low Carbon Development launched in 2014 provided a high-level policy direction for the adoption and implementation by government of plans to enable the State to move to a low carbon economy by 2050

(Government of Ireland, 2014). This national climate policy recognises the threat of climate change for humanity; anticipates and supports mobilisation of a comprehensive international response to climate change, and global transition to a low-carbon future; recognises the challenges and opportunities of the broad transition agenda for society; and aims to achieve transition to a competitive, low-carbon, climate-resilient and environmentally sustainable economy.

This long-term vision is based on an aggregate reduction in carbon dioxide (CO_2) emissions of at least 80% (compared to 1990 levels) by 2050 across the electricity generation, built environment and transport sectors; and in parallel, an approach to carbon neutrality in the agriculture and land-use sector, including forestry, which does not compromise capacity for sustainable food production.

It stated that the evolution of climate policy in Ireland should be an iterative process, based on the adoption by the government of a series of national plans over the period. Greenhouse gas mitigation and adaptation to the impacts of climate change will be addressed in parallel national plans – respectively through National Low-Carbon Roadmaps and National Climate Change Adaptation Frameworks (section 3.3).

The Position provided elements on how the NCCAF should work which is by articulating a strategic policy context for appropriate action at a sectoral and local level, in response to the impacts of climate change in Ireland in the shorter and longer term. It states that the objective of the NCCAF should be to inform and mobilise an integrated approach, involving all stakeholders on all institutional levels, to ensure that adaptation measures are taken and implemented, including through incorporation into future investment plans where appropriate, to manage and reduce sectoral and local vulnerability to the negative impacts of climate change. Also, by providing a clear mandate for government departments, agencies and LAs to develop and implement sectoral and local adaptation plans. Statutory authority for these mitigation and adaptation plans was subsequently provided for in the Climate Action and Low Carbon Development Act 2015.

For further information consult:

Government of Ireland. 2014. National Policy Position on Climate Action and Low Carbon Development. Available on: https://www.gov.ie/en/publication/6f393-national-climate-policy-position/

3.2. Climate Action and Low Carbon Development Acts, 2015 – 2021

The first Climate Action and Low Carbon Development Act was published in 2015 to provide for the approval of plans by the government in relation to climate change for the purpose of pursuing the transition to a "low carbon, climate resilient and environmentally sustainable economy", establish the Climate Change Advisory Council, and provide for matters connected (Government of Ireland, 2015).

In July 2021, the Government of Ireland enacted the Climate Action and Low Carbon Development (Amendment) Act 2021 which brought advances to the first law. In this, the Government of Ireland stated that the national climate objective is to "*to reduce the extent of further global warming, pursue and achieve, by no later than the end of the year 2050, the transition to a climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy*" (Government of Ireland, 2021), i.e., the new Act included the concerns with biodiversity and brought the Net Zero emissions concept into its purposes.

The 2015 Act brought the definitions and the legal basis for the making of the National Mitigation Plan, the National Adaptation Framework, and the Sectoral Adaptation Plans. The 2021 Act brought the requirements to develop a National Long Term Climate Action Strategy and the obligation for LAs to prepare Local Climate Action Plans comprising mitigation and adaptation measures. The actions proposed in the Local Climate Action Plans should be incorporated in Local Development Plans and be consistent with the most recently approved national climate frameworks. These law instruments have the purpose of enabling the State to pursue and achieve the stated national climate objective and should be reviewed in every period of 5 years.

According to the Acts, the National Mitigation Plan shall specify the manner in which it is proposed to achieve the national transition objective; specify the policy measures that, in the opinion of the government, would be required in order to manage greenhouse gas emissions and the removal of greenhouse gas at a level that is appropriate for furthering the achievement of the national objective; take into account any existing obligation of the State under the law of the European Union or any international agreement; and, specify the mitigation policy measures (referred to as the "sectoral mitigation measures") to be adopted by the Ministers of the government in relation to the matters for which each such Minister of the Government has

responsibility for the purposes of: (i) reducing greenhouse gas emissions, and (ii) enabling the achievement of the national objective.

The Acts state that a National Adaptation Framework (NAF) shall specify the national strategy for the application of adaptation measures in different sectors and by a LA in its administrative area in order to reduce the vulnerability of the State to the negative effects of climate change, and avail of positive effects of climate change that may occur and take into account any existing obligation of the State under the law of the European Union or any international agreement.

By "Adaptation", the Acts define as "*any adjustment to any system designed or operated by human beings (including an economic, agricultural or technological system), or any naturally occurring system, including an ecosystem, that is intended to counteract the effects (whether actual or anticipated) of climatic stimuli, prevent or moderate environmental damage resulting from climate change or confer environmental benefits*".

Having regard to the NAF, the Acts state that Sectoral Adaptation Plans shall be made by each Minister of the Government (in relation to the matter for which each such Minister of the Government has responsibility). These plans should specify the adaptation policy measures the Minister of the Government concerned proposes to adopt for the purposes of enabling adaptation to the effects of climate change to be achieved in relation to the matter to which the sectoral adaptation plan relates and enabling the achievement of the national transition objective.

The Acts instituted the Climate Change Advisory Council (*An Chomhairle Chomhairleach um Athrú Aeráide* in Irish) and provided instructions regarding its membership, organisation, and functions. The functions of the Advisory Council shall be to advise and make recommendations to the governments and ministers in relation to the preparation of climate frameworks, compliance with any existing obligation of the State under the law of the European Union or any international agreement, amongst others matters. The 2021 Act tasked the Climate Change Advisory Council with proposing carbon budgets and stated that the first two five-year carbon budgets should equate to a total reduction of 51% emissions over the period to 2030.

The 2021 Act also provided for a carbon budget scheme by adopting a series of five-year carbon budgets, including sectoral budget targets for each relevant sector (named as sectoral emissions ceiling). Sectoral actions should be updated annually in the Climate Action Plan. The recently published Act also provided for a joint committee of the Houses of the Oireachtas

where each appropriate Minister should report the achievements about legally-binding targets for their own sectoral area.

The Acts ensure the citizen participation in the making of those plans by establishing that the government shall publish notices on the internet and in more than one newspaper circulating in the State inviting members of the public and any interested parties to make submissions in writing in relation to the proposed plans within the period specified in the notices (not exceeding 2 months from the date of the publication of the notice).

Other provisions given by the Climate Action and Low Carbon Development Acts and a list of legislative changes/amendments to this Act, and to statutory instruments, should be consulted on the Irish Statute Book website (http://www.irishstatutebook.ie/). A consolidated version of this Act is not available yet.

For further information consult:

Government of Ireland. 2015. Climate Action and Low Carbon Development Act. Available on: http://www.irishstatutebook.ie/eli/2015/act/46/enacted/en/html

Government of Ireland. 2021. Climate Action and Low Carbon Development (Amendment) Act 2021. Available on: http://www.irishstatutebook.ie/eli/2021/act/32/enacted/en/print.html?printonload=true

3.3. National Climate Change Adaptation Frameworks

3.3.1. National Climate Change Adaptation Framework (2012)

According to the National Climate Change Adaptation Framework (NACCF) published in 2012, climate change adaptation comprises all spontaneous responses and planned action taken to cope with the impacts of changing climate conditions (DECLG, 2012). The NACCF recognises that a planned approach to adaptation is needed to tackle climate variability and to anticipate possible future changes, with the aim of cost-effectively reducing risk and damage, and exploiting any potential benefits. The framework considered that it is important to be able to build on positive opportunities that may be presented to respond effectively to reduce any negative impacts and to prepare for longer term consequences.

This national policy framework for climate change adaptation draws together the work done by government and the wider public sector on adaptation in Ireland, with the objectives of providing the policy context for a strategic national adaptation response to climate change; promoting dialogue and understanding of adaptation issues; identifying and promoting adaptation solutions; and committing to actions to support the adaptation process. The NACCF aimed to provide a strategic policy focused to ensure that adaptation measures were taken across different sectors and levels of government to reduce Ireland's vulnerability to the negative impacts of climate change. The aim of this framework was to ensure that an effective role was played by all stakeholders in putting in place an active and enduring adaptation policy regime and provide a governance structure for climate change adaptation to be addressed at national and local level. It mirrored the approach taken at EU level in the White Paper on Adaptation, following a two-phased approach to adaptation in Ireland.

The first phase was aimed at identifying national vulnerability to climate change, based on potential impacts relative to current adaptive capacity. Reliable information on the range of socio-economic vulnerabilities, the costs and benefits, and the options available and appropriate to Ireland, were considered key elements to inform effective adaptation planning. The second phase was aimed at addressing the development and implementation of sectoral and local adaptation action plans as part of the comprehensive national response to the impacts of climate change. Sectoral plans were encouraged to be prepared by the relevant Department or Agency and adopted by the relevant Minister, on the identified key climate-sensitive sectors such as water, biodiversity, marine, agriculture, forestry, energy, transport, communications, tourism, heritage, and health. It ensured that the process of making sectoral adaptation plans should be open, transparent, and inclusive, giving opportunity to interested organisations and stakeholders, at sectoral and national levels, to input to the process of preparing the plans.

The framework recognised LAs as having a pivotal role in planning for, and responding to, emergency situations given to their close relationship with the community, enabling to respond faster and more effectively to local climate once they possess up-to-date knowledge of the local natural and man-made environment and, therefore, having a critical role to play in managing climate risks and vulnerabilities. The framework recommends that local adaptation strategies should develop and express a vision for a well-adapted local community that is resilient to the impacts of climate change, through: determining an area’s vulnerability to climate risks; identifying, prioritising and costing adaptation actions; developing and implementing a

comprehensive action plan; and, ensuring that climate change impacts and risks are embedded into all decision-making.

The NACCF also established local development planning as the mechanism for the delivery of local climate adaptation action. LAs were encouraged to make assessments of the extent to which their development plans adequately addressed adaptation to climate change and, where appropriate, review the process of their development plan if climate adaptation was not already adequately addressed. The framework stated that it is important that adaptation plans identify those who will be responsible for monitoring the plan, the criteria against which plans will be reviewed, the review process mechanism and the timescales for reviews to be carried out, in order to ensure plans effective monitoring and review. It also encouraged the full engagement of key stakeholders at the local level planning process, in a transparent and inclusive way.

For further information consult:

DECLG / Department of the Environment, Community and Local Government. 2012. National Climate Change Adaptation Framework. Available on: https://www.gov.ie/en/publication/df8e2-national-climate-change-adaptation-framework/

3.3.2. National Adaptation Framework (2018)

The National Adaptation Framework (NAF) published on 2018 was developed from the NCCAF 2012 (section 3.3.1) and approved in accordance with the Climate Action and Low Carbon Development Act 2015 (section 3.2). The NAF sets out the international policy context of the climate and incorporated key drivers, such as the Agenda 2030 for Sustainable Development and the Sendai Framework for Disaster Risk Reduction and brought the latest visions for a low carbon, climate resilient and sustainable development (DCCAE, 2018a).

The NAF recognises the urgent need to consider response to the more immediate short-term impacts of climate change (e.g. emergency planning and how to respond to extreme weather events), while also building long-term resilience (climate change adaptation). The plan states that adaptation is the approach for addressing the current and future risks posed by a changing climate and it is aimed at reducing the vulnerability of our environment, society and economy and increasing resilience. It brings opportunity through green growth, innovation, jobs and ecosystem enhancement as well as improvements in areas such as water and air quality.

