

# Moray Coastal Change Adaptation Plan

**Cullen to Muckle Hythe Coast**

**Final Report**

**September 2023**

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## Contract

This report describes work commissioned by Will Burnish on behalf of Moray Council by a letter dated 9 August 2022. Moray Council’s representative for the contract was Will Burnish. Doug Pender, Angus Pettit, Jenny Shadrick and Katie Corbett of JBA Consulting carried out this work.

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## Purpose

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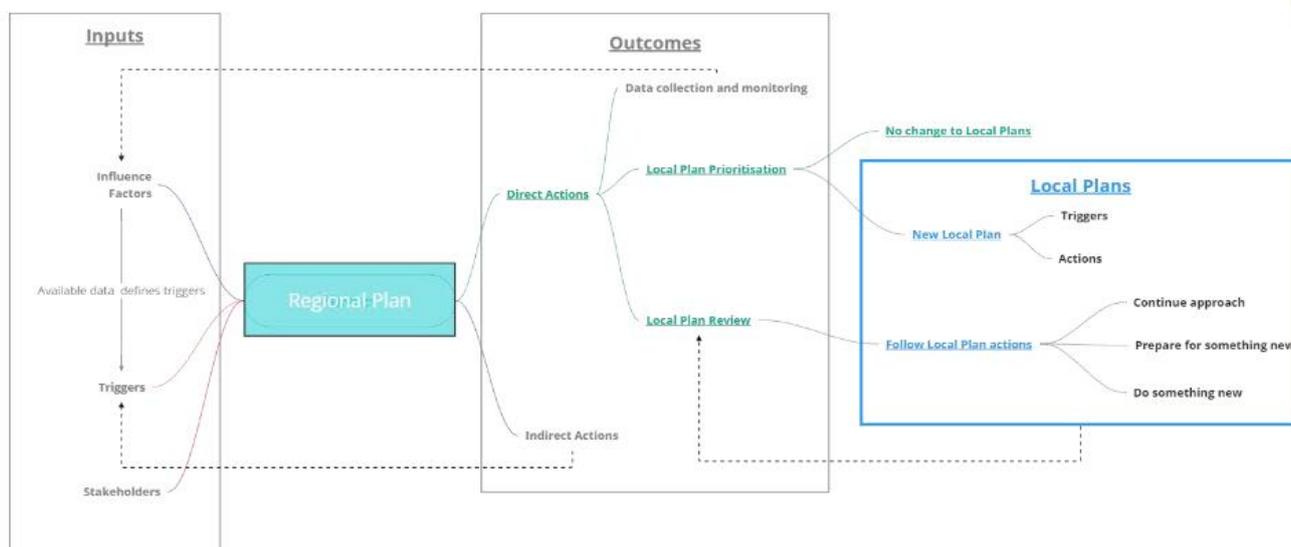
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## Executive summary

The report documents the Coastal Change Adaptation Plan (CCAP) for the Cullen to Muckle Hythe Coast Community Area (CA) in Moray. It forms one of the eleven Local Plans, for the Moray Council region.

It aligns with the wider Regional Plan<sup>1</sup> and forms the highest level of detail of the overall Coastal Change Adaptation Planning process adopted by Moray Council.



The CCAP provides an overview of the coastal flood and erosion risks on the Cullen to Muckle Hythe Coast, which are used to underpin development of possible Adaptation Pathways for this community. These are presented, along with an Adaptation Framework to support proactive coastal risk management, enable implementation of climate change adaptation actions and link with climate resilient development planning along Moray’s coast.

The Plan has been developed using available datasets from Moray Council, SEPA and the Dynamic Coast Project. It aims to directly support statutory and non-statutory Moray Council policies, plans and strategies and aligns with key coastal climate change adaptation guidance and resources within and beyond Moray Council.

This Plan documents the Phase 0 starting point of adaptation, meaning that no definitive preferred Adaptation Pathway and associated Action Plan have been developed. Rather this Plan sets out an Adaptation Framework and process for Moray Council to implement to effectively plan and support sustainable adaptation.

To develop Adaptation Pathways, the coast of the CA was classified into Coastal Management Units (CMUs) defined by 1) classification of coastal landform type, and 2) classification of risk associated with coastal flooding and erosion. A total of six CMUs were identified, and six associated Adaptation Pathways were developed for each CMU.

<sup>1</sup> Moray Coastal Change Adaptation Plan: Regional Plan - IRR-JBAU-XX-XX-RP-MO-0001-S4-P03-Regional\_Plan



The Adaptation Framework is to be delivered through the defined Implementation Plan by defining Triggers and setting associated Actions against these. A single Implementation Plan is applied to the entire CA, where the outcome of the process determines what direction will be followed within the Adaptation Pathway. The Implementation Plan has three key stages:

- 1) Monitoring and Triggers
- 2) Actions
- 3) Outcomes

Trigger points are identified and set following a risk-based approach and will be identified through repeat monitoring of available data that informs coastal flood and erosion risk.

Realisation of Triggers signal a need for review or change of the Adaptation Pathway. Actions bridge the gap between Triggers and Outcomes and define what processes need to be implemented before an appropriate Outcome is identified. Adaptation interventions are potential measures that can be applied. There are four possible categories:

- 1) No intervention
- 2) Enhance natural features
- 3) Protect
- 4) Create Space

A set of Phase 0 Actions have been identified, that require immediate attention because of Triggers being met in this iteration of the Cullen to Muckle Hythe Coast CCAP. Furthermore, this initial stage of the adaptation planning process has identified several knowledge gaps and

opportunities for activities to be undertaken upfront to support coastal change adaptation at Cullen to Muckle Hythe Coast.

The current iteration of the Cullen to Muckle Hythe Coast CA CCAP is at Phase 0. Triggers met in Phase 0 and associated Actions for each CMU are summarised in the table below. These will be delivered during the first cycle.

Full details of the Phase 0 Actions are included in Appendix C and documented in Section 4.4.

CMU	Trigger	Action
1	Erosion buffer exceeded	Undertake assessment and plan for intervention
2	Erosion buffer exceeded	Undertake assessment and plan for intervention
3	No current Triggers	No current Actions
4	No current Triggers	No current Actions
5	Erosion buffer exceeded	Undertake assessment and plan for intervention
6	No current Triggers	No current Actions

As well as Triggers and Actions that correspond directly to the Adaptation Pathway and specified CMUs, Proactive Actions that support the whole of the Cullen to Muckle Hythe Coast are summarised below:

- 1) Develop modelling framework to support future assessments.
- 2) Establish coordinated and consistent beach monitoring plan for CMUs 1, 2, 3, 5.
- 3) Adaptation and resilience workshop with local community and stakeholders.
- 4) Identify landownership and safeguarding.

Again, these will be delivered during this first cycle.

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## Abbreviations

CCAP	Coastal Change Adaptation plan
CA	Community Area
CMU	Coastal Management Unit
DC	Dynamic Coast
mAOD	meters Above Ordinance Datum
MHWS	Mean High Water Spring
NFRA	National Flood Risk Assessment
NRP	Non-residential Property
RCP	Representative Concentration Pathways
RP	Residential Property
SEPA	Scottish Environment Protection Agency
SLR	Sea Level Rise

## Glossary

Accretion*	The build-up of sediment resulting in the seaward movement of the coast/ Mean High Water Springs.
Actions*	A plan or policy option that promotes an adaptive approach to coastal change that makes use of long term or resilient solutions such as preserving natural features.
Action Plan*	The proposed strategy or course of action to be taken depending on trigger point reached.
Adaptation*	The adjustment in economic, social or natural systems in response to actual or expected climate change, to limit harmful consequences and exploit beneficial opportunities.
Adaptation Pathways*	A flexible way of managing future uncertainty by planning for multiple scenarios without rigid timelines responding to the nature of future changes as they unfold.
Asset*	An item, such as a building, that is deemed to have an economic, social, or cultural value (or combination of).
Decision point*	A management action based on a trigger being reached.
Erosion*	The removal of sediment resulting in the landward movement of the coast (Mean High Water Springs)
Hard coast*	Coast that is comprised mainly of materials resistant to erosion such as hard rock types or artificial structures.
Implementation Plan	The framework developed in this first iteration, or Phase 0 of the Adaptation Pathway to support Moray Council in the development of Action Plans for each CMU.
Implementation Plan Actions	Actions that Moray Council will deliver in response to a Trigger being met and will determine the Outcome of the phase of the Adaptation pathway.
Outcomes	Outcomes of the Implementation Plan determines the current path of the Adaptation Pathway.
Soft coast*	A coast composed of unconsolidated sediments, which is not inherently resilient to erosion, but relies on the balance of natural processes to maintain its shape in response to storms and everyday processes.
Triggers*	Either a physical process or an enabler/inhibitor that when reached or a threshold crossed.

\*Term definitions from Scottish Government Coastal Change Adaptation Plan Guidance<sup>2</sup>

<sup>2</sup> Scottish Government (2023) Coastal Change Adaptation Plan Guidance – Interim [https://www.dynamiccoast.com/files/ccapg\\_2023feb.pdf](https://www.dynamiccoast.com/files/ccapg_2023feb.pdf)

# 1 Introduction

## 1.1 Coastal Change Adaption Planning in Moray

Our climate is changing and throughout history, our coast has responded to changes in sea level, storms, and other climate parameters. This means that the current position of Moray's coast is not fixed but is dynamic and will continue to evolve as our climate changes.

We can no longer use traditional, engineered, coastal risk management approaches in isolation to manage and protect society against risks associated with coastal change. Instead, we must, as a society, become more resilient and adapt to our changing coast. To enable this, we must be proactive in making combined coastal risk and land management decisions which provide long-term space for the coast to naturally respond to coastal climate change risks.

Developing and implementing an Adaptation Framework now to address how society responds to the current and future risks can help to reduce costs and negative impacts such as assets eroding into the sea or suffering repeat, frequent flooding. More positively, a proactive approach to adaptation and climate resilient development planning now can generate wider benefits and opportunities for coastal communities and the ecosystems which sustain and support them.

The Coastal Change Adaptation Plans (CCAPs) provide a key first step in this process; they are a practical mechanism to enable proactive engagement with and involvement of communities to co-develop a shared vision for long-term societal resilience to coastal climate change risk and impacts.

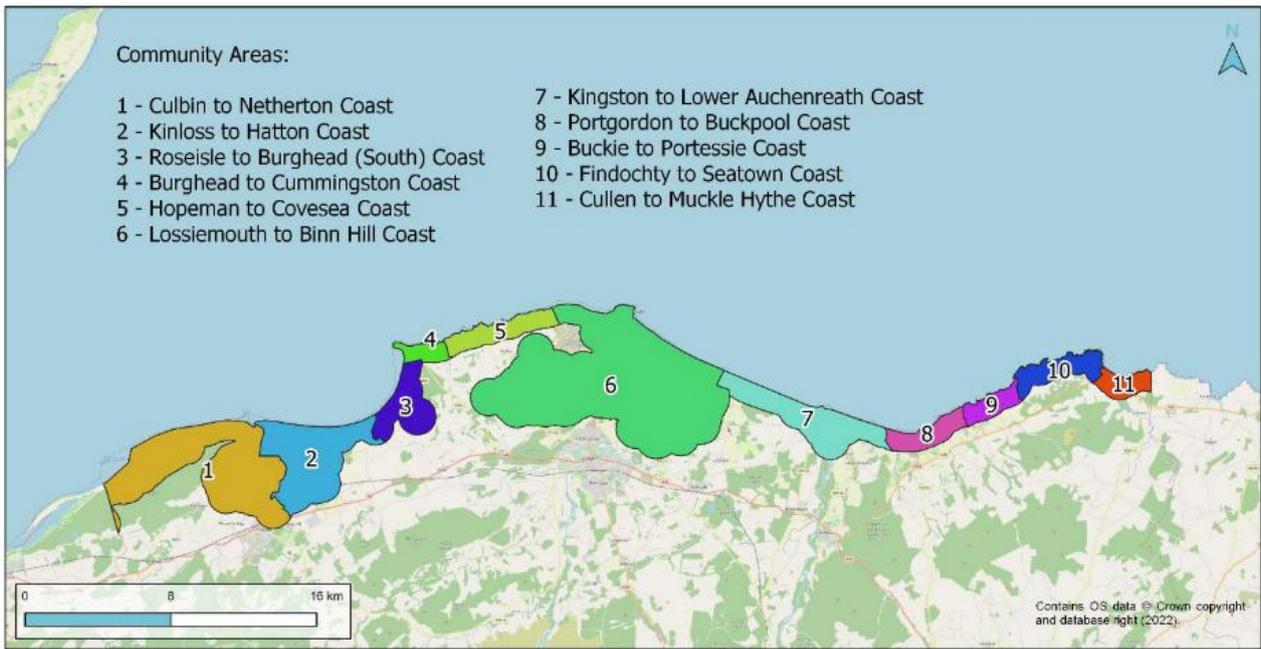
To support this adaptation journey in Moray the coast has been subdivided into Community Areas (CAs) (Figure 1-1). Cullen to Muckle Hythe Coast is one of the CAs with the highest priority for a local adaptation plan, due to the rapidly changing coast and risk of flooding, and as recognised in the Regional CCAP.

Most of the coast of the Cullen to Muckle Hythe Coast CA is made up of soft material susceptible to erosion. Dynamic Coast has projected almost 170 m of shoreline retreat could be realised by 2100 at the Cullen Links Golf Club. In addition, the community of Cullen could be at risk of wave overtopping, deterioration of coastal structures and from coastal flooding in the future.

This provides the justification for a more detailed, local, CCAP which is contained in this document.

The entire Coastal Change Adaptation Plan for Moray is contained within a series of documents, the following should be consulted alongside this CCAP to provide context on the overall process.

- IRR-JBAU-XX-XX-RP-MO-0001-S4-P03-Regional\_Plan
  - Provides the region wide plan and process to deliver coastal adaptation across Moray.
- IRR-JBAU-XX-XX-RP-MO-0007-S4-P03-Coastal\_Change\_Adaptation
  - Provides information on the concept of coastal change adaptation and how this has been applied to the Moray Coastal Change Adaption Plan.



**Figure 1-1: Extent and location of CAs within Moray.**

### 1.2 What is a Local CCAP?

A Local CCAP follows the same principle as the Regional CCAP but is assessed and developed at a finer level of detail for a specified CA. A local CCAP is developed where a CA has been identified as a high priority, based on risk, development, management and socio-economic Influence Factors (see Regional Plan for more details). It divides the coast of the CA into individual Coastal Management Units (CMUs) and presents Adaptation Pathways for each. See section 2.2 for more details on CMUs and CMU classification.

### 1.3 What are adaptation pathways?

Adaptation Pathways are flexible tools that can be used by local authorities, politicians, local businesses and residents to make current and future decisions across all involved sectors to accommodate coastal change and associated uncertainty.

As well as the traditional management, they should identify opportunities to work with natural processes, enhance the environment and include necessary supportive steps to create space (e.g., accommodate erosion through land safeguarding) in preparation for inevitable future sea level rise and associated increases in erosion and flooding.

### 1.4 What do adaptation pathways do?

Adaptation Pathways aim to identify climate resilient risk management and development pathways for each CMU; the phases in the pathways, provide flexibility for decisions at various points on the pathway to be modified dynamically through time.

Triggers are used in Adaptation Pathways to signal when the current management approach should be reviewed, and possibly changed, in response to updated information or change of circumstance .e., risk has increased.

### 1.5 What is the focus of the Local CCAP?

Adapting to coastal and climate change requires two parallel streams:

1. Land-based initiatives to **prevent** new future risk.
2. Management initiatives to **reduce** current and future risk.

The Local CCAP presented here focuses only on the management initiatives but, only by considering these in parallel with those land-based will result in a sustainable adaptation journey for Moray. This should identify both the need and practical steps required to safeguard land to support where areas of retreat may be considered in the future.

### 1.6 Where are we on the adaptation journey?

The aim of this first CCAP is to consolidate our understanding of the physical risks and how these interact with communities and their assets to identify the present day and future hazards of our changing coast for Cullen to Muckle Hythe Coast. It then identifies and promotes a process that, when implemented by Moray Council, will support community adaptation to coastal change.

The adaptation journey is a multiphase, multiyear process and aims to transition communities into a more sustainable and resilient future. We are currently at **Phase 0**, meaning that no definitive preferred Adaptation Pathway and associated Action Plan have been developed.