The current operative framework specifies the national strategy for the application of adaptation measures in different sectors and by LAs in their administrative areas in order to reduce the vulnerability of the State to the negative effects of climate change and to avail of any positive effects that may occur. Therefore, the NAF sets out the context and guiding principles to ensure LAs, regions and key sectors can assess the key risks and vulnerabilities of climate change, implement climate change resilience actions and ensure climate adaptation considerations are mainstreamed into all local, regional and national policy making – while building on progress achieved prior to the NAF.

According to this Framework, adaptation should seek to minimise costs and maximise the opportunities arising from climate change. Adaptation actions range from building adaptive capacity (e.g. increasing awareness, sharing information and targeted training) through to policy and finance based actions. Adaptation actions must be risk based, informed by existing vulnerabilities of society and systems and an understanding of projected climate change. Adaptation actions taken to increase climate resilience must also consider impacts on other sectors and levels of governance. However, in terms of implementation the NAF does not identify specific locations or propose adaptation measures or projects in relation to sectors but proposes adaptation measures be developed across sectors and local government, in accordance with this framework, respecting the principle of subsidiarity. The sectors should reflect their key priorities within the annual budgetary and estimates processes.

For further information consult:

DCCAE / Department of Communications, Climate Action & Environment. 2018a. National Adaptation Framework: Planning for a Climate Resilient Ireland. Available on: https://www.gov.ie/en/publication/fbe331-national-adaptation-framework/

3.4. Climate Action Plan (2019)

The Climate Action Plan - To Tackle Climate Breakdown (Government of Ireland, 2019) has been unanimously endorsed by the Dáil, while at the same time declaring a Climate and Biodiversity Emergency. It is a government roadmap composed of a coherent set of policy actions committed to achieving a net zero carbon energy systems objective for Irish society and, in the process, it aims to create "*a resilient, vibrant and sustainable country*". The Plan states that, in addition to the proposals to reduce Ireland's greenhouse gas emissions, the

changes required should also have positive economic and societal co-benefits, including cleaner air, warmer homes, and a long-term sustainable economy in line with the UN Sustainable Development Goals.

The Plan outlines the current state of climate breakdown across different sectors (such as Electricity, Built Environment, Transport, Agriculture, Enterprise and Services, and Waste and the Circular Economy) identifying the nature and scale of the challenges. It sets out new governance structures necessary to implement changes (including the creation of a Climate Action Delivery Board and a Climate Action Council) and includes a course towards achieving ambitious decarbonisation targets by 2030. The Plan set a commitment that 70% of the electricity needs will come from renewable sources by 2030. It emphasises that under the NPF 2018 (section 2.3.2), €30bn should be allocated to meet this challenge and that over 25% of public investment over the coming decade is linked to climate action.

The Plan also encourages citizen engagement in order to promote a successful transition, with targets such as: engagement Capacity Building and empowering Local Community Action; realising the new economic opportunities in communities and regions; Just Transition for those facing particular challenges in adjusting through reskilling, energy poverty schemes and community participation; and, empowering the new generation to have their voices heard and get access to the science and the opportunity to lead change.

Chapter 11 on "Agriculture, Forestry and Land Use" sets targets to forestry replanting and management as a way to foster carbon sinking in addition to peatlands rehabilitation and hedgerows as potential mitigation options. This chapter does not mention coastal-marine ecosystems, such as salt-marshes, dune systems and seagrass, as holding this important role in carbon sinking for climate mitigation and as a nature-based solution for climate adaptation.

The report recognises the imminent climate change impacts to Ireland's coastal zone such as: rising sea levels threatening habitable land and particularly coastal infrastructure; extreme weather, including more intense storms and rainfall affecting our land, coastline and seas; further pressure on our water resources and food production systems with associated impacts on fluvial and coastal ecosystems; and increased chance and scale of river and coastal flooding.

Chapter 16 on "Adaptation" recognises that people throughout Ireland have already experienced first-hand these potential impacts of climate change, particularly through floods and storms and the damage that can ensue. Also, acknowledges that these events are expected

to increase in frequency, and highlights the need for adaptation measures to help the country cope with the effects of climate change.

It reinforces the motto that adaptation actions seek to minimise costs and maximise the opportunities arising from climate change. Adaptation actions range from building adaptive capacity (e.g. increasing awareness, sharing information and targeted training) through to policy and finance based actions. Adaptation actions should be risk based, informed by existing vulnerabilities of Irish society and systems, and an understanding of projected climate change. Actions taken to increase resilience must also consider impacts on other sectors and levels of governance.

The Plan stresses the importance of elaborating the 12 sectoral adaptation plans proposed by the NAF (section 3.3.2) in order to set out adaptation actions to reduce the vulnerability to climate impacts. It highlights the critical role to be played by LAs in preparing their local adaptation strategies and the role of the four established Local Authority Climate Action Regional Offices (CAROs) in supporting the preparation of local adaptation strategies and driving climate action (adaptation and mitigation) at LA level. Also recognises a number of resources in place to assist the sectors and LAs with adaptation planning, such as the online resource Climate Ireland, the Local Authority Climate Change Adaptation Strategy Development Guidelines (section 3.5), and the Sectoral Guidelines for Planning for Climate Change Adaptation (section 3.6).

For further information consult:

Government of Ireland. 2019. Climate Action Plan. Available on: https://www.gov.ie/en/publication/ccb2e0-the-climate-action-plan-2019/

3.5. Local Authority Adaptation Strategy Development Guidelines (2018)

Followed by the non-statutory NCCAF 2012 (section 3.3.1) that outlined the need for LAs to take a long-term view of climate change adaptation, the first Local Authority Adaptation Strategy Development Guidelines was published in 2016 (Gray, 2016). The purpose of these Guidelines was to support LAs in the development of a local climate change adaptation strategy and its structure and content draws on the 2013 Guidelines on Developing Adaptation Strategies provided to European Union Member States by the European Commission, with the aim of fostering coherence between strategies developed at local and national scale.

With the advent of the statutory NAF 2018 (section 3.3.2) in line with the Climate Action and Low Carbon Development Act 2015 (section 3.2), these Guidelines were reviewed and updated to reflect changes that have occurred in adaptation policy at national level and were published in 2018 as statutory Guidelines. The Local Authority Adaptation Strategy Development Guidelines published in 2018 have been developed to assist LAs to develop their own adaptation strategies and ensure that they will complement Sectoral Adaptation Plans to be prepared under the NAF by ensuring that a coherent and consistent approach to adaptation planning is adopted by LAs in Ireland (DCCAE, 2018b). The updated Guidelines have been edited by the Climate Ireland research team at MaREI (the SFI Research Centre for Energy, Climate and Marine) and published by the Department of Communications, Climate Action & Environment (DCCAE).

The Guidelines recognizes that LAs are the level of government closest to local communities and enterprise and the first responders in many emergencies, so able to obtain real positive change on the ground, contributing both to the delivery of the national transition objective of low carbon, climate resilience in the long term and also improving the ability to plan for and respond to severe weather events in the shorter term.

LAs are identified as a key stakeholder responsible for implementing adaptation actions in their area, for example, LAs are key stakeholder in the preparation of flood emergency response plans in the flood risk management sector, they are responsible for the control of invasive species in the biodiversity sector and are key in the management of fluvial flooding on local roads in the transport sector (DCCAE, 2018b).

LAs count on the support of the four CAROs established in 2018 in the development of their strategies. The local strategies should be used to mainstream adaptation over time into the plans and policies by informing those and providing a high level guide on how climate change can be integrated into all the relevant operations of the LA over time.

The Guidelines were structured in six chapters, as follows:

Chapter 1 provides background information on what adaptation entails and provides the rationale behind implementing a local scale adaptation strategy and the following chapters detail the distinct phases of the process of developing an adaptation strategy. The phases were structured around a 5 step planning cycle, these are: 1) Preparing the Ground; 2) Assessing the Adaptation Baseline; 3) Identifying Future Climate Impacts, Vulnerabilities and Risks; 4)

Identifying, Assessing and Prioritising Adaptation Actions; 5) Drafting, Implementing and Monitoring the Strategy.

Chapter 2 outlines the initial steps required in launching a strategy development process, describing key roles and who can fulfil them, and setting out important factors to consider in the early stages of strategy development.

Chapter 3 explains how to assess the role that weather extremes and periods of climate variability currently play within the local jurisdiction, and it describes why doing so is a fundamental element of working towards a more climate-resilient future.

Chapter 4 moves from the present to the identification of future climate risks, describing a staged risk assessment process and positioning the adaptation strategy within more detailed risk assessments undertaken during shorter term decision-making processes such as statutory plan-making.

Chapter 5 based on the risk assessment process undertaken in the previous chapter, this chapter describes the determination of adaptation goals and objectives and the types of adaptation actions that are available and outlines how each might be identified, assessed, prioritised, and implemented.

Chapter 6 outlines the steps required to move from a phase of planning to one of implementation, and it explains the importance of monitoring and evaluation in ensuring that the strategy is achieving its anticipated adaptation objectives.

In order to support LAs in the process of developing their adaptation strategies, an online Local Authority Adaptation Wizard has been developed and deployed on "Climate Ireland" (a centralised information resource developed by researchers at University College Cork: www.climateireland.ie). The wizard is based around the 5 steps of the adaptation decision making process described in these guidelines and provides further support to LAs by identifying and providing access to key sources of the most up-to-date climatic and adaptation information and through the provision of templates to support information and data collection.

For further information consult:

DCCAE / Department of Communications, Climate Action & Environment. 2018b. Local Authority Adaptation Strategy Development Guidelines. Available on:

https://www.gov.ie/en/publication/41066-local-authority-adaptation-strategy-development-guidelines/

3.6. Sectoral Planning Guidelines for Climate Change Adaptation (2018)

The "Sectoral Planning Guidelines for Climate Change Adaptation" (DCCAE, 2018c) have been developed in order to assist the government departments to prepare statutory Sectoral Adaptation Plans in relation to the priority area they are responsible for and aim to ensure that a coherent and consistent approach to adaptation planning is adopted by the key sectors in Ireland. The guidelines were developed as part of the Environmental Protection Agency (EPA) research project 'A Climate Information Platform for Ireland' with funding provided by the Department of Communications, Climate Action and Environment (DCCAE). These were based on international best practice and developed in consultation with the Department of Transport, Tourism and Sport (DTTAS), the Department of Agriculture, Food and the Marine (DAFM) and other key sectors (DCCAE, 2018c).

According to these Guidelines, adaptation strategies involve taking practical actions to reduce vulnerability to the negative impacts of a changing climate and enhance opportunities or benefits and encompass a wide range of actions and can be classified as soft, green or grey and may range from simple solutions to large scale transformational projects:

- Soft adaptation: It involves alteration in behaviour, regulation or system of management, examples include: Extending timeframes of plans further into the future; zoning development away from sensitive areas; and instituting or strengthening building codes in hazard prone areas.
- Green adaptation: It seeks to utilise ecological properties to enhance the resilience of human and natural systems to climate change impacts. For example, increasing green space in urban areas could provide areas for retention of floodwaters and significantly ameliorate the impacts of rising surface temperatures resulting from climate change;
- Grey adaptation: It involves technical or engineering solutions to climate impacts, examples include raising roads where flooding is expected to occur.

The Guidelines are based on a staged and proportionate approach to adaptation planning and are structured around a 6 step planning cycle, these are: 1) Preparing the Ground; 2) Climate

Impact Screening; 3) Prioritisation; 4) Priority Impact Assessment; 5) Develop your Plan; 6) Implement, Evaluate and Review.