### 1.7 What is the Phase 0 Adaptation Framework?

The overall aim of the Adaptation Framework set out in this Local CCAPs is to:

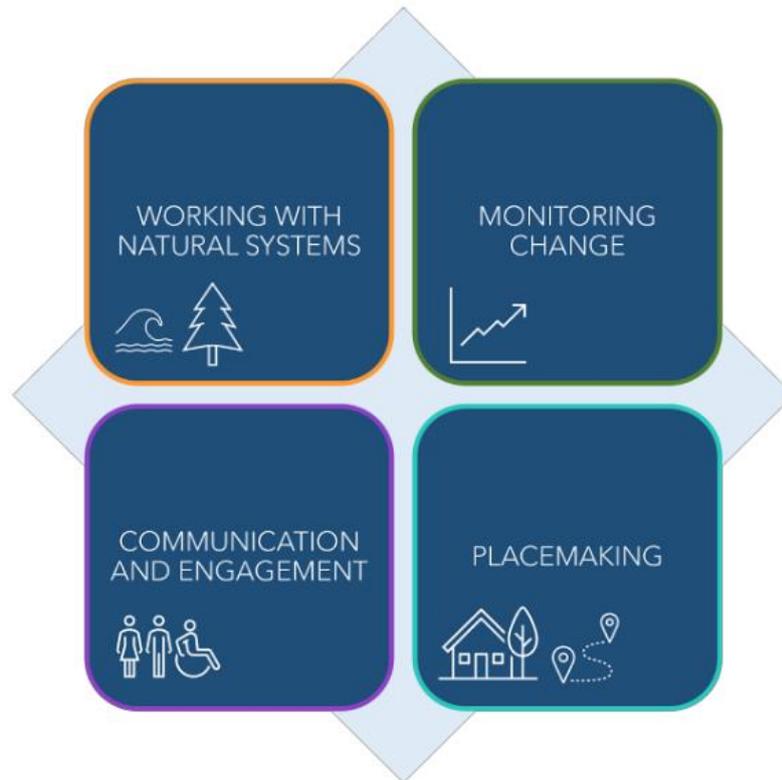
*Guide Moray Council towards development of detailed Adaptation Pathways and associated Action Plans for the Cullen to Muckle Hythe Coast CA.*

To achieve this goal the following objectives have been set for Phase 0:

- Identify and characterise local CMUs within the CA suitable for development future Adaptation Pathways.
- Present coastal flood and erosion risk for each CMU.
- Develop an Implementation Plan to be used by Moray Council to support adaptive decision making, future action planning and evaluation of adaptation options.
- Identify CA and CMU specific Triggers that will influence adaptation decision making.
- Identify and set Proactive Actions that will support delivery of the CCAP in each CMU.
- Inform and support the Local Development Plan<sup>3</sup> and Local Planning Policy. These should be implemented in parallel to avoid future risk by making space for change.

### 1.8 How has this Adaptation Framework been developed?

The approach to coastal change adaptation in Moray is presented in the Regional Plan which distils the Scottish Government guidance<sup>2</sup> into **four key pillars of adaptation** (Figure 1-2). Development and implementation of the CCAP Implementation Plan should align with these principles.



**Figure 1-2: Four pillars of coastal adaptation for Moray.**

### **1.9 How does the local CCAP link to the Regional CCAP?**

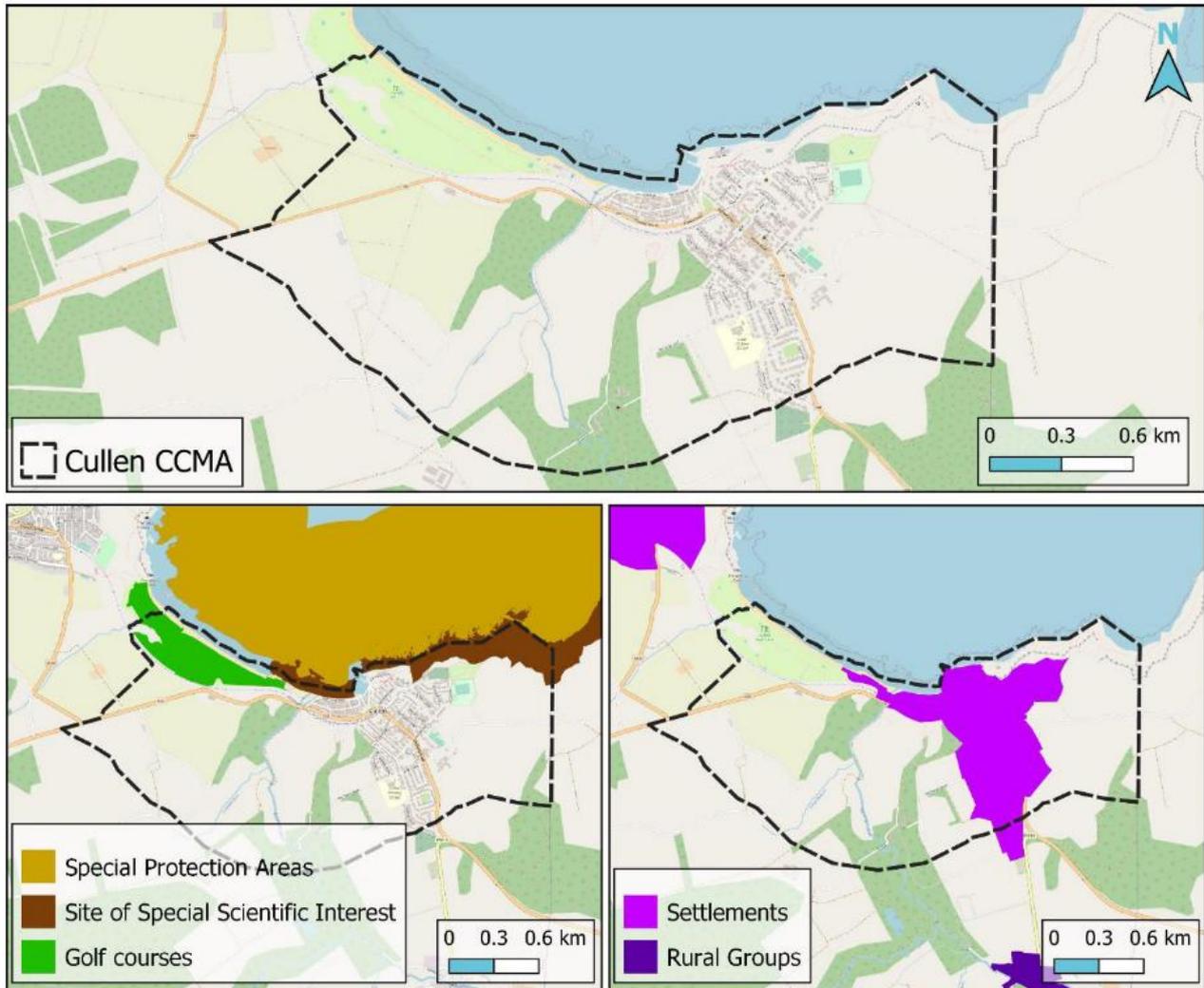
The Regional CCAP links to the Local CCAP in three key ways:

1. Defines the **prioritisation** of Local CCAP with risk, development, management, and socio-economic Influence Factors (see Regional Plan for more details).
2. Sets wide **Proactive Actions** that, when implemented, should be used to support Local CCAP Action Plans.
3. Provides the links between the **land-based** components of the Adaptation Planning process. This includes links with the LDP and delivery of necessary regional actions required to effectively support and plan for adaptation at a local level e.g., land safeguarding.

## 2 Plan Overview

### 2.1 Plan area and characteristics

The Cullen to Muckle Hythe Coast CA covers an area of approximately 3.6 km<sup>2</sup>, includes a range of coastal environments and land uses and is located east of the Buckie to Portessie Coast CA (Figure 2-1).



**Figure 2-1: Maps of Cullen to Muckle Hythe Coast CA showing settlements, greenspace, environment and special consideration areas.**

**Settlements:**

The CA has a population of 1,475 from 661 households<sup>3</sup>, with no rural groups.

**Greenspace and Environment:**

Most of the CA coast is a NatureScot designated Site of Special Scientific Interest (SSSI). The waters offshore of the CA coast are a NatureScot designated Special Protection Area (SPA). Cullen Links Golf Club is in the CA and provides valuable recreational and tourist amenity for the village and surrounding area.

**Habitats:**

There are three key habitats along the coastal extent of Cullen to Muckle Hythe Coast CA as identified by NatureScot (Figure 2-2). These include coastal vegetated shingle, unvegetated mobile shingle, unvegetated sandy shores, mobile dunes, and fixed dunes.



**Figure 2-2: Coastal habitats in Cullen to Muckle Hythe Coast as identified by NatureScot.**

**2.2 Coastal Management Units**

To facilitate the development of the Local CCAP, the coast of the CA is classified into Coastal Management Units (CMUs) defined by:

1. Classification of coast type.
  - a. Natural – beaches, cliffs, dunes, saltmarshes, etc.
  - b. Defended - formal engineered structures.
  - c. Hybrid – combination of a and b
2. Risk associated with coastal flooding and erosion.
  - a. Risk and Hazard  
Assets present in CMU, which are at risk of flooding/erosion hazard
  - b. Risk and unknown Hazard  
Assets present in CMU, no data on flood/erosion risk available
  - c. No Risk and Hazard  
No assets present in CMU, no flooding/erosion hazard
  - d. No risk and no Hazard  
No assets present in CMU, no flooding/erosion hazard

<sup>3</sup> Moray Council. 2020. Moray Local Development Plan. Volume 2: Settlement Statements: Cullen. [http://www.moray.gov.uk/moray\\_standard/page\\_133431.html](http://www.moray.gov.uk/moray_standard/page_133431.html)

Assets referred to in the risk classification include residential properties, key roads and infrastructure.

Following this, the Cullen to Muckle Hythe Coast CA coast has been subdivided into six CMUs (Figure 2-3). These are described below including a summary of the coastal change and flood risk. Full details of each CMU are provided in Appendix A.



**Figure 2-3: Cullen to Muckle Hythe Coast CA divided coastal extents.**

### 2.2.1 CMU 1: Beach West - natural

The coast is fronted by a natural sandy beach backed by vegetated dunes and grassland. Cullen Golf Club is adjacent to the coast at CMU 1. There is also a tall, vegetated rock outcrop in the west. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding.

Historic coastal retreat (from ca. 2011 to 2016) has been high (up to 2.6 m/yr), with Dynamic Coast future erosion rates projecting maximum shoreline retreat of ca. 170 m by 2100. This poses a risk to vegetated dunes and grassland, as well as the Cullen Links Golf Club course. There is no risk to infrastructure, residential properties, or non-residential properties.

### 2.2.2 CMU 2: Beach West - hybrid

The coast is fronted by a natural sandy beach. It is backed by a concrete wall across most of the unit. Rock armour spans approximately 50 m in length at the western side. At the eastern end of the CMU, at the Burn of Cullen confluence, there are no defences. Cullen Golf Club, a car park and one non-residential property are adjacent to the coast at CMU 2.

SEPA flood maps and NFRA datasets show flood water following the Burn of Cullen during the 1 in 200-year and 1 in 200-year plus climate change events. This results in very minor flooding to grassland either side of the A98 road and therefore the risk from coastal flooding is negligible.

Historic coast retreat (from ca. 2011 to 2016) has been high (up to 2.7 m/yr) with Dynamic Coast future erosion rates projecting maximum shoreline retreat of ca. 160 m by 2100. This would pose a risk to two non-residential properties, the footbridge over the Burn of Cullen, Cullen Links Golf Club's car park and access road, and the beach car park.

### **2.2.3 CMU 3: Beach West – built structures**

The coast is fronted by a sandy beach and backed by concrete stepped revetment and recurve sea wall. There are numerous properties and roads adjacent to the coast at CMU 3. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding to land and assets in this unit. At CMU 3, Dynamic Coast show median historic (from ca. 2011 to 2016) retreat rates of 0.6 m/yr and maximum of 1.1 m/yr, lower than the two CMUs to the west. There has also been some minor accretion in the east. Future erosion rates project a maximum shoreline retreat of ca. 45 m by 2100. This would pose a risk to a high number of assets including 32 non-residential properties, 203 residential properties and 250 m of Port Long Road. However, it should be made clear that the condition, residual life and subsequent deterioration of the structures are the critical control on any erosion risk to CMU3.

### **2.2.4 CMU 4: Cullen Harbour – built structures**

CMU 4 covers Cullen Harbour which is constructed from a mix of concrete and stone walls. It provides flood and erosion protection to properties and roads behind. Due to the built structures, there is no data available from Dynamic Coast. As a result, the hazard is unknown from coastal erosion in this unit, to the land and to assets. SEPA flood maps show there is currently no identified risk from flooding at CMU 4.

### **2.2.5 CMU 5: Beach East - hybrid**

The coast along CMU 5 is mostly natural and formed of shingle beaches and exposed rocky shore platforms. There is a carpark defended with rock revetment. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding.

Very little historic (from ca. 1964 to 2011) retreat has occurred here (maximum of 0.1 m/yr) Dynamic Coast estimates however, that erosion rates will increase in the future leading to maximum shoreline retreat of ca. 30 m by 2100. This poses a risk to a number of residential and non-residential properties; the car park; and the coastal path at the eastern end of Port Long Road.

### **2.2.6 CMU 6: Beach East - natural**

This stretch of coast is formed of natural shingle beaches and exposed rocky shore platforms. There are no key assets adjacent to the coast in CMU 6. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding to land and assets.

Historically (from ca. 1964 to 2011), while most of this CMU has experienced accretion (up to 0.34 m/yr), in the east there has been no change, whilst low historic retreat (0.1 m/yr) has occurred at one location in the centre of the western bay. Dynamic Coast estimates that erosion will occur across this CMU in the future leading to maximum shoreline retreat of ca. 26 m by 2100. Despite this future erosion, there are currently no built assets predicted to be at risk.

### 2.3 CMU categorisation for local adaption plan

Review of the characteristics and risk associated with each CMU led to the classifications summarised in Table 2-1. These were used to develop initial Adaptation Pathways, Triggers, and an associated Implementation Plan.

**Table 2-1: Cullen to Muckle Hythe Coast CMU categorisation for local adaptation plan**

CMU	Coastal Type Classification	Risk Classification
1	Natural	Risk and Hazard
2	Hybrid	Risk and Hazard
3	Built Structures	Risk and Hazard
4	Built Structures	Risk and unknown Hazard
5	Hybrid	Risk and Hazard
6	Natural	No risk and Hazard

### 3 Adaptation Pathways

Development of Adaptation Pathways for each CMU are based on the classification presented in (Table 2-1). This aims to provide a flexible approach to adaptation that works towards a defined and desirable end outcome for the CMU and CA.

Details of this outcome are however, not defined at this stage, and will ultimately be dependent on monitoring changes to the following factors:

- **Natural systems**
  - Habitat.
  - Greenspace.
- **Climate**
  - Climate change guidance.
  - SEPA flood maps or risk assessments.
  - Coastal flood occurrence.
  - Coastal erosion risk.
- **Risk exposure**
  - Change in defence condition.
  - Update to SEPA flood warning system.
  - Erosion risk buffer exceeded.
  - Flood risk threshold exceeded.
- **Socio-economics**
  - Changes of asset ownership.
  - Changes of land ownership.
  - Community pressures.
  - Tourism.

Adaptation Pathways for each CMU are presented in the following sections.

#### 3.1 CMU 1 and 6 Adaptation Pathways

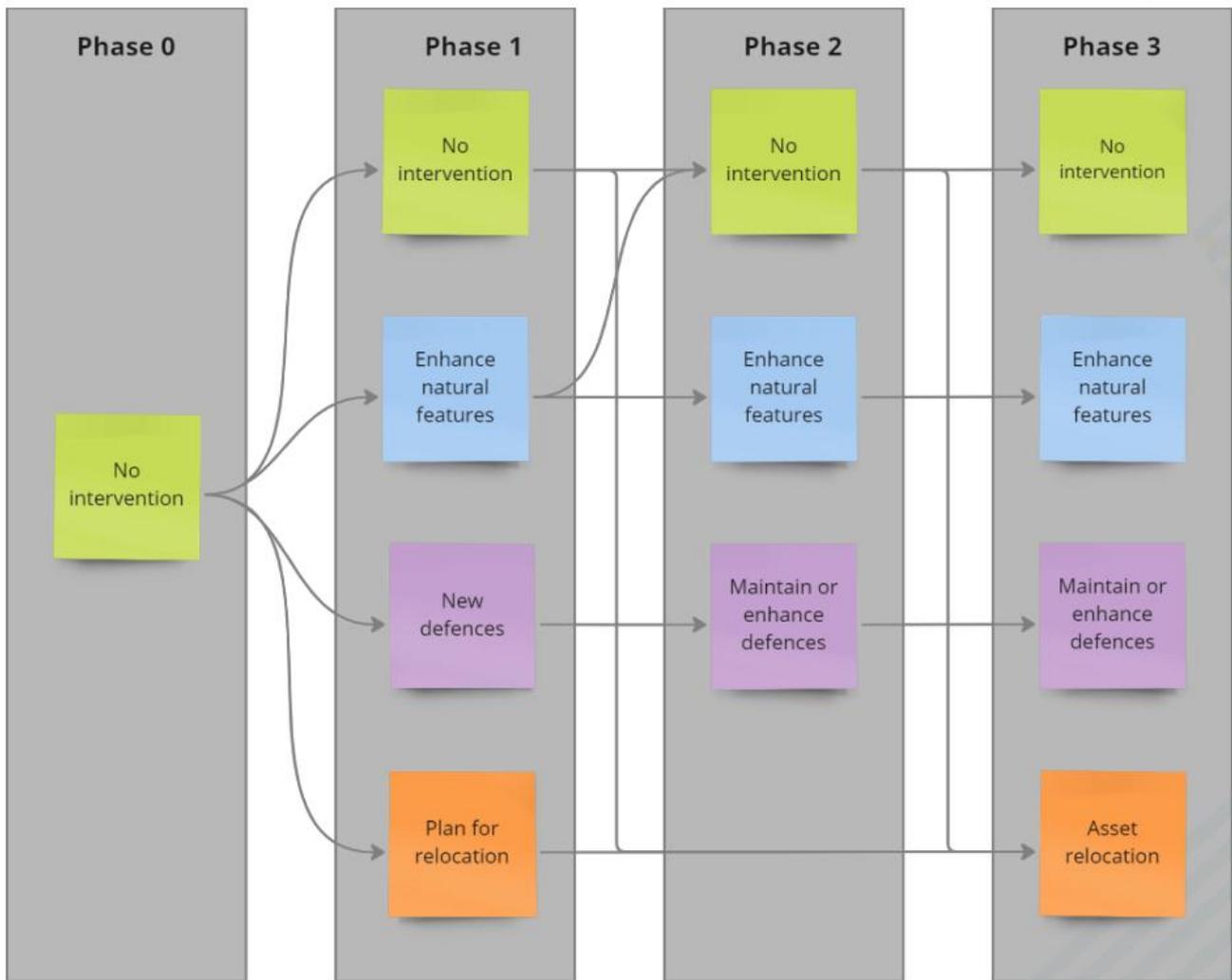
CMUs 1 and 6 have been assigned an adaptation pathway for natural coasts. There is risk of erosion at Cullen Golf Club at CMU 1, whereas there are no assets currently at risk at CMU 6 (Figure 3-1):

- **CMU 1 = Natural with risk and hazard**
- **CMU 6 = Natural with no risk and hazard**

Phase 0 of the adaptation pathway (1<sup>st</sup> column) is the current management approach/action being delivered by Moray Council in respect to these CMUs. Here this is **No Intervention**.