The early steps (1 & 2) focus on preparing the ground for an effective adaptation planning process and identifying what changes and impacts have the potential to give rise to wider and unacceptable sectoral impacts. Step 3 involves prioritising ongoing and potential future climate impacts in the context of sectoral and policy objectives/targets. Step 4 builds on the scoping stage and examines those changes and impacts considered a sectoral priority, it involves a more thorough assessment of exposure, sensitivity and adaptive capacity (i.e. vulnerability). Steps 5 and 6 involve identifying a series of goals, objectives, and actions, shifting the focus from potential impacts and vulnerabilities to identifying, prioritising, and implementing adaptation actions. The Guidelines indicates this sequence, but it recognises that adaptation decision-making is an iterative process and moving backwards or forwards to revisit a step or anticipate a future step may also be appropriate.

Sectors are required to prepare their plans in line with the process described in these Guidelines while also being aware of the overall requirements regarding the development of sectoral adaptation plans in Sections 5, 6 and 7 of the Climate Action and Low Carbon Development Act 2015 and the NAF (particularly Chapters 3 and 4) (DCCAE, 2018c).

For further information consult:

DCCAE / Department of Communications, Climate Action & Environment. 2018c. Sectoral Planning Guidelines for Climate Change Adaptation. 65p. Available on: https://www.gov.ie/en/collection/51df3-sectoral-adaptation-planning/

3.7. Flood Risk Management Climate Change Sectoral Adaptation Plan (2019)

Before presenting the Flood Risk Management Climate Change Sectoral Adaptation Plan (2019) a brief explanation regarding the Catchment Flood Risk Assessment and Management "CFRAM" Programme (2018) will be introduced.

3.7.1. Catchment Flood Risk Assessment and Management (CFRAM)

The Catchment Flood Risk Assessment and Management (CFRAM) Programme was a large flood risk study carried out by the OPW, in consultation with LAs (OPW, 2018). It consisted of a detailed engineering assessment of 300 areas or communities believed to be at significant

risk of future flooding - localities that are home to approximately two-thirds of the population and where 80% of properties are potentially at risk from rivers and seas. Ninety of these communities are coastal areas (OPW, 2019). This was completed through six CFRAM Projects covering 29 River Basins, and other location-specific projects. The OPW established a National Technical Coordination Group that set common standards, methods, and approaches, to assess and plan manage flood risk (OPW, 2019). Flood maps were developed for current conditions and for two future scenarios for the end of the century which took into account the potential impacts of climate change (Available on www.floodinfo.ie). The proposed future scenarios are:

i) Mid-Range Future Scenario (MRFS): typical or near to the general average of the future climate projections); and
ii) High-End Future Scenario (HEFS): a more extreme future based on the upper end of the range of projections of future climatic conditions and the impacts such changes would have on the drivers of flood risk).

The changes in flood-related parameters under each scenario are set out in Figure 21. These parameters were not derived from a specific set of projections from the IPCC reports but were based on a range of sources available at the time. Therefore, the MRFS and HEFS provide potential futures scenarios that permit flood hazard and risk assessments to be undertaken to identify possible impacts of climate change on flooding, which, in turn, enables an assessment of the vulnerability of different communities and areas around Ireland to such possible changes. This shall inform the adaptive approach on how flood risk in these communities should be managed now and into the future.

Parameter	MRFS	HEFS
Extreme Rainfall Depths	+ 20%	+ 30%
Peak Flood Flows	+ 20%	+ 30%
Mean Sea Level Rise	+ 500 mm	+ 1000 mm
Land Movement	- 0.5 mm / year[1]	- 0.5 mm / year[1]
Urbanisation	*No General Allowance – Review on Case-by-Case Basis*	*No General Allowance – Review on Case-by-Case Basis*
Forestation	- 1/6 Tp[2]	- 1/3 Tp[2] + 10% SPR[3]

Note 1: Applicable to the southern part of the country only (Dublin – Galway and south of this)

Note 2: Reduction in the time to peak (Tp) to allow for potential accelerated runoff that may arise as a result of drainage of afforested land

Note 3: Add 10% to the Standard Percentage Runoff (SPR) rate: This allows for temporary increased runoff rates that may arise following felling of forestry.

Figure 22: Allowances in Flood Parameters for the Mid-Range and High-End Future Scenarios (Source: OPW, 2019).

The allowances for the MRFS and HEFS for mean sea level rise are close to the average and the top end of the projections from the IPCC AR5 Report respectively. The scenarios also lie mid-range and at the upper end of the projections of sea level rise in the IPCC 1.5°C report (IPCC, 2018a). Research on the application of the scenario-neutral approach for flood risk management indicates that allowances for change in peak flood flows also cover the significant majority of projected changes for the catchments tested and across the four Representative Concentration Pathways (RCP) emissions scenarios (OPW, 2019). The comparability of the two future scenarios adopted for the CFRAM Programme against current international projections gives confidence that they are acceptable as plausible futures for use in assessing potential requirements for adaptation. Ongoing and future research may provide revised projections of potential impacts, which in turn may necessitate revised hazard and risk assessments (OPW, 2019).

According to CFRAM (OPW, 2018) Fingal County belongs to the Eastern River Basin District and Portrane is included in the flood risk management plan for the Nanny-Delvin River Basin (UoM08). The central objective of this plan is to manage and reduce the potential consequences of flooding in order to support the objectives of the Habitats Directive. The plan sets out measures for the cost effective and sustainable, long-term management of flood risk in the

River Basin including areas such as that of Portrane, where the flood risk is potentially significant (OPW, 2018).

For further information consult:

OPW / Office of Public Works. 2018. Catchment Flood Risk Assessment and Management (CFRAM) Programme. Available on: https://www.gov.ie/en/collection/396090-catchment-flood-risk-assessment-and-management-plans/

3.7.2. Flood Risk Management Climate Change Sectoral Adaptation Plan (2019)

The first Climate Change Sectoral Adaptation Plan for Flood Risk Management was produced by the OPW in 2015 under the mandate of the NCCAF (section 3.3.1). The current Flood Risk Management Climate Change Sectoral Adaptation Plan has been prepared under the NAF (section 3.3.2) and updates its predecessor by considering new information available on climate change and its potential impacts and developments in flood risk management since 2015, including progress made on the actions set out in the non-statutory adaptation, particularly in the areas of research, assessment (such as the information generated through the CFRAM Programme) and the planning, design and implementation of flood relief schemes (OPW, 2019). This Plan was structured in line with the Sectoral Planning Guidelines for Climate Change Adaptation (section 3.6). The purposes of this Plan are to:

- Outline the potential impacts of climate change on flooding and flood risk management in Ireland;
- Identify the objectives for an effective and sustainable approach to adaptation as part of flood risk management for the future;
- Promote a coordinated approach to adaptation: within the flood risk management sector and sustainable flood risk management measures in other sectors; and, across the policies and actions of other Sectors including LAs; and,
- Recommend any further actions required to meet the objectives for adaptation.

The Plan is a comprehensive document which addresses a variety of topics including the background to flood risk management in Ireland, current management practice, climate impact screening, the prioritisation of impacts, amongst others. It highlights the work that has been undertaken to assess the level of risk associated with flooding in Ireland, including the:

- Preliminary Flood Risk Assessment (PFRA): a national screening for flood risk under current conditions at a national level to identify the areas of potentially significant flood risk;
- Catchment-based Flood Risk Assessment and Management (CFRAM) Programme completed in 2018 (see section 3.7.1).

The document states that Natural Water Retention Measures have wide-ranging benefits for water quality, sediment control, climate mitigation through carbon sequestration, biodiversity and flood reduction. It also highlights the connection between increased fluvial and groundwater flooding potential, biodiversity loss, habitat reduction, distribution of invasive species, and impaired site access. The plan also highlights that increased coastal flooding and the associated saltwater intrusion leads to damage to coastal habitats and the loss of species. It points towards a potential solution in the form of wetland habitat creation which can be coastally located or inland aiming at improving natural water retention measures by reducing runoff and downstream flooding. However, there are also risks to biodiversity from flood management works and coastal defences as engineering works may create barriers to species movement, require land use change and may damage habitats (DCHG, 2019).

The Plan acknowledges climate change will increase the flood risk associated with the continued sea level rise, more severe Atlantic storms which could generate more significant storm surges and extreme waves, an increase in the number of heavy rainfall days each year, and wetter winters. It considers that adaptation actions are required to ensure effective and sustainable management of flood risk into the future.

This Plan sets out a long-term goal for adaptation in flood risk management, along with a set of objectives and adaptation actions aimed at achieving those objectives. The long-term goal is “Promoting sustainable communities and supporting our environment through the effective management of the potential impacts of climate change on flooding and flood risk” and the adaptation objectives to deliver this goal are:

Objective 1: Enhancing knowledge and understanding of the potential impacts of climate change for flooding and flood risk management through research and assessment.

Objective 2: Adapting flood risk management practice to effectively manage the potential impact of climate change on future flood risk.

Objective 3: Aligning adaptation to the impact of climate change on flood risk and flood risk management across sectors and wider government policy.

Twenty-one actions have been identified across the three above mentioned adaptation objectives across the areas of activity in flood risk prevention, protection and preparedness and resilience, as well as in further research and capacity building.

Flooding was recognised to have the potential to affect all sectors and LAs, and the Plan indicated that coordination is critical towards ensuring a coherent and whole of government approach to climate resilience in relation to flooding and flood risk management.

The plan emphasises that flood risk preparedness, response and resilience is an area of work identified for development by the National Flood Risk Policy Review, since it is not always possible to reduce the likelihood or severity of flooding to a community at risk through protection measures. Therefore, actions and measures should be taken to reduce the risk to people and damage to property and assets. This approach involves 'non-structural' measures such as:

- Increasing public awareness and preparedness prior to, during and after flood events to reduce potential damages caused by floods.
- Providing flood warning so that the public and response authorities can prepare for and respond effectively to flood events.
- Ensuring effective flood event response planning by the emergency response authorities, so that the response is effective and timely to reduce impacts on people and property.

The plan reports that the Interdepartmental Flood Policy Coordination Group, led by the OPW, was established to "consider the extent that non-structural solutions could inform the implementation strategy of the Flood Risk Management Plans and to ensure that policies that can benefit communities and individuals directly – to be prepared for and respond to or live with flood risk – are carefully considered". A range of measures have been implemented or are under the Group consideration, mainly informed by the CFRAM Programme. The establishment of a Flood Forecasting Service is seen by the plan as an important resource to further improve emergency response and community resilience.

Finally, to ensure progress and continual improvement in adaptation, the implementation of this Plan should be monitored and reviewed through current structures. This should be informed by indicators to enable critical assessment and to measure progress. An annual review of progress should be undertaken to inform the Annual Sectoral Adaptation Transition Statement for Flood Risk Management.

For further information consult:

OPW / Office of Public Works. 2019. Flood Risk Management - Climate Change Sectoral Adaptation Plan. Available online: https://www.gov.ie/pdf/?file=https://assets.gov.ie/46534/3575554721374f7ab6840ee11b8b066a.pdf#page=1

3.8. Biodiversity Climate Change Sectoral Adaptation Plan (2019)

Before presenting the Biodiversity Climate Change Sectoral Adaptation Plan (2019) there is a need to introduce the legal frameworks for the biodiversity protection and conservation in Ireland, particularly the Wildlife Acts (1976 -2012) and the National Biodiversity Action Plan (2017 - 2021).

3.8.1. Wildlife Acts, 1976 -2012

The Wildlife Acts, 1976 - 2012, are the core of Irish legislation providing for the protection of wildlife and the control of activities that may adversely affect wildlife (Government of Ireland, 1976). The Acts provide for the protection and conservation of wild fauna and flora and to conserve important ecosystems under the designation of Nature Reserves, Refuges for Fauna and wild birds' sanctuaries. The Wildlife (Amendment) Act, 2000 strengthened the legislative basis for biodiversity conservation by improving former measures and introducing new ones to enhance the conservation of wildlife species and their habitats. The 2000 Act introduced a statutory protection for the designation of national areas of high biodiversity and relevant natural attributes, the so called the Natural Heritage Areas (NHAs).

The Minister responsible for nature conservation should secure and promote the conservation of biological diversity, give assistance and advice on wildlife matters, indicate research needs, and promote public knowledge and understanding. The 2000 Act gave statutory responsibilities

to the Minister in order to promote the conservation of biological diversity in light of Ireland's commitment to the UN Convention on Biological Diversity (CBD).

The CBD (1992) defines biological diversity as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part, including diversity within species, between species and of ecosystems*". Therefore, the scope of the Wildlife Acts was subsequently broadened to include most Irish species, including most fish and aquatic invertebrate species which were excluded from the 1976 Act. It also strengthened the protective regime for Special Areas of Conservation.

Special Areas of Conservation (SACs) are designated under the EU Habitats Directive (Directive 92/43/EEC) and Special Protection Areas (SPAs) under the Birds Directive (Directive 79/409/EC), which form the basis of Europe's nature conservation policy - the Natura 2000 network of protected sites. These are transposed into Irish legislation through the European Communities (Birds and Natural Habitats) Regulations 2011 - 2021.

The EU Habitats Directive places strict legal obligations on Member States to ensure the protection, conservation and management of the habitats and species of conservation interest in all European Sites. The requirement for impact assessments under several EU Directives ensures that biodiversity is given due consideration for any proposed developments, including those towards climate change adaptation. Article 6 of the Directive obliges Member States to undertake an 'appropriate assessment' (AA) for any plan or project which may have a likely significant effect on any European Site. The outcomes of such AAs affect the decisions that may be made by competent national authorities in relation to the approval of plans or projects.

Environmental assessment can be undertaken for individual projects (such as motorways, airports or factories) on the basis of the Environmental Impact Assessment Directive (2011/92/EU), and/or for public plans or programmes on the basis of the Strategic Environmental Assessment Directive (2001/42/EC). The common principle of both Directives is to ensure that plans, programmes and projects likely to have significant effects on the environment are subject to an environmental assessment, prior to their approval.

Other provisions given by the Wildlife Acts and a list of legislative changes/amendments to this Act, and to statutory instruments, should be consulted on the Irish Statute Book website (http://www.irishstatutebook.ie/). A consolidated version of this Act with its amendments up

to 09 September 2020 can be accessed on the Law Reform Commission website (https://revisedacts.lawreform.ie/eli/1976/act/39/revised/en/html).

3.8.2. National Biodiversity Action Plan (2017 - 2021)

Climate change was considered one of the main threats and pressures reported on EU protected habitats and species in Ireland, with a likely increasing pressure over the next decades (DCHG, 2017). An assessment of the status of EU protected habitats and species in Ireland showed that 91% of the 58 habitats have unfavourable conservation status, wherein 50% were 'Inadequate' and 41% were 'Bad', while many of the coastal habitats and lakes were assessed as 'Inadequate', with ongoing declines while 'Inadequate' but improving trends are noted for some marine habitats (DCHG, 2017).

In 2002, Ireland published its first National Biodiversity Action Plan (2002- 2006) in order to meet the commitments of the CBD and EU Biodiversity Strategy. The second National Biodiversity Action Plan, "Actions for 2011- 2016", was launched in November 2011 and built upon the achievements of the first Plan. The current National Biodiversity Action Plan (NBAP) 2017-2021, is the third version of such plan for Ireland and captures the objectives, targets and actions for biodiversity that should be undertaken by a wide range of government, civil society and private sectors to achieve the following Ireland's Vision for Biodiversity: "That biodiversity and ecosystems in Ireland are conserved and restored, delivering benefits essential for all sectors of society and that Ireland contributes to efforts to halt the loss of biodiversity and the degradation of ecosystems in the EU and globally" (DCHG, 2017).

Biodiversity awareness is recognized as a central element in wider efforts to combat loss of habitats and species and to combat the potentially devastating effects of climate change. The NBAP aims to achieve Ireland's Vision for Biodiversity through addressing issues ranging from improving the management of protected areas to increasing awareness and appreciation of biodiversity and ecosystem services. The NBAP provides a framework to track and assess progress towards Ireland's Vision for Biodiversity over a five-year timeframe from 2017 to 2021. To achieve the Vision, seven strategic objectives were identified, these are:

Objective 1: Mainstream biodiversity into decision-making across all sectors:

> Target 1.1. Shared responsibility for the conservation of biodiversity and the sustainable use of its components is fully recognised, and acted upon, by all sectors;

Target 1.2. Strengthened legislation in support of tackling biodiversity loss in Ireland.

Objective 2: Strengthen the knowledge base for conservation, management and sustainable use of biodiversity:

Target 2.1. Knowledge of biodiversity and ecosystem services has substantially advanced our ability to ensure conservation, effective management, and sustainable use by 2021.

Objective 3: Increase awareness and appreciation of biodiversity and ecosystems services:

Target 3.1 Enhanced appreciation of the value of biodiversity and ecosystem services amongst policy makers, businesses, stakeholders, local communities, and the general public.

Objective 4: Conserve and restore biodiversity and ecosystem services in the wider countryside:

Target 4.1. Optimised opportunities under agriculture and rural development, forestry and other relevant policies to benefit biodiversity;

Target 4.2. Principal pollutant pressures on terrestrial and freshwater biodiversity substantially reduced by 2020;

Target 4.3. Optimised benefits for biodiversity in Flood Risk Management Planning and drainage schemes;

Target 4.4. Harmful invasive alien species are controlled and there is reduced risk of introduction and/or spread of new species;

Target 4.5. Improved enforcement of wildlife law.

Objective 5: Conserve and restore biodiversity and ecosystem services in the marine environment:

Target 5.1. Progress made towards good ecological and environmental status of marine waters over the lifetime of this Plan;

Target 5.2. Fish stock levels maintained or restored to levels that can produce maximum sustainable yield, where possible, no later than 2020.

Objective 6: Expand and improve management of protected areas and species:

Target 6.1. Natura 2000 network designated and under effective conservation management by 2020;

Target 6.2. Sufficiency, coherence, connectivity, and resilience of the protected areas network substantially enhanced by 2020;

Target 6.3. No protected species in worsening status by 2020; majority of species in, or moving towards, favourable status by 2021.

Objective 7: Strengthen international governance for biodiversity and ecosystem services:

Target 7.1. Strengthened support for biodiversity and ecosystem services in external assistance;

Target 7.2. Enhanced contribution to international governance for biodiversity and ecosystem services;

Target 7.3. Enhanced cooperation with Northern Ireland on common issues;

Target 7.4. Reduction in the impact of Irish trade on global biodiversity and ecosystem services.

The Department of Culture, Heritage and the Gaeltacht (DCHG) is the official body responsible for oversight of the implementation of this Plan and for coordinating the other Public Authorities, NGOs and private sector organisations involved in the process. The Action Plan provides for stakeholder participation through the Biodiversity Working Group which comprises Departments, Agencies and other bodies that have a role in implementing the Plan, and the Biodiversity Forum which represents various economic sectors, NGOs, academics other relevant stakeholders with the responsibility to monitor the implementation of the Plan and advise the Minister accordingly.

For further information consult:

DCHG / Department of Culture Heritage and the Gaeltacht. 2017. National Biodiversity Action Plan. Available on:

https://www.npws.ie/sites/default/files/publications/pdf/National%20Biodiversity%20Action%20Plan%20English.pdf

3.8.3. Biodiversity Climate Change Sectoral Adaptation Plan (2019)

The Biodiversity Climate Change Sectoral Adaptation Plan reinforces that Irish biodiversity is vulnerable to the impacts of climate change, which is a major and growing driver of biodiversity loss (DCHG, 2019). On the other hand, the Plan also emphasises the importance of biodiversity and ecosystem functions and services for human well-being and recognises they play a key role in building resilience (adaptive capacity to climate change) and contributing to mitigation and disaster risk reduction.

Actions within the Biodiversity Sectoral Climate Change Adaptation Plan were built on the foundations of the NBAP (section 3.8.2) and were aimed at improving sustainable agriculture and fisheries, achieving a better soil and land management, and restoring natural systems. The Plan was prepared under the NAF (section 3.3.2) and the NPF (section 2.3.2) and responds to the statutory requirements of the Climate Action and Low Carbon Development Acts (section 3.2) and the Climate Action Plan (section 3.4). The preparation of the plan followed the methodology proposed in the Sectoral Guidelines for Climate Change Adaptation (section 3.6).

The main goal of the Plan is "*to protect biodiversity from the impacts of climate change and to conserve and manage ecosystems so that they deliver services that increase the adaptive capacity of people and biodiversity while also contributing to climate change mitigation*". The purpose of the Plan is to identify adaptation options that will help to protect biodiversity and ecosystem services from the impacts of the changing climate and to enable ecosystems to play their role in increasing resilience to climate change. The key objectives of the Plan are:

1. Protect, restore and enhance biodiversity to increase the resilience of natural and human systems to climate change;
2. Improve understanding of the impacts of climate change on biodiversity;
3. Improve landscape connectivity to facilitate mobility in a changing climate;
4. Engage society and all sectors to protect biodiversity to enhance resilience;
5. Ensure sufficient financing is available to implement the Biodiversity Climate Change Adaptation Plan; and

6. Put adequate monitoring and evaluation measures in place to review the implementation of the Biodiversity Climate Change Adaptation Plan.

Particularly, in regard to coastal ecosystems, the Action 1.8 (under the Objective 1) demands to: "*Develop an integrated coastal management strategy which includes ecosystem-based adaptation actions to manage climate risk and build resilience to climate change*".

The Plan clearly recognises coastal habitats (such as fixed dunes) as one of the most vulnerable to climate change due to the impact of the changing temperature combined with the additional threat of sea level rise. The Plan states that biodiversity needs to be safeguarded against climate change and in turn can increase our resilience to the impacts of climate change, for instance, a healthy dune system gives protection from increased storminess and well vegetated uplands reduce the risk of soil erosion and landslides following intense rainfall.

The Plan highlights that adaptation and mitigation options from other sectoral adaptation plans can have positive and negative impacts on biodiversity. For example, increased coastal flooding can lead to damages to sand dune habitats, erosion of coastal habitats, loss of species and habitats due to coastal squeeze, loss of species and habitats due to saltwater intrusion. In this regard, the installation of seawall defences to protect from sea level rise is an adaptation option which can have negative effects on biodiversity and may not offer the optimal long term option. Likewise, flood defences schemes may alter water flows and habitat characteristics with dramatic impacts on biodiversity.

The Plan recommends employing "intelligent adaptation options" to reduce the vulnerability of biodiversity to the adverse impacts of climate change, such as actions to help species and ecosystems adapt to specific climate change impacts, such as reducing habitat fragmentation, maintaining genetic diversity, assisting migration (translocation) and manipulating disturbance regimes; and Ecosystem-based Approaches (EbA) to adaptation, which refer to the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. Such approaches include management and establishment of protected areas and conservation agreements, coastal and wetland maintenance and restoration, adaptive forest management, the use of agro-ecosystems in farming systems, ecotourism activities and direct species management (based on recommendations of the CBD Secretariat, 2016). Therefore, the consideration of nature-based

solutions together with screening for maladaptation is considered very important to increase the potential of low cost win-win climate actions.