For the adaptation pathway to move to Phase 1 (2<sup>nd</sup> column containing potential coastal risk management actions) a pre-defined trigger must be realised. Then, depending on the outcome of any Implementation Plan Actions, this may or may not result in a change to the management approach adopted for the CMU.

Consultation of the CCAP Implementation Plan (Section 4.1) will guide the process and ultimately the pathway to adaptation.



**Figure 3-1: Adaptation Pathway for CMUs 1 and 6 (natural coast). Grey lines represent possible future pathways.**

### 3.2 CMU 2 and 5 Adaptation Pathways

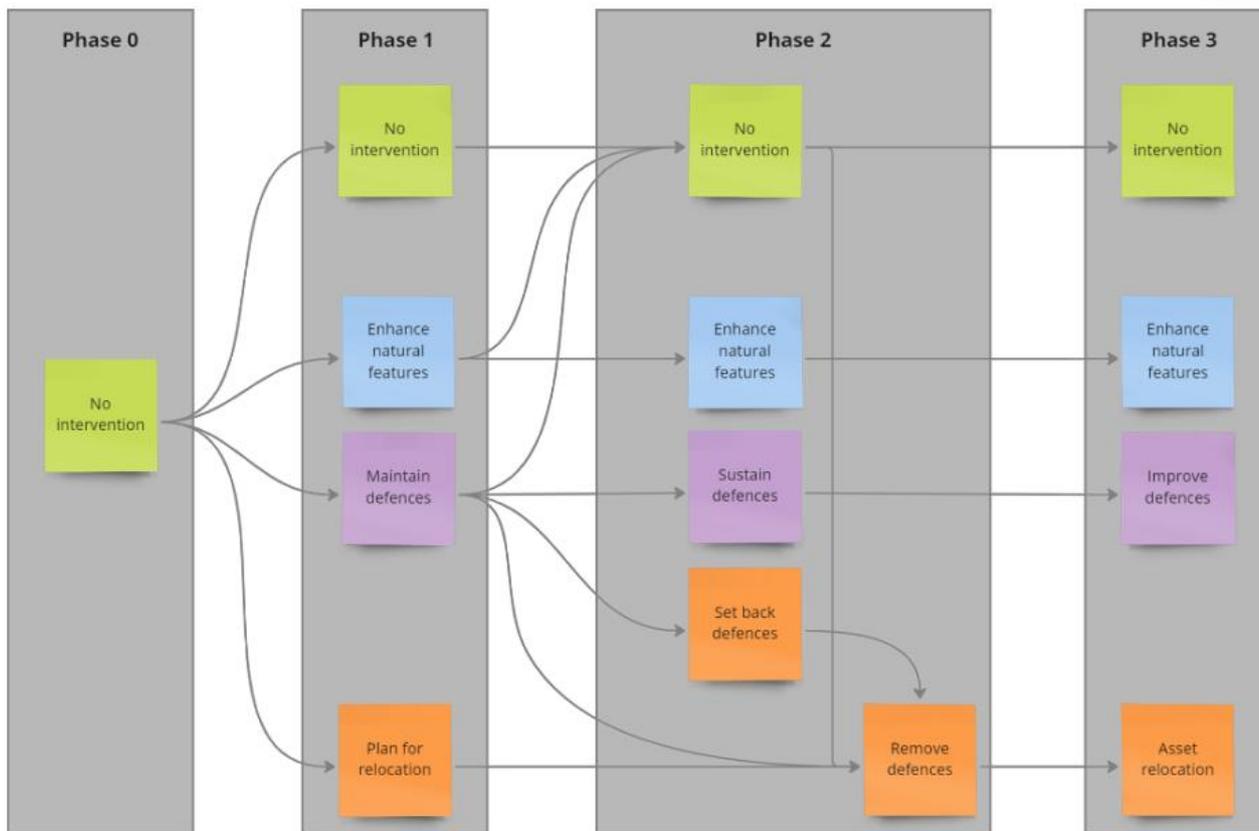
CMUs 2 and 5 are classified as hybrid coast with risk (Figure 3-2). CMU 2 has a small natural section in the east of the unit, however it is mostly defended by a concrete wall and section of rock armour. CMU 5 is a predominantly natural coast except for a concrete wall section in the east of the unit:

- **CMU 2 = Hybrid with risk and hazard**
- **CMU 5 = Hybrid with risk and hazard**

Phase 0 of the adaptation pathway (1<sup>st</sup> column) is the current actions undertaken by Moray Council in respect to these CMUs. Here this is **No Intervention** as Moray Council are not obligated to maintain the structures in the CMU 2 or 5. The structures should be maintained by the individual asset owners.

For the adaptation pathway to move to Phase 1 (2<sup>nd</sup> column containing potential actions) a pre-defined trigger must be realised. Then, depending on the outcome of any Implementation Plan Actions, this may or may not result in a change to the management approach adopted for the CMU.

Consultation of the CCAP Implementation Plan (Section 4.1) will guide the process and ultimately the pathway to adaptation.



**Figure 3-2: Adaptation Pathway for CMUs 2 and 5 (hybrid coast). Grey lines represent possible future pathways.**

### 3.3 CMU 3 and 4 Adaptation Pathways

CMU 3 is a sandy beach backed by a stepped concrete revetment and recurved seawall and is classified as built structures with hard engineering assets, with risk of overtopping and erosion (Figure 3-3). CMU 4 is Cullen Harbour constructed of concrete and stone walls and is classified as built structures, with unknown hazard.

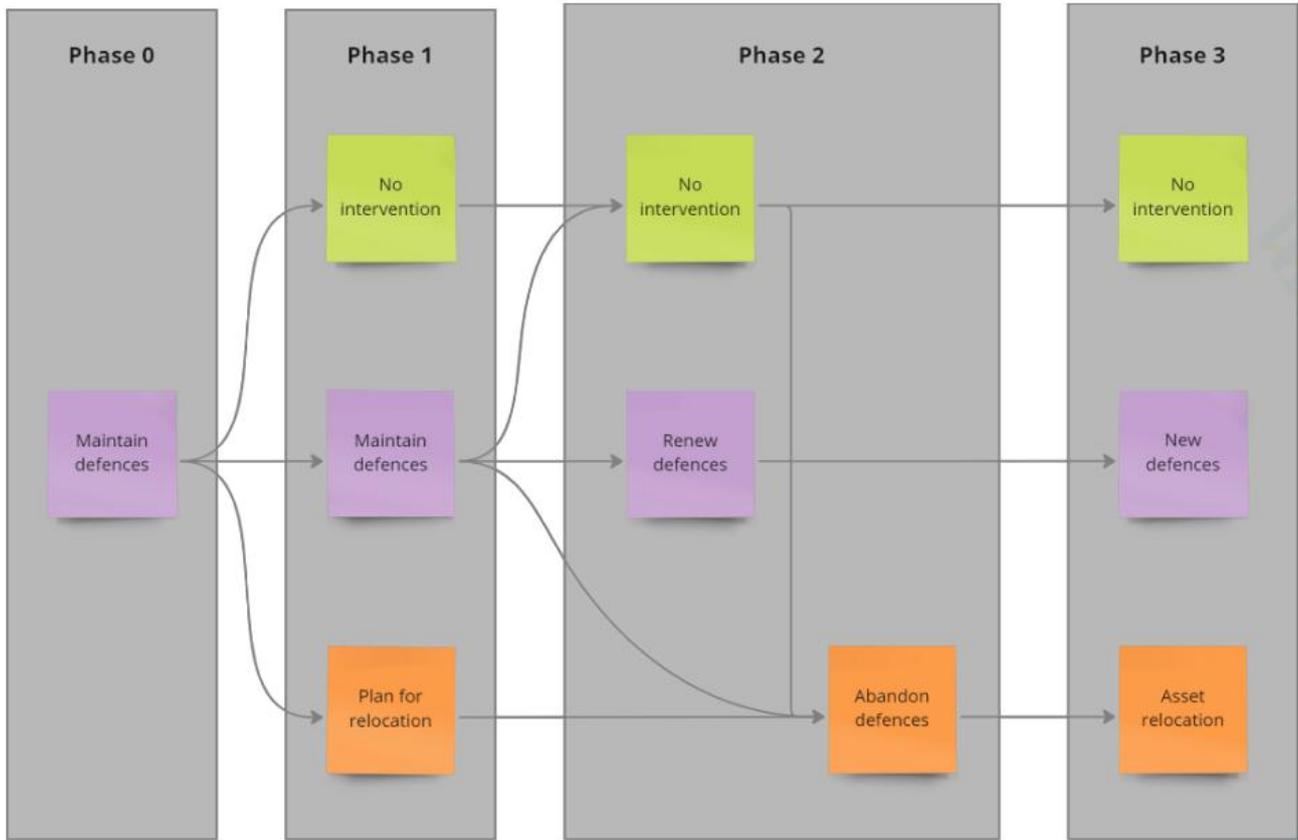
At CMU 3, should delivery of the Implementation Plan result in a pathway that identifies a protect outcome category in future phases, considerations should be given to enhance natural features as part of the risk management approach. At CMU 4, there is no pathway to “enhance natural features” as natural features do not contribute or provide any control on the flood risk.

- **CMU 3 = Built structures with risk and hazard**
- **CMU 4 = Built structures with risk and unknown hazard**

Phase 0 of the adaptation pathway (1<sup>st</sup> column) is the current actions undertaken by Moray Council in respect to these CMUs. In CMU 3 and CMU 4, this is **Maintain Defences** as Moray Council are responsible for the structures.

For the adaptation pathway to move to Phase 1 (2<sup>nd</sup> column containing potential actions) a pre-defined trigger must be realised. Then, depending on the outcome of any Implementation Plan Actions, this may or may not result in a change to the management approach adopted for the CMU.

Consultation of the CCAP Implementation Plan (Section 4.1) will guide the process and ultimately the pathway to adaptation.



**Figure 3-3: Adaptation Pathways for CMU 3 and CMU 4 (built structures coast). Grey lines represent possible future pathways.**

## 4 Adaptation Process

### 4.1 Implementation Plan

To support the delivery of the Adaptation Framework, a single Implementation Plan is applied to the entire Cullen to Muckle Hythe Coast CA with generic triggers and actions set that are relevant across the CA. Specific triggers and actions are then assigned to each CMU based on the Risk Assessment. Outcomes of the Implementation Plan link to the Adaptation Pathway specific to each CMU.

Delivery of the Implementation Plan has three stages (Figure 4-1):

- 1) Monitoring and Triggers (Section 4.2)
- 2) Actions (Section 4.3)
- 3) Outcomes (Section 4.6)

The outcome of the Implementation Plan determines what path will be followed within the Adaptation Pathway when moving to a new phase.

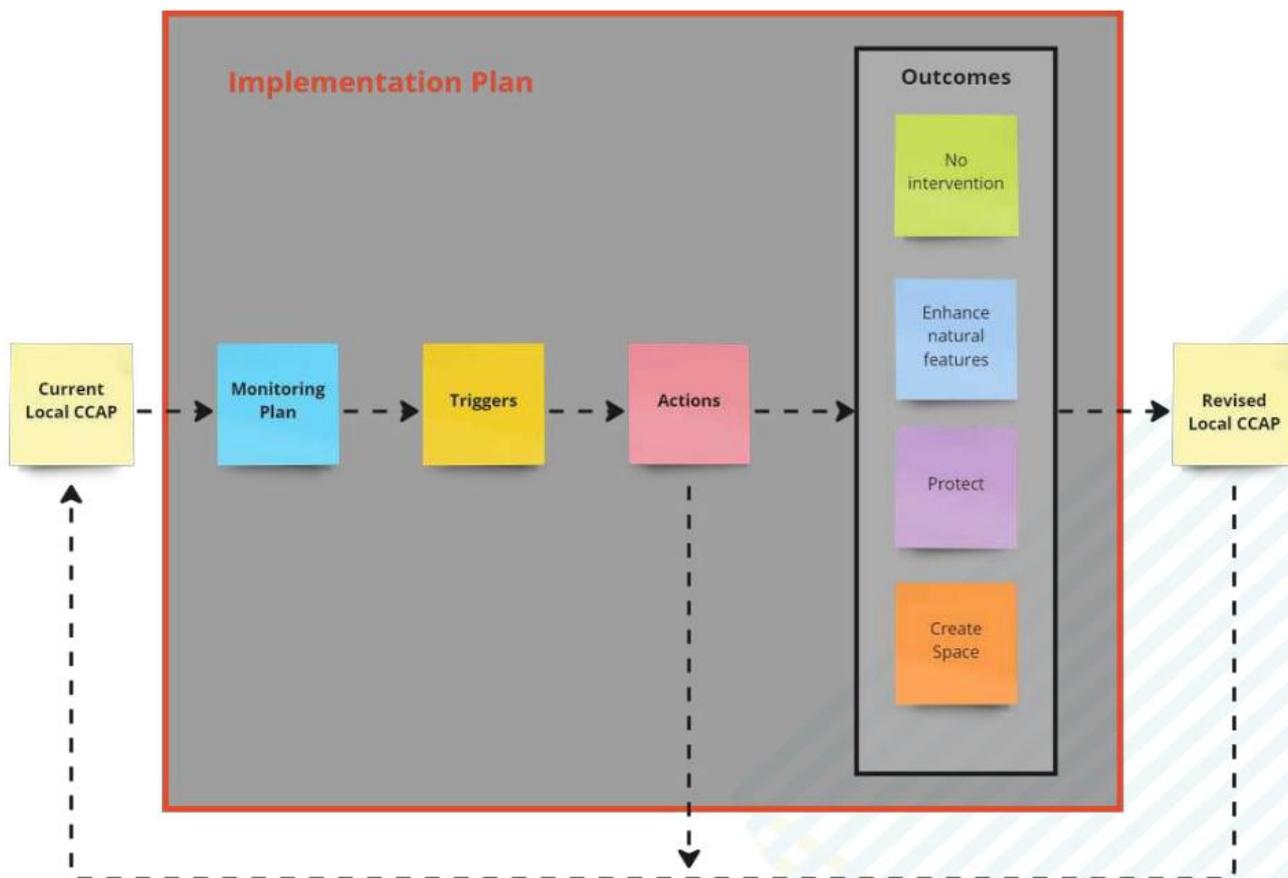


Figure 4-1: High-level Implementation Plan.

### 4.2 Monitoring and Triggers

#### 4.2.1 Monitoring

Triggers are realised through monitoring of available data that informs risk of flooding and erosion. Triggers signal the requirement to deliver the Implementation plan, which may lead to a review of the Risk Assessment and potential change to the Adaptation Pathway. Triggers are categorised as:

- Natural systems triggers.
- Climate triggers.
- Risk exposure triggers.
- Socio-economic triggers.

These are subsequently grouped into categories with each requiring a plan for monitoring within the CA:

- Third party data and information
- Moray Council data and information
- Moray Council monitoring
- External pressure

#### 4.2.2 Trigger Classification

Classification of the triggers falls into two parts.

1. Generic triggers applicable to the entire CA.
2. Bespoke triggers applicable to individual CMUs.

Climate, natural system, and socio-economic triggers are generic for the whole CA, but risk exposure triggers related to physical flooding, erosion and overtopping thresholds are specific to each CMU. For the Cullen to Muckle Hythe Coast CA, all triggers are summarised in Table 4-4.

All trigger types considered for the Cullen to Muckle Hythe Coast CA are summarised below:

- 1) Flooding triggers (section 4.2.3)
- 2) Overtopping triggers (section 4.2.4)
- 3) Erosion triggers (section 4.2.5)
- 4) Built structure condition triggers (section 4.2.6)
- 5) New information trigger (section 4.2.7)

Effective review of these requires development of a monitoring plan of risk for each CMU as follows:

- CMU 1: monitoring of erosion risk.
- CMU 2: monitoring of erosion risk.
- CMU 3: monitoring of erosion and overtopping risk.
- CMU 4: no monitoring currently required.
- CMU 5: monitoring of erosion risk.
- CMU 6: no monitoring currently required.

#### 4.2.3 CMU-specific flooding triggers

Based on SEPA's NFRA data, there are currently no assets at risk from flooding for the entire Cullen to Muckle Hythe Coast CA. Once an asset is highlighted in SEPA flood maps and NFRA data as being at risk from flooding, a CMU-specific flooding trigger will be applied. Where there is risk of flooding, the elevation of assets at risk are compared to sea levels taken from the SEPA tide gauge at Buckie.

#### 4.2.4 CMU-specific overtopping triggers

Where there is risk of flooding from wave overtopping (not currently accounted for in SEPA NFRA data), an overtopping risk assessment has been undertaken. This has then been used to develop threshold levels based on return periods. To enable proactive planning the risk assessment has been undertaken for four SLR scenarios:

- 0 m (present-day)
- +0.2 m

- +0.5 m
- +1.0 m

The maximum and minimum volumes have been extracted for each return period to produce an envelope of potential overtopping under each sea level rise scenario (Appendix A). This has been undertaken for CMU 3, where wave overtopping will be the flood risk mechanism for adjacent properties.