The document understands biodiversity as a cross cutting theme with implications for all sectors and all levels of decision making and emphasises the importance that all sectors in Ireland recognise their role in reducing the pressures on biodiversity, protecting, and restoring ecosystem services and contributing to adaptation measures to increase resilience to climate change. It summons up other sectoral and local adaptation plans to take account of this Plan and the actions that intersect with the decision making under their control. It stated that responsibility should be shared with the citizens, state agencies, business, LAs and all government departments.

For further information consult:

DCHG / Department of Culture, Heritage and the Gaeltacht. 2019. Biodiversity Climate Change Sectoral Adaptation Plan, Prepared under the National Adaptation Framework. Available on: https://www.npws.ie/sites/default/files/publications/pdf/Biodiversity-Climate-Change-Sectoral-Adaptation-Plan.pdf

4. Regional Coastal, Planning and Development, and Climate Legislation, Policies and Plans

4.1. Regional Planning Guidelines for the Greater Dublin Area (2010 - 2022)

The Regional Planning Guidelines for the Greater Dublin Area (RPG-GDA) (RPGO, 2010) set out the planned direction for growth within the Greater Dublin Area up to 2022 and works to implement the strategic planning framework set out in the NSS (section 2.3.1). It aims to achieve this through the appraisal of the critical elements involved in ensuring sustainable and good planning, and through the protection of sensitive and environmentally important locations. The RPG-GDA informs and directs the City and County Development Plans of each of the Councils in the Greater Dublin Area. These guidelines aim to provide the links between national policies and LA planning policies and decisions. They also have a crucial role in supporting regionally important infrastructure and the investment priorities of the NDP and Transport 21.

The RGP-GDA 2010-2022 builds upon the experience and progress made under the first Guidelines (2004) and establishes new and innovative policy ideas to guide sustainable and balanced growth throughout the Greater Dublin Area. It states that an integrated model of policy development is a key component of the RPG-GDA, with economic, infrastructure and settlement policies being interdependent. This was complemented by new approaches to environmental and social policy which incorporated themes of green infrastructure development, climate change, flood risk management and social inclusion.

The RPG-GDA acknowledges that a regional approach to ICZM is supported by the NSS. Therefore, the RPG-GDA is seen as a regional approach to ICZM offering means to sustainably manage the development of the coastal zone through a collaborative and community focussed approach to planning and management of coastal resources.

The RPG-GDA highlights that the coastline of the Dublin and Mid East Regions represent an area of existing and future economic potential, tourism potential, mineral and food potential, and an energy resource and declares that a balance must be struck between the wide range of activities possible. This balance includes the requirements of provisions for recreation, public slipways and marina activity according to international and national obligations to protect and responsibly manage designated cultural and natural heritage coastal areas.

The plan recognises that coastal erosion and flooding has the potential to affect properties, businesses and infrastructure and can lead to loss of coastal archaeology and sites of architectural or tourism importance, and recommends that precautionary approaches should be taken including the creation of buffer zones to restrict development within areas of high risk erosion, predicted sea level rise or high coastal flooding risk and suitable sustainable options for protecting key assets (natural, built and infrastructure); and a full exploration of all the issues including habitat impact, through the collaborative preparation of Coastal Zone Management Plans with LAs, state bodies and communities working together. It states that the CFRAM Studies (section 3.7.1) and the Irish Coastal Protection Strategy (section 1.4) should also provide valuable information to LAs about flood risk in coastal areas, which can input into future Coastal Zone Management Plan.

The RPG-GDA spots the Dublin Bay Taskforce (DBTF) established by the Minister for Environment, Heritage and Local Government in 2008 as a forerunner for the effective application of ICZM across the regions and recommends that marine leisure should be

represented in the institutional arrangements. It understands that the initial process of ICZM undertaken through the DBTF has resulted in the development of an initial set of recommendations for the Dublin Bay coastal area which will form the building blocks for enhanced management, consensus building and furthering the scope of consultation and cooperation.

The main strategic policy presented by the RPG-GDA regarding an ICZM was to "Promote the development of cross boundary ICZM with all coastal LAs in the Greater Dublin Area so that future Development Plans can be guided in relation to the management of coastal areas drawing from a mutually supported plan for marine and coastal areas that has engaged with key stakeholders (Strategic Policy GIP4). To achieve this strategic policy, the following strategic recommendations were presented:

- The completion of an ICZM for Dublin Bay, building on research and the completion and implementation of the recommendations of the Dublin Bay Taskforce and working collaboratively to achieve an agreed framework plan or strategy incorporating land and marine planning and policies in an integrated manner and with regard to Article 6 of the Habitats Directive (Strategic Recommendation GIR22).
- The expansion of collaborative ICZM, and consideration of the complementary process and framework of marine spatial planning, for similar cohesive coastal landscape blocks to Dublin Bay along the eastern seaboard. This process shall take account of the Water Framework Directive; Birds Directive; Marine Strategy Framework Directive; Flood Risk Assessment studies; article 6 of the Habitats Directive; best available information on the regional impacts of climate change; and all current and future alignments between these Directives, assessments, and plans (Strategic Recommendation GIR23).
- That the concept of coastal parks is considered in future planning as a means of enhancing coastal habitats marine protection and sustainable marine based tourism and of integrating coastal (blue) infrastructure with green infrastructure (Strategic Recommendation GIR24).

Since Fingal is part of the Greater Dublin Area, any proposed scheme within the Rogerstown estuary area should be consistent with the objectives of the plans outlined by the RPG-GDA and development should make a positive contribution to fulfilling the strategic objectives of the policy documents in a manner consistent with planning and environmental policies.

For further information consult:

RPGO / Regional Planning Guidelines Office - Dublin Regional Authority and Mid-East Regional Authority. 2010. Regional Planning Guidelines for the Greater Dublin Area 2010-2022. Available on: https://emra.ie/dubh/wp-content/uploads/2015/02/Greater-Dublin-Area-Regional-Planning-Guidelines-2010-2022-Volume-I.pdf

4.2. Regional Spatial and Economic Strategy - Eastern and Midland Region (2019 - 2031)

Regional Spatial and Economic Strategy for the Eastern and Midland Region (2019 - 2031) (RSES-EMR) is a strategic plan which identifies regional assets, opportunities and pressures and provides appropriate policy responses in the form of Regional Policy Objectives (EMRA, 2019). It provides a framework for investment to better manage spatial planning and economic development to sustainably grow to 2031 and beyond.

The RSES-EMR provides a Spatial Strategy to manage future growth and ensure the creation of healthy and attractive places to live, work, study, visit and invest in; Economic Strategy that builds on our strengths to sustain a strong economy and support the creation of quality jobs that ensure a good living standard for all; Metropolitan Plan to ensure a supply of strategic development areas for the sustainable growth and continued success and competitiveness of the Dublin Metropolitan Area; Investment Framework to prioritise the delivery of key enabling infrastructure and services by government and state agencies; and Climate Action Strategy to accelerate climate action, ensure a clean and healthy environment and to promote sustainable transport and strategic green infrastructure.

The principal statutory purpose of the RSES-EMR is to support the implementation of the NPF (section 2.3.2) and the economic policies of the government by providing a long-term strategic planning and economic framework for the development of the regions. The RSES-EMR is required under the Planning and Development Act 2000 (section 2.2) to address employment, retail, housing, transport, water services, energy and communications, waste management, education, health, sports and community facilities, environment and heritage, landscape, sustainable development and climate change (EMRA, 2019).

The RSES-EMR (2019-2031) includes clear policy and supporting actions to avoid and minimise impacts on European sites (EMRA, 2019). It has identified a number of key Regional

Strategic Outcomes which include the need and commitment to conserve and enhance the biodiversity of protected habitats and species including landscape and heritage protection; to identify, protect and enhance green infrastructure and ecosystem services; to ensure the sustainable management of natural resources; to build climate resilience, to support the transition to a low carbon economy by 2050 and the protection of the healthy natural environment to ensure clean air and water.

Portrane (County Fingal) was identified as a primary area of potential coastal erosion risk for the region. The RSES-EMR recognises the potential of coastal erosion and flooding to seriously affect properties, businesses, transport infrastructure, coastal habitats and cultural heritage sites. It recommends the development of strategic coastal flood and erosion hazard maps for the national coastline to be used by local authorities to inform assessment of potential hazards associated with future proposed development, guide decisions on local coastal planning and development, and to develop appropriate plans and strategies for the sustainable management of coastlines (EMRA, 2019). The Strategy highlights that an ICZM approach could assist in meeting obligations under the Water Framework Directive, Marine Strategy Framework Directive, and Nature Directives.

Regional Policy Objectives in this topic are:

RPO 7.3 – The Eastern and Midland Region Assembly (EMRA) will support the use of ICZM to enable collaborative and stakeholder engagement approaches to the management and protection of coastal resources against coastal erosion, flooding and other threats.

RPO 7.4 – Statutory land use plans shall take account of the risk of coastal erosion, whereby new development should be avoided in areas at risk of coastal erosion to the greatest extent practicable.

For further information consult:

EMRA / Eastern and Midland Regional Assembly. 2019. Regional Spatial and Economic Strategy. Available on: https://emra.ie/dubh/wp-content/uploads/2020/05/EMRA_RSES_1.4.5web.pdf

5. Fingal County Coastal, Planning, and Climate Legislation Policies and Plans

5.1. Fingal County Development Plans

5.1.1. Fingal County Development Plan (2005 - 2011)

The Fingal Development Plan, 2005-2011 set out Fingal County Council's policies and objectives to develop and improve in a sustainable manner the environmental, social, economic, and cultural assets of the County (FCC, 2005). This Plan was prepared in accordance with the requirements of the Planning and Development Act, 2000 (section 2.2) which introduced changes in the national and local planning process. These changes included the provisions to foster public involvement at a much earlier stage in the plan preparation process and set out mandatory objectives to be included in Development Plans. FCC included these mandatory objectives and specific local objectives, including land zoning objectives, provision of infrastructure, conservation and protection of the environment, and integration of the planning and sustainable development of the area with the social, community and cultural requirements of the area and its population.

Regarding the management of the coast, the 2005 Plan indicated that the coast should be managed and developed in a way which protects and enhances its natural heritage and landscape and, therefore, the development of an ICZM was encouraged with policies for harbours, marinas, beach bathing quality, and fisheries and aquaculture. It also recognised that the impacts of predicted sea level rise due to climate change should be considered, including flooding and coastal erosion. FCC (2005) policies indicates, inter alia, the need for coastal protection and enhancement of natural heritage and landscapes; that natural coastal defences (beaches, sand dunes, salt marshes, and estuaries) are protected and not compromised by inappropriate works or developments; and to protect beaches and coastal areas from motor vehicles in the interest of public safety, quality of amenity and environmental integrity. Specific policies' objectives related to coastal erosion include to protect and rehabilitate sand-dune systems in the County where necessary, and to assess all coastal defence plans and projects for their environmental impact. The Plan stated that "*retaining and enhancing these elements provides a sustainable and cost-effective alternative to the provision of hard coastal defences*" (FCC, 2005).

Specifically, regarding coastal management in Portrane, the Plan set out the objectives to ensure that development in the Burrow Beach area protects the existing residential character and the amenities of this sensitive coastal estuarine area; and to prohibit the replacement of chalets/holiday huts by permanent dwellings and encourage the removal of existing chalets and huts at Burrow Beach.

For further information consult:

FCC / Fingal County Council. 2005. Fingal Development Plan, 2005-2011. Available on: https://www.fingal.ie/sites/default/files/2019-03/Fingal%20Development%20Written%20Statement%20Full%20Version.pdf

5.1.2. Fingal County Development Plan (2011 - 2017)

The Fingal Development Plan 2011-2017 (FCC, 2011) built its policies and objectives upon the previous plan and many statements were kept the same, however, proposed policies for coastal areas increased in number. The 2011 Plan also paid more attention to the problem of coastal erosion and introduced concepts such as "Soft Engineering Approach" and "Hard Engineering Approach". By Soft Engineering, the Plan defined as "*an approach that uses ecological principles and practices, which support the natural process of erosion and deposition, to maintain and enhance natural systems (such as sand dunes, beaches, salt marshes, mudflats). In essence soft engineering uses existing habitats and vegetation to soften the land-water interface while maintaining the integrity of the shoreline*". By Hard Engineering the Plan defines as a "*controlled disruption of natural processes by using man-made structures*" at a high cost for its installation and maintenance.

In this Plan, FCC recognised a strong need for restricting and containing development near the coast immediately in order to protect areas of soft coastline and associated soft defences into the future. FCC (2011) stated that developments along the coast must consider the need for coastal protection in all instances and take into account the role coastal habitats (such as beaches, salt marshes and sand-dunes) play in this. The Plan highlights that retaining and enhancing these elements and providing space for associated natural processes to take place, provides a sustainable and cost-effective alternative to the provision of hard coastal defences (FCC, 2011).

FCC (2011) policies on coastal management indicates, inter alia, to protect the special character of the coast by preventing inappropriate development along the coast; designate a Coastal Zone during the lifetime of the Plan to provide for the proper planning and sustainable development of the coast, while protecting its landscape and seascape character, its unique natural and cultural heritage, its amenities and economic value, and its role in coastal defence; prohibit development where they pose a significant or potential threat to coastal habitats or features, and/or where the development is likely to result in altered patterns of erosion or deposition elsewhere along the coast; and prohibit development within areas liable to coastal flooding other than in accordance with The Planning System and Flood Risk Management – Guidelines for Planning Authorities 2009 issued by the DEHLG and the OPW (guidelines presented in section 1.3).

The Plan presented as objectives for Portrane area, inter alia, to ensure the sensitive coastal estuarine area of Burrow Beach is adequately protected and that any proposed development is subject to a Habitats Directive Assessment screening; and prohibit the replacement of chalets/holiday huts by permanent dwellings and encourage the removal of existing chalets and huts at Burrow Beach (FCC, 2011) – aligning with the objectives presented in the preceding Plan.

For further information consult:

FCC / Fingal County Council. 2011. Fingal Development Plan 2011-2017. Written Statement. 426p. Available on: https://www.fingal.ie/sites/default/files/2019-03/Written%20Statement%202011%20-%202017%20%2828%20MB%29_compressed_compressed%20%281%29.pdf

5.1.3. Fingal County Development Plan (2017 - 2023)

The Fingal County Council Development Plan 2017-2023 replaced the previous plan and set out the Council's proposed policies and objectives for the development of the County over the Plan period. The Development Plan seeks to develop and improve, in a sustainable manner, the social, economic, environmental, and cultural assets of the County (FCC, 2017).

The Plan was prepared in accordance with the requirements of the Planning and Development Act, 2000 (section 2.2) which set out mandatory requirements for inclusion in the local development plans, such as objectives for the zoning, the provision of infrastructure, the

conservation and protection of the environment, and the integration of the planning and sustainable development with the social, community and cultural requirements of the area and its population. It also includes the requirement to prepare a 'core strategy' for the County, which must be consistent with National and Regional development objectives as set out in the NSS (section 2.3.1) and RPG-GDA (section 4.1).

FCC carried out a SEA and an AA under the Habitats Directive, in accordance with European and National legislations. These assessments were undertaken so the impact of the proposed Plan objectives on the environment could be evaluated and used to inform the direction of the Plan to ensure that the built environment responds to sensitivities and requirements of the wider natural environment.

This Plan consists of an extensive Written Statement with 502 pages, Maps and Appendices. The Written Statement is divided into 12 separate chapters with Chapters 1 and 2 setting out the vision, strategic context, aims, goals and the settlement and core strategies for the County. Chapters 3 to 10 set out the policies, objectives and actions required under a range of topics including placemaking and communities, green infrastructure, economic development, infrastructure and movement, urban and rural Fingal, and natural and cultural heritage. Chapters 11 and 12 set out the land use zoning policies and development management standards for the County. The Appendices include the Council's Housing Strategy, the Record of Protected Structures and Recorded Monuments, Technical Guidance Notes for Use Classes, a statement detailing implementation of Ministerial Guidelines, and Map Based Local Objectives (to be read in conjunction with the Development Plan Maps). The Maps provide a graphic representation of the proposals of the Plan indicating land use zoning and other objectives of the Council.

The main aims of the Fingal Development Plan are:

1. Plan for and support the sustainable long-term development of Fingal as an integrated network of vibrant socially and economically successful urban settlements and rural communities, strategic greenbelts and open countryside, supporting and contributing to the economic development of the County and of the Dublin City Region.
2. Provide for the future wellbeing of the residents of the County by:
    - Supporting economic activity and increasing employment opportunities.
    - Protecting and improving the quality of the built and natural environments.

• Ensuring the provision of adequate housing, necessary infrastructure and community facilities.

• Promoting and improving quality of life and public health.

• Build on the progress made in the County following the conclusion of the previous development plan.

3. Incorporate sustainable development, climate change mitigation and adaptation, social inclusion, high quality design and resilience as fundamental principles, cross cutting and underpinning the Development Plan.

4. Promote an appropriate balance of development across the County, by developing a hierarchy of high quality, vibrant urban centres and clearly delineated areas of growth, and favouring expansion in areas nearest to existing or planned public transport nodes.

5. Ensure an adequate supply of zoned lands to meet forecasted and anticipated economic and social needs, while avoiding an oversupply which would lead

6. Foster the development of socially and economically balanced sustainable communities.

7. Facilitate the actions and implementation of the Local Economic and Community Plan, as appropriate.

8. Facilitate the potential for growth in tourism by implementing the Fingal Tourism Strategy 2015-2018, as appropriate.

9. Continue to influence regional and national planning and development policies in the interest of the County.

10. Co-operate with the EMRA, LAs and other stakeholders in meeting the needs and development requirements of the County and the GDA in accordance with the NSS and the RPG-GDA and any successor policy documents.

11. Facilitate and encourage innovation in order to drive sustainable development, protecting against potential negative impacts.

The Plan lists 25 means in which the Strategic Policy will deliver on these main aims. Some of the most relevant to this study are:

1. Promote sustainable development by providing for the integration of economic, environmental, social and cultural issues into Development Plan policies and objectives, utilising the SEA and AA processes.

2. Contribute to the creation of a more socially inclusive, equal and culturally diverse society by providing for appropriate community infrastructure, quality public realm and

improving access to information and resources. Seek new innovative ways of enhancing social inclusion and ensure the Plan can facilitate initiatives arising from the Social Inclusion and Community Activation Programme, where appropriate.

3. Add quality to the places where Fingal's communities live, work and recreate by integrating high quality design into every aspect of the Plan promoting adaptable residential buildings and ensuring developments contribute to a positive sense of place and local distinctiveness of an area.

6. Consolidate development and protect the unique identities of the settlements of Howth, Sutton, Baldoyle, Portmarnock, Malahide, Donabate, Lusk, Rush and Skerries.

11. Protect, maintain and enhance the natural and built heritage of the County, particularly the coastal areas which are of such importance to residents of and visitors to the Dublin region.

17. Work with Irish Water to secure the timely provision of water supply and drainage infrastructure necessary to end polluting discharges to waterbodies, comply with existing licences and Irish and EU law, and facilitate the sustainable development of the County and the Region.

18. Secure the timely provision of infrastructure essential to the sustainable development of the County, in particular in areas of resource and waste management, energy supply, renewable energy generation and Information and Communications Technology.

20. Ensure new developments have regard to the requirements of the Planning System and Flood Risk Management Guidelines.

22. Minimise the County's contribution to climate change, and adapt to the effects of climate change, with particular reference to the areas of land use, energy, transport, water resources, flooding, waste management and biodiversity, and maximising the provision of green infrastructure including the provision of trees and soft landscaping solutions.

23. Promote and maximise the benefits of quality of life, public health and biodiversity arising from implementation of policies promoting climate change adaptation and mitigation.

24. Encourage innovation and facilitate the development of pilot schemes that support climate change mitigation and adaptation.

25. Prepare a Sustainable Energy Strategy for the County in consultation with relevant stakeholders and interest groups setting out strategies, policies and actions to facilitate a reduction in greenhouse gas emissions and the harvesting of renewable energy resources most appropriate to the County.

The Plan is underpinned by the principles of sustainable development, climate change adaptation, social inclusion and high-quality design. Although this study will not go into detail regarding each one of these subjects, several key environmental challenges that were identified in the Plan for Fingal are outlined below:

- Protecting the ecological integrity of Natura 2000 European sites, the Special Amenity Areas and the Dublin Bay Biosphere Reserve, while allowing for ongoing growth and development.
- Management of the coastline including the management of flood risk and dune conservation measures will be increasingly important in response to the impacts of predicted climate change and increased population pressure.
- Maintenance and improvement of the environmental and ecological quality of Fingal's watercourses and coastal waters pursuant to the requirements of the Water Framework Directive.
- Management of flood risk along the County's watercourses taking account of climate change predictions.
- Management of the County's varied landscapes so that change maintains and enhances landscapes of high-quality and improves landscapes.

The Development Strategy for Portrane is to protect and retain the distinctive village character of Portrane and protect and enhance existing natural amenities and built heritage. Strengthen the urban form of the village and improve local service facilities. Ensure Burrow Beach is protected from inappropriate development including the need to ensure any development takes full account of Climate Change Adaptation. The proposed development plan objectives for Portrane relevant to this study are:

- Objective Portrane 5: Ensure the sensitive coastal estuarine area of the Burrow is adequately protected and that any proposed development is subject to environmental assessment including Screening for AA.
- Objective Portrane 6: Prepare a study to decide on the optimal future development of lands in the Burrow area, having regard to the local issues of coastal erosion, flooding, drainage and the significant landscape and biodiversity sensitivities in the area including a Flora Protection Order, SPA, NHA, SAC and designated Ecological Buffer Zone.

- Objective Portrane 7: The replacement of chalets/holiday huts by permanent dwellings, which can be resided in on an all year basis within 'High Amenity' zoned land at the Burrow, will be considered in the context of verifiable documentary evidence indicating the unit is occupied on a year round basis and has been for a period of 7 years or more, flood risk, site size, EPA standards for waste water disposal, access, impact on Habitats Directive Annex I Habitats including the priority habitats fixed dune and protected species, and other appropriate standards.