An overtopping trigger is realised once overtopping volume during the 1 in 2-year and 1 in 30-year return period events exceed given threshold levels<sup>4</sup>. There are two levels to the trigger realisation that require different actions:

1. Level 1: overtopping volume exceeds 10 l/s/m during a 1 in 30-year event.
  - Increase monitoring and plan for assessment.
2. Level 2: overtopping volume exceeds 5 l/s/m during a 1 in 2-year event.
  - Undertake assessment and plan for intervention.

The overtopping rates itself does not require monitoring rather the updated overtopping calculations, should new data become available (e.g., extreme waves or sea levels, defence survey, beach levels etc). The Triggers are therefore an indication of the performance level of the structure.

In the event of an overtopping event being realised, Moray Council should consult with SEPA to understand where the realised rates fit on the overtopping volume estimates (section A.4.2) to assess whether this represented an exceedance of these initial triggers. Depending on the outcome the value of overtopping triggers should be adjusted to reflect the outcome, if appropriate.

Overtopping results from the risk assessment (Table 4-1) show that level 1 trigger will be met with 0.2 m of sea level rise. Level 2 overtopping triggers are only met after 0.5 m of sea level rise and therefore climate change data should be monitored to understand when action is required. Current projections estimate that, by 2100, sea levels on the Moray coast could rise up to 0.9m<sup>5</sup>.

**Table 4-1: Overtopping triggers for CMU 3. Cells shaded red indicate that an overtopping trigger has been met.**

Sea Level Rise	Overtopping Trigger Level 1 Maximum 1 in 30-year overtopping rate (l/s/m)	Overtopping Trigger Level 2 Maximum 1 in 2-year overtopping rate (l/s/m)
0.0 m (present-day)	5.3	0.8
0.2 m	12.2	2.2
0.5 m	33.9	8.3
1.0 m	115.6	41.5

#### 4.2.5 CMU-specific erosion triggers

Where there is risk of erosion, the distance from the asset at risk to the coast is used to define the trigger. For properties, roads and other features, the coast is defined by the landward extent of the natural feature e.g., beach, barrier, spit or cliff except for CMU 4 whereby the

<sup>4</sup> It should be noted that, at this stage, thresholds are based primarily on judgement, tolerable limits in guidance and associated consequence in the immediate vicinity of the beach crest. A more detailed assessment of when overtopping volume results in flooding to properties is recommended.

<sup>5</sup> <https://www.sepa.org.uk/media/594168/climate-change-guidance.pdf>

coast is defined by the seaward position of the coastal defence. Assets considered at risk from erosion include:

- Residential and non-residential properties
- Key roads
- Other features, such as carparks and golf courses

To note, if two assets are in the same location (e.g., a road and property) only the most seaward asset will be used to define an erosion trigger for that CMU.

For CMUs with a Moray Council owned coastal defence, at Cullen this is CMU 3, the erosion trigger will be defined using the position of the MHWS and the toe of the coastal defence structure.

As with the other CMU-specific triggers, a two-level erosion trigger approach is defined using buffers around the asset at risk. The associated action is dependent on the asset at risk and the associated consequences.

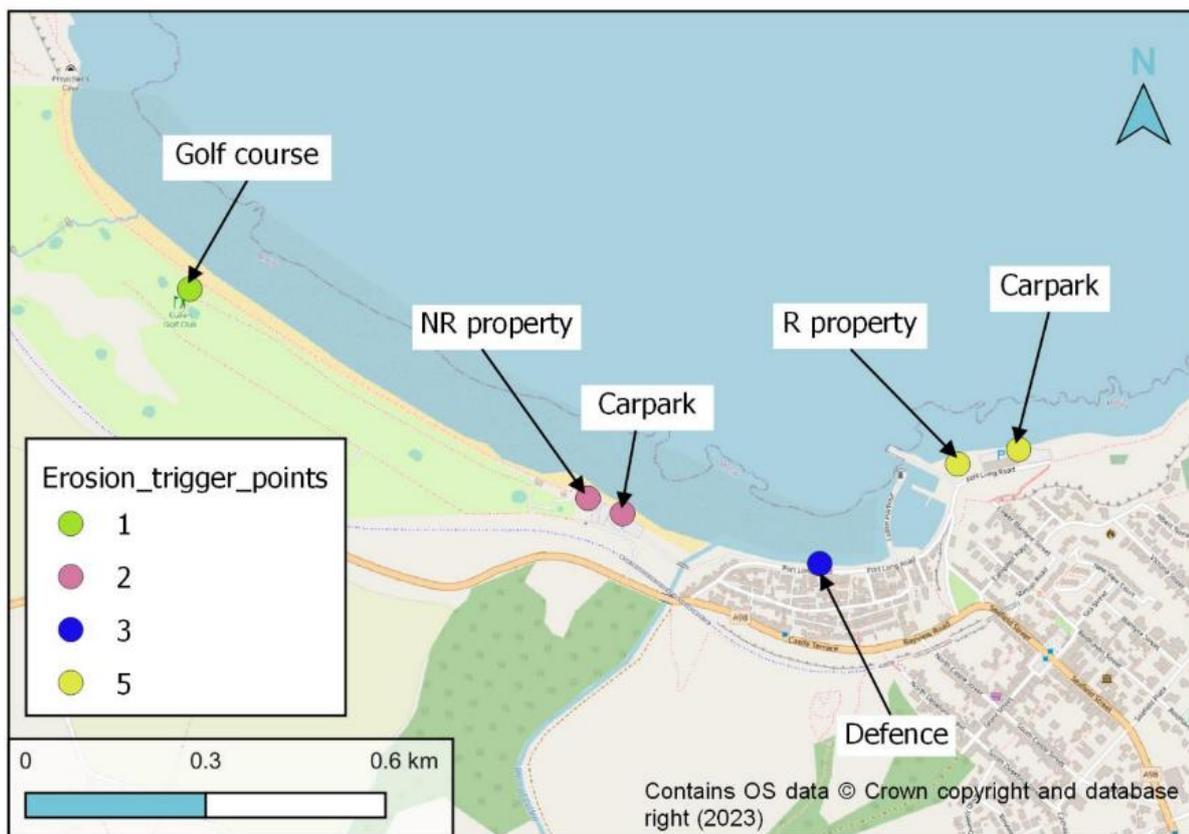
Erosion buffer distances (metres) for each level are defined as follows:

- **Properties**
  1. Maximum of historic erosion rate multiplied by 20 or 20 m.
    - Increase monitoring and plan for assessment.
  2. Maximum of historic erosion rate multiplied by 10 or 10 m.
    - Undertake assessment and plan for intervention.
- **Roads and other features**
  1. Maximum of historic erosion rate multiplied by 5 or 5 m.
    - Increase monitoring and plan for assessment.
  2. Maximum of historic erosion rate multiplied by 2 or 2 m.
    - Undertake assessment and plan for intervention.
- **Coastal Defences**
  1. MHWS at toe of defence.
    - Increase monitoring and plan for assessment.
  2. Toe of defence exposed.
    - Undertake assessment and plan for intervention.

All level 1 erosion triggers have been met for CMUs 1, 2 and 5 (Table 4-2). Level 2 erosion triggers have been met for all properties triggers in CMU 2 and 5; the Golf Club in CMU 1; and the carpark in CMU 2 (Table 4-2). Location of all assets used for erosion triggers are shown in Figure 4-2 and Table 4-3.

**Table 4-2: CMU-specific erosion triggers for Cullen to Muckle Hythe Coast properties, roads and features. Cells shaded red indicate that an erosion trigger has been met.**

CMU	Maximum historical change rate (m/year)	Present-day distance of property to coast (m)		Erosion trigger Level 1: Coast X m from property	Erosion trigger Level 2: Coast X m from property
2	2.7	NRP	11.0	54.0	27.0
5	0.1	RP	8.0	20.0	10.0
CMU	Maximum historical change rate (m/year)	Present-day distance of feature to coast (m)		Erosion trigger Level 1: Coast X m from feature	Erosion trigger Level 2: Coast X m from feature
1	2.6	Golf club	0.0	13.0	5.2
2	2.7	Carpark	2.0	13.5	5.4
5	0.1	Carpark	3.0	5.0	2.0
CMU	Maximum historical change rate (m/year)	Present-day distance of MHWs to defence toe (m)		Erosion trigger Level 1: MHWs at toe?	Erosion trigger Level 2: Toe exposed?
3	1.1	Sea Wall	1.4	No	No



**Figure 4-2: Cullen to Muckle Hythe Coast erosion trigger locations for residential property (R property), non-residential property (NR property) and other key features.**

**Table 4-3: Cullen to Muckle Hythe Coast erosion triggers**

CMU	Asset	Trigger Met	Erosion Trigger
1	Golf course	Yes (level 1 and 2)	
2	NR Property	Yes (level 1 and 2)	
2	Carpark	Yes (level 1 and 2)	
3	Coastal Defence	No	

5	R Property	Yes (level 1 and 2)	
5	Carpark	Yes (level 1)	

The erosion triggers realised for CMU 2 are complex due to the resistance provided by the built coastal structures. Here both the condition of these and the future changes to the beach will control the risk. While the proximity of the assets to the shoreline has resulted in Level 1 and 2 triggers being realised the combined behaviour of structure and beach must be understood. It may be that the condition of the structure (4.2.6) is the controlling factor. This should be reviewed upon completion of the next asset condition survey undertaken by Moray Council.