The Plan recognises that coastal erosion is intrinsically linked with coastal flooding as the loss of natural coastal defences such as sand dunes due to erosion can increase the risk of flooding in coastal areas. In respect to coastal flooding, some objectives relevant to this study are:

- Objective SW01: Protect and enhance the County's floodplains, wetlands and coastal areas subject to flooding as vital green infrastructure which provides space for storage and conveyance of floodwater, enabling flood risk to be more effectively managed and reducing the need to provide flood defences in the future and ensure that development does not impact on important wetland sites within river / stream catchments.
- Objective SW02: Allow no new development within floodplains other than development which satisfies the justification test, as outlined in the Planning System and Flood Risk Management Guidelines 2009 for Planning Authorities.
- Objective SW03: Identify existing surface water drainage systems vulnerable to flooding and develop proposals to alleviate flooding in the areas served by these systems.
- Objective SW04: Require the use of sustainable drainage systems to minimise and limit the extent of hard surfacing and paving and require the use of sustainable drainage techniques where appropriate, for new development or for extensions to existing developments, in order to reduce the potential impact of existing and predicted flooding risks.
- Objective SW05: Discourage the use of hard non-porous surfacing and pavements within the boundaries of rural housing sites.
- Objective SW06: Encourage the use of Green Roofs particularly on apartment, commercial, leisure and educational buildings.
- Objective SW07: Implement the Planning System and Flood Risk Management-Guidelines for Planning Authorities or any updated version of these guidelines. A site-

specific Flood Risk Assessment to an appropriate level of detail, addressing all potential sources of flood risk, is required for lands identified in the SFRA, located in many areas (including Portrane).

- Objective SW10: Require the provision of regional stormwater control facilities for all Local Area Plan lands and Strategic Development Zones with a view to incorporating these control facilities in currently developed catchments prone to flooding.
- Objective SW11: Ensure that where flood protection or alleviation works take place that the natural and cultural heritage of rivers, streams and watercourses are protected and enhanced to the greatest extent possible.
- Objective SW12: Require an environmental assessment of all proposed flood protection or alleviation works.

Specific objectives related to biodiversity and natural heritage presented in the Plan that are relevant for the conservation of Rogerstown Estuary and Portrane peninsula are exposed below:

- Objective NH09: Support the National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, in the maintenance and, as appropriate, the achievement of favourable conservation status for the habitats and species in Fingal to which the Habitats Directive applies.
- Objective NH10: Ensure that the Council takes full account of the requirements of the Habitats and Birds Directives, as they apply both within and without European Sites in the performance of its functions.
- Objective NH11: Ensure that the Council, in the performance of its functions, takes full account of the objectives and management practices proposed in any management or related plans for European Sites in and adjacent to Fingal published by the Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs.
- Objective NH16: Protect the ecological integrity of proposed Natural Heritage Areas (pNHAs), NHAs, Statutory Nature Reserves, Refuges for Fauna, and Habitat Directive Annex I sites.
- Objective NH17: Ensure that development does not have a significant adverse impact on pNHAs, NHAs, Statutory Nature Reserves, Refuges for Fauna, Habitat Directive Annex I sites and Annex II species contained therein, and on rare and threatened species including those protected by law and their habitats.

- Objective NH33: Ensure the preservation of the uniqueness of a landscape character type by having regard to the character, value and sensitivity of a landscape when determining a planning application.
- Objective NH35: Resist development such as houses, forestry, masts, extractive operations, landfills, caravan parks and large agricultural/horticulture units which would interfere with the character of highly sensitive areas or with a view or prospect of special amenity value, which it is necessary to preserve.
- Objective NH36: Ensure that new development does not impinge in any significant way on the character, integrity and distinctiveness of highly sensitive areas and does not detract from the scenic value of the area.

The Plan highlights the importance of Fingal's coastal zone due to its environmental and cultural heritage aspects. As stated in the Plan, the coast is an ever-changing dynamic environment, subject to the continuous natural process of erosion and deposition. It also stresses that erosion rates might be intensified due to sea level rise as a consequence of climate change. It states that defending long stretches of soft shoreline from erosion and coastal flooding may become technically and economically unsustainable in the future as a result of climate change conditions. The Plan presents several specific objectives related to coastal protection. These are:

- Objective NH53: Ensure the County's natural coastal defences, such as beaches, sand dunes, salt marshes and estuary lands, are protected and are not compromised by inappropriate works or development.
- Objective NH54: Where coastal erosion is considered a threat to existing properties, explore the technical and economic feasibility of coastal adaptation and coastal retreat management options.
- Objective NH55: Employ soft engineering techniques as an alternative to hard coastal defence works, wherever possible.
- Objective NH56: Identify, prioritise and implement necessary coastal protection works subject to the availability of resources, whilst ensuring a high level of protection for natural habitats and features, and ensure due regard is paid to visual and other environmental considerations in the design of any such coastal protection works.

- Objective NH57: Undertake erosion risk management studies for high risk areas so that the long-term erosion risks to property can be clearly identified long before the risk may be expected to occur.
- Objective NH58: Develop a coastal erosion policy for Fingal based on best international practice to outline how the Council will deal with existing properties at risk of erosion and how future coastal erosion problems will be managed having regard to national climate change legislation, mitigation and adaptation policies, and the need to protect the environment.
- Objective NH59: Protect the special character of the coast by preventing inappropriate development along the coast, particularly on the seaward side of coastal roads. New development for which a coastal location is required shall, wherever possible, be accommodated within existing developed areas.
- Objective NH60: Strictly control the nature and pattern of development within coastal areas and ensure that it is designed and landscaped to the highest standards, and sited appropriately so as not to detract from the visual amenity of the area. Development shall be prohibited where the development poses a significant or potential threat to coastal habitats or features, and/or where the development is likely to result in altered patterns of erosion or deposition elsewhere along the coast.
- Objective NH61: Prohibit development along the coast outside existing urban areas where such development could not be adequately safeguarded over the lifetime of the development without the need to construct additional coastal defences.
- Objective NH62: Establish, within one year of the making of this Development Plan, a coastal monitoring programme to provide information on coastal erosion on an ongoing basis.

The plan states that new developments in coastal areas will only be permitted where the Council is satisfied that the development will not add to the requirement, if any, for any coastal defence works in the area over the lifetime of the development and where that the likelihood of coastal erosion over the lifetime of the development is minimal.

The thematic maps develop by this Plan are available on:
http://fingalcoco.maps.arcgis.com/apps/webappviewer/index.html?id=cdba99d434874d8697b7451ea25bdba1

For further information consult:

FCC / Fingal County Council. 2017. Fingal Development Plan 2017-2023. Written Statement. 502p. Available on: https://www.fingal.ie/sites/default/files/2019-03/Fingal%20Development%20Plan%202017-2023%20-%20Written%20Statement_compressed_compressed.pdf

5.2. Fingal County Council Beach & Foreshore Bye-Laws, 2006

In exercise of the powers conferred by Part VII of the Local Government Act, 1994 FCC passed the Fingal County Council Beach & Foreshore Bye-Laws in 2006 in order to regulate a variety of issues concerned to beach management. For the purposes of the bye-laws FCC defined foreshore as "*the seabed and shore below the line of high water of ordinary or medium tides of the sea (shown HWM on Ordnance Survey Map), and extending for a distance of 200 metres seaward from the low water mark or 400 metres seaward of the HWM mark whichever is the lesser, and every tidal river and tidal estuary and every channel, creek and bed of the sea or any such river or estuary and shall include any and all properties of the Council*" (FCC, 2006).

For the purpose of these bye-laws, a beach includes:

i. any strand, and/or dunes;
ii. any sea for a distance from the strand to 200 metres (seaward) from the low water mark;
iii. any walls, railings, barriers, fence, roadway, seats, footpath, ramps alleyways, access, walkways, step, sewer, drain or gully thereon;
iv. any post, sign, notice, sign board, life saving apparatus or equipment, toilet, litter receptacle, lamp, lamp post, appliance, flag pole, flag, water pipe, gas pipe, hut, shelter, ornament, building or other structure forming part thereof or erected by the Council or by the authority of the Council either on the beach or for the benefit of users on the beach;
v. Any tree, shrub, bush hedge, flower, flower bed, turf, grass or other plant growing thereon or place thereon by the authority of the Council;
vi. Any implement, barrow, article, tractor, trailer or thing thereon belonging to the Council or placed thereon by the authority of the Council.

These bye-laws provide control for: Nuisance (includes for example litter, graffiti, games, golf, noise, fires, motor vehicles); Dune damage; Dogs; Horses; Trading and Advertising;

Obstruction; Alcoholic Beverages; Controlled Drugs; Caravans; Filming; Sports Training; Fishing; and Surfing/Sailing/Jet-skis and Fast Power Boats. Any person who infringes these bye-laws are considered guilty of an offence and should be liable on summary conviction to a fine.

The strict control of vehicles on beaches, dunes and salt-marshes and the prohibition of damages to the dunes, are particularly important clauses aimed at preventing damage to coastal systems. In relation to dune systems, the bye-laws clearly state that "*no person shall wilfully cause damage to the dune system on any beach or foreshore and should take due care when walking/sitting in the dune areas*" (FCC, 2006). While many of the stipulations in the statutes aim to prevent damage to coastal systems, these only produce indirect results for climate change adaptation and/or mitigation and do not provide solutions to the problem of coastal erosion and flooding.

For further information consult:

FCC / Fingal County Council. 2006. Fingal County Council Beach & Foreshore Bye-Laws 2006. Available on: https://www.fingal.ie/sites/default/files/2019-04/beach_and_foreshore_byelaws_2006.pdf

5.3. Beach Management Plan for the Burrow, Portrane (2007)

Fingal County Council (FCC), with support from the Heritage Council, commissioned a consultative process with the objective of producing a beach management plan for Burrow Beach, in summer/autumn 2006. The objective of the Beach Management Plan for Burrow Beach Beach (FCC, 2007) was to provide direction for FCC and the local community to implement effective beach and dune management practices for Burrow Beach in order to ensure the preservation of these areas, maintenance of natural biodiversity and preservation of the character of the beach while allowing for recreational use and enjoyment by present and future generations. The publication is an action plan based on partnership, setting out a range of practical and achievable actions in the short, medium, and long term.

Consultation with stakeholders was emphasised in the development of the planning process in order to ensure wide participation. So, a number of consultation methods were included in the plan preparation process, such as meetings with key stakeholders, an opinion survey, and an open public meeting. These consultation methods served to inform the plan with the local

knowledge and experience from stakeholders. The process also aimed to test the methods with a view to future replication of consultation-based beach management plans. The information collected was supplemented with documentary research and additional telephone and email correspondence with interested parties.

The consultation revealed that Burrow Beach is characterised by a high level of regard and support by loyal users and local residents. A considerable local pride was observed in the area and a strong community spirit has driven local activity such as beach clean-ups, and local representation and involvement. Appropriate preservation of the function and stability of the dune system and the maintenance of the natural biodiversity of beach and dune systems was a common theme throughout the consultation process. Four main issues were raised throughout the consultation period, these included:

- The environment, including ecology, flora and fauna and erosion;
- Amenities and Access, including such areas as local facilities, information, tourism and the boardwalk.
- Local quality of life, including such elements as litter and waste, recreational uses of the beach and behaviour and safety;
- Improved public awareness, including signage, designations and planning;

As a result, four main outcomes for implementing effective beach management practices have been identified:

Outcome 1: Physical environment conservation measures. This outcome had two objectives: 1) To preserve, protect and where necessary restore the dune systems of Burrow Beach whilst providing for community use and enjoyment. 2) To protect and conserve biodiversity on Burrow Beach and dune systems through appropriate environmental management. This outcome contained 10 specific actions.

Outcome 2: Amenities and access. This outcome has as an objective to provide safe public access to the beach, while protecting the environmental values associated with the beach and dune systems, especially at the northern end of Burrow Beach. This outcome comprised 4 specific actions.

Outcome 3: Local quality of life. The objective of this outcome was to preserve the character of the area while allowing for recreational use by both the local community and tourists. This outcome included 3 specific actions.

Outcome 4: Improved public awareness including designations and planning. The main objective of this outcome was to develop and promote public information and education programs on beach and dune conservation and preservation issues. This outcome contained 6 specific actions.

Some of the main actions proposed by the planning process were creating a boardwalk, fencing off parts of the dunes, information signage at strategic locations along the beach, closing off the access gate at the northern end of the peninsula to prevent vehicle access, among others.

For further information consult:

FCC / Fingal County Council. 2007. Development of a Beach Management Plan for the Burrow, Portrane, Co. Dublin - An Action of the Fingal Heritage Plan, 2005-2010. Available on:http://www.fingalbiodiversity.ie/resources/fingal_coast/2007%20Beach%20Manage%20Portrane.pdf

5.4. Coastal Liaison Group (2016)

In 2016, FCC established the Fingal Coastal Liaison Group aiming to respond to the ongoing concerns in relation to coastal erosion and flooding; to form coherent structured response to address these issues and to improve communication between stakeholders; and to provide a forum for discussion of approaches to planning for and dealing with the problems of coastal erosion and flooding (FCC, 2021).

The Coastal Liaison Group is made up of County Councillors, Council Officials, and community members from the three areas affected by these issues: Rush (North Beach and South Beach), Portrane, and Sutton. The group has the following purposes:

- "To discuss and as far as possible address any matters of concern to the communities living in Rush, Portrane and Sutton in relation to coastal erosion and coastal flooding in these areas.

- To review and make recommendations in relation to the management of coastal erosion and coastal flooding in Fingal.
- Facilitate broader community participation in coastal, and natural resource management through informing and liaising with member community groups.
- Foster opportunities for joint projects, information sharing and grant funding to address issues of concern in relation to coastal management.
- Provide best practice advice in accordance with the provisions of the Fingal Development Plan and other relevant policy documents in the context of integrated planning and management of the Fingal coastline.
- Incorporate the latest knowledge of climate change into coastal planning to assist the Council with the integration of adaptation strategies into planning policies.
- Review scientific advice and integrate this knowledge into the preparation and review of coastal management plans." (FCC, 2021).

For further information consult:

FCC / Fingal County Council. 2021. Fingal Coastal Liaison Group. Available on: https://www.fingal.ie/council/service/fingal-coastal-liaison-group

5.5. Fingal County Climate Change Action Plan (2019 - 2024)

The Fingal County Council Climate Change Action Plan 2019-2014 (FCC, 2019) was developed by the Dublin energy agency Codema on behalf of FCC, with the assistance and support of the Water and Environmental Services Strategic Policy Committee in accordance with guidance provided in the Local Authority Adaptation Strategy Development Guidelines (section 3.5). The Plan consisted of an extensive process of research, policy analysis, one-to-one meetings and workshops with staff and regional working groups.

The Plan aims to set out how FCC will improve energy efficiency and reduce greenhouse gases while making Fingal a more resilient region, with engaged and informed citizens (FCC, 2019). The four targets of the Plan are:

- A 33% improvement in the Council's energy efficiency by 2020;
- A 40% reduction in the Council's greenhouse gas emissions by 2030;

- To make Dublin a climate resilient region, by reducing the impacts of future climate change-related events;
- To actively engage and inform citizens on climate change.

In order to achieve these targets, this Plan sets out the current and future climate change impacts and greenhouse gas emission levels in the County, through the development of mitigation and adaptation baselines.

The mitigation baseline calculated the greenhouse gas emissions for the Council's own activities and also for the entire Fingal County (including a breakdown of the residential, transport and commercial sectors). It found that FCC produced 12,620 tonnes of CO_2 in 2017 and has reduced its emissions by 19% in the last 10 years. In addition, the Council has improved its energy efficiency by 30.3% and is currently on track to meet its energy efficiency target (FCC, 2019).

The adaptation baseline recognised that the effects of climate change are already impacting the area at a significant rate and are very likely to increase in frequency and intensity (FCC, 2019). Fingal has experienced extreme temperatures, as witnessed recently in 2018, with Met Éireann issuing its first ever Status Red warning for snow in February, followed by one of the hottest summers on record during June and July. The number of days with heavy rainfall has increased, and the amount of extreme flooding events in the County has risen in the last 10 years. Sea level appears to be rising faster than initially forecasted and has risen by twice the global average in the last 20 years. Hereafter, the adaptation baseline information in regard to sea level rise and flooding (the issues most relevant to this report) will be further explored.

Regarding sea level rise, the adaptation baseline identified impacts in five areas:

Critical Infrastructure and the Built Environment: Increases in sea levels and wave overtopping, along with increased occurrence of coastal storms, will put the built environment at risk. This will include residential housing and critical infrastructure, which are typically built along the coast.

Transport: Projected rises in sea level, wave heights and occurrence of coastal storms will put transport services (such as roads and the DART) that are along the coast and close to tidal rivers at increased risk.

Biodiversity: Rising sea levels, wave heights and occurrence of coastal storms will greatly affect coastal habitats, with estuaries and wetlands being particularly at risk.

Waste Management: Increases in sea levels and tides will put pressure on sanitation systems, (which are typically situated at low levels) located close to the coast.

Water Resources: Rising sea levels, wave heights and tides put water supply and aquifers at risk. Therefore, sea level rise will need to be constantly managed to avoid flooding.

The Plan recommends adaptation actions to be implemented by the LA in order to reduce and address the current and future effects of sea level rise, these include:

- Approaches that reduce coastal flooding and erosion through the addition of artificial sediments, dune rehabilitation and restoration;
- Grey solutions, which include infrastructure such as seawalls that protect nearby infrastructure from coastal flooding and sea level rise. Infrastructure for adaptation is designed to best available information and data, and takes into consideration current and projected flood levels;
- Restoration of wetland ecosystems along the coast, in order to provide natural protection against flooding and erosion;
- Policy and planning regulatory measures including the control and management of new developments in areas at risk. Implementing the OPW Flood Risk Guidelines and recommendations of the OPW flood risk studies, such as the Fingal East Meath Flood Risk Assessment and Management Studies (FEM-FRAMS) and CFRAMs.

Regarding flooding, the adaptation baseline identified impacts in the following five areas:

Critical Infrastructure and the Built Environment: Coastal, fluvial and pluvial flooding will put additional stress and risk on the built environment. This additional risk will cause all areas in the built environment to suffer (businesses, residential, critical infrastructure, etc.).

Transport: Increases in coastal, fluvial and pluvial flooding will cause road damage, which can lead to disruptions to all transport services.

Biodiversity: Increasing extreme flood events can cause loss of habitats and damage to ecosystems.

Waste Management: Flooding of landfill sites increases the risk of surface and groundwater contamination.

Water Resources: Increases in flooding incidents put more pressure on water systems, which are typically located at the lowest elevation possible and are therefore at a greater risk of flooding.

The Plan recommends the following adaptation actions with the purpose of tackling both current and future risks from flooding:

- Economic: Ensure that expenditure for flood risk management is based on cost benefit analysis;
- Social: Reduce risk to life and health, while protecting key infrastructure and ensuring that there is no increased risk to other areas;
- Environmental and heritage: Protect, and enhance, if possible, biodiversity and cultural heritage.

The Plan states that Fingal has maintained flood resilience through the use of spatial planning and infrastructure projects with a preference given to nature-based solutions. Some of these flooding adaptive measures include:

- Community and business flood resilience measures: such as flood forecasting and monitoring systems to forecast coastal surges.
- Site-specific measures: this may involve using existing natural landscapes or existing infrastructure to reduce flooding. Examples of this are raised property floor levels and limited development in the area.
- Generic measures: such as Sustainable urban Drainage Systems, which is mandatory for all new developments. If this cannot be provided for at the site, then there must be alternative means of reducing run-off. To reduce flood risks in new developments, the Greater Dublin Strategic Drainage Study states that no new development is permitted within 10-15 metres on either side of watercourses, planning applications must include a surcharge risk assessment and drainage systems must be isolated from basements.
- Flood management: the use of The Planning System and Flood Risk Management Guidelines from the OPW, as a measure for flood management and adaptation. These

guidelines are to be properly implemented and included in any development, planning and flood mitigation/adaptation measures.

After examining the current situation of Fingal's emissions, vulnerabilities to climate change related risks and likely future impacts, the Plan formulated actions to reduce the source and effects of these impacts. The actions have been organised into five key areas:

- Energy and Buildings. This includes 35 actions, mainly: Public lighting upgrades; Building retrofits with energy performance guarantees; Energy master-planning for the Dublin region.
- Transport. This topic includes 26 actions, which stand out: Better integration of transportation and land use planning; Developing public transport routes; Creating pedestrian friendly streets; Increasing public bikes facilities and a modal shift to active travel and commuting.
- Flood Resilience. This topic includes 26 actions, mainly considering: Flood resilient urban design; Cross-boundary flood management; Developing flood warning systems; Develop a coastal monitoring programme to measure coastal erosion along the Fingal coast; Protect and conserve floodplains, wetlands and coastal areas subject to flooding through available policy instruments.
- Nature-Based Solutions. This topic includes 19 actions, standing out: Protecting native species; Map habitats and species at risk of climate change and develop a monitoring programme; Maintaining public parks; Developing greenways and a green infrastructure strategy that incorporates climate change mitigation and adaptation to increase climate resilience.
- Resource Management. This topic includes 27 actions, such as: Implement waste awareness initiatives with staff and the public; Support marine litter clean-up activities; Support of local community groups; Campaigns to reduce food waste.

The action F13 on Flood Resilience "Develop and implement Coastal Protection Plan for Portrane" stands out for this report. The plan highlights Portrane as a case study and declares that FCC is considering several options to defend the coast at Portrane and Rush, such as groynes associated with beach supplementation, seawalls, or even considering managed retreat (FCC, 2019).

The Council is committed to encourage citizens to act on climate change through a range of awareness and behavioural change actions. FCC aims to actively inform and engage the public, through a range of innovative programmes and partnerships and facilitating bottom-up, community-led solutions.

This Plan should be implemented by FCC and regularly monitored and updated by the Climate Action Team established by the Council. It should count with the support of the Interdepartmental Steering Group representative of all Council Departments. They will be assisted by the Dublin Metropolitan CARO, ensuring that the overall plan is fully updated every five years to reflect latest policy, technology and climate-related impacts.

Finally, it is important to highlight that this document was prepared in accordance with the requirements of the Planning and Development (SEA) Regulations 2004 and the Habitats Directive 92/43/EEC. The Plan was screened to determine whether it has any significant impact on any Natura 2000 site. This screening determined that Stage 2 AA was required. The SEA and AA process, carried out in tandem with the preparation of the Plan, have ensured full integration and consideration of environmental issues throughout the action plan preparation process. Through these assessment processes, a number of the actions have been recommended for mitigation and incorporated into this Plan. The SEA Environmental Report and Screening Statement in support of the AA and Natura Impact Report were published as separate documents.

For further information consult:

FCC / Fingal County Council. 2019. Fingal County Council Climate Change Action Plan 2019-2024. Available on: https://www.fingal.ie/sites/default/files/2019-08/20190812_fcc_climate_change_action_plan_final_0.pdf


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Coláiste na hOllscoile Corcaigh
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EU Funds:
Ireland Wales
Programme
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Cláir Chisti Iorpacha Struchtúrtha
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2014-2020
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