**4.2.6 CMU-specific condition triggers**

Where a built structure is present in a CMU, a CMU-specific trigger will be applied to the condition of the built structure. Currently, built structures are present in:

- CMU 2
- CMU 3
- CMU 4
- CMU 5

As with the other CMU-specific triggers, a two-level condition trigger approach and associated action is defined using the Grades of built structure condition according to the EA and Defra condition assessments<sup>6</sup>:

- **Condition trigger level 1:**
  1. Defence condition Grade 4:
    - Increase monitoring and plan for assessment.
- **Condition trigger level 2:**
  1. Defence condition Grade 5:

<sup>6</sup> Environment Agency (2013) Practical guidance on determining asset deterioration and the use of condition grade deterioration curves: Revision 1.

- Undertake assessment and plan for intervention.

These CMU-specific condition triggers assume built coastal structures are currently Grade 3 but this should be reviewed upon completion of the Regional Proactive Actions for defence condition.

#### 4.2.7 New information trigger

New information on hazards, vulnerability, built structure and infrastructure assets etc will become available all the time as the CCAP is implemented. The new information trigger acknowledges this and accounts for changes to properties, roads, key features, or assets available from Dynamic Coast or the NFRA.

This new information may be provided by a Council/ stakeholder member or local resident of the CA and would trigger a review of the relevant part of the CCAP.

- **New Information trigger:**
  1. New information received of asset at risk:
    - Understand risk and, if relevant, set adaptation triggers and actions.
    - Incorporate into monitoring plan.

#### 4.2.8 Moray Coastal Trail

Impact of flooding and erosion on the Moray Coastal Trail<sup>7</sup> (MCT) is yet to be quantified but it will likely become badly affected by coastal change and flooding in both the short and long-term.

As part of delivery of the Regional Plan a more detailed assessment will be undertaken to understand the impacts of climate change on the MCT (Regional Proactive Action 9). This will provide opportunities for investigation options to enhance and retain the amenity.

In this CA it is understood that the MCT may be affected in several locations by future coastal erosion. As part of delivery of the Regional Plan a more detailed assessment will be undertaken to understand the impacts of climate change on the MCT (Regional Proactive Action 9). This will provide opportunities for investigation options to enhance and retain the amenity.

### 4.3 Actions

Actions, like Triggers, are also applied to the entire CA, or to specific CMUs where the risk of flooding and/or erosion is identified. Actions will be specific to CMUs where, for example, a coastal defence is present; a natural protective feature is present; the risk of flooding/erosion is localised; or assets are at risk of flooding/erosion.

Actions applicable to all and specific CMUs in Cullen to Muckle Hythe Coast CA have been identified in Table 4-4. These are based on the Phase 0 Triggers only and it is possible that more will be required as a reactive response to change. Delivery of the Regional Plan<sup>8</sup> Proactive are also required to support. The types of Actions are summarised below:

#### Review risk assessment:

- Involves a review of available data and associated risk assessment. Increased monitoring, planning, implementing an assessment, and planning for intervention, because of the erosion and flooding triggers, are included in the review risk assessment action.

<sup>7</sup> <https://www.morayways.org.uk/routes/the-moray-coast-trail/>

<sup>8</sup> Moray Coastal Change Adaptation Plan: Regional Plan - IRR-JBAU-XX-XX-RP-MO-0001-S4-P03-Regional\_Plan

**Community engagement:**

- **Places:** Involves local stakeholders such as Councillors and affected community groups.
- **Practice:** Involves third party stakeholders, such as SEPA, Scot Gov, NatureScot etc.
- **Asset:** Includes privately owned structures, specific to built structure or hybrid CMUs.

**Post flood data collection:**

- Involves citizen science surveys, photographs etc.

**New risk assessment:**

- Following a review of the current risk assessment and/or community engagement, a new risk assessment may be required. Should a new assessment be deemed necessary this should follow appropriate guidance<sup>9</sup> and include all necessary components to develop a preferred Adaptation Pathway and associated Action Plan for delivery. E.g., risk, economics, social, environment, engineering, land use planning etc.

Actions bridge the gap between Triggers and Outcomes and define what processes need to be implemented before the most appropriate Outcome is recognised and delivered for each CMU. Actions linked to specific triggers and relevant Cullen to Muckle Hythe Coast CMUs are included in Table 4-4. These highlight what may be delivered during the Phase 0 cycle and are dependent on the associated Trigger being realised.

**Table 4-4: Trigger categories, triggers and associated actions for each Cullen to Muckle Hythe Coast CMU.**

Trigger Category	Trigger	Action	CMU
<b>Natural systems</b>	Changes to habitat	Community engagement (places)	All
	Changes to greenspace	Community engagement (places)	All
<b>Climate</b>	Update to climate guidance	Review risk assessment, community engagement (practice)	All
	Update to SEPA flood maps	Review risk assessment, community engagement (practice)	All
	Coastal flood occurrence	Review risk assessment, community engagement (places, asset), post-flood survey	All
<b>Socio-economic</b>	Change of asset use	Community engagement (asset)	All
	Change of asset owner	Community engagement (asset)	All
	Community pressure	Review risk assessment, community engagement (places)	All
<b>Risk exposure</b>	Defence condition	Review risk assessment (if MC defence), Community engagement (asset)	CMU 2 CMU 3 CMU 4

<sup>9</sup> Scottish Government. 2016. Flood protection appraisals: guidance for SEPA and responsible authorities <https://www.gov.scot/publications/guidance-support-sepa-responsible-authorities/pages/2/>

			CMU 5
	Update to SEPA flood warning	Review risk assessment, community engagement (places, practice)	All
	Erosion buffer exceeded	Review risk assessment, community engagement (places)	CMU 1 CMU 2 CMU 3 CMU 5
	Overtopping threshold exceeded	Review risk assessment, community engagement (places, asset)	CMU 3
	Update to Dynamic Coast	Review risk assessment, community engagement (places)	All

#### 4.4 Phase 0 Actions

Phase 0 Actions require immediate attention and have been identified by associated triggers realised through the development process of this initial CCAP for Cullen to Muckle Hythe Coast. These are outlined below:

- CMU 1:
  - Trigger 1: Erosion buffer exceeded (level 1)
    - **Action 1:** Increase monitoring and plan for assessment.
  - Trigger 1: Erosion buffer exceeded (level 2)
    - **Action 2:** Undertake assessment and plan for intervention.
  
- CMU 2:
  - Trigger 1: Erosion buffer exceeded (level 1)
    - **Action 1:** Increase monitoring and plan for assessment.
  - Trigger 1: Erosion buffer exceeded (level 2)
    - **Action 2:** Undertake assessment and plan for intervention.
  
- CMU 5:
  - Trigger 1: Erosion buffer exceeded (level 1)
    - **Action 1:** Increase monitoring and plan for assessment.
  - Trigger 1: Erosion buffer exceeded (level 2)
    - **Action 2:** Undertake assessment and plan for intervention.

An overall summary of all CMUs, Triggers, buffers, and Phase 0 Actions is provided as a standalone record in Appendix C for clarity.

#### 4.5 Supporting Steps and Proactive Actions

The nature of adaptation means that future decisions and directions are unknown and will be affected by external changes not necessarily under Moray Council’s influence. It is critical that proactive supporting steps and Proactive Actions are undertaken to enable effective decision making in the future.

**Proactive Actions** are defined as those whereby there is only benefit. Undertaking these can therefore only have a positive impact on supporting adaptation or increasing resilience.

Four such actions have been identified at this stage in the adaptation planning process. These have been developed focusing on the key pillars identified previously and through review and understanding of key knowledge gaps. They therefore aim to close these knowledge gaps at this stage and support delivery of wider aspects of the Adaptation Framework for Cullen to Muckle Hythe Coast.

A summary of these actions is provided in Table 4-5 with further details on each included in Appendix B. These are designed to complement the wider Proactive Actions identified in the Regional CCAP.

**Table 4-5: Local Proactive Actions.**

Action	Details	Pillars
1	Develop modelling framework to support future assessments	Working with Natural Processes 
2	Establish coordinated and consistent beach monitoring plan for CMUs 1, 2, 3, 5	Monitoring Change 
3	Adaptation and resilience workshop with local community and stakeholders	Community and Engagement 
4	Identify landownership and safeguarding	Place Making 

#### 4.6 Outcomes

Outcomes are the potential intervention measures that will be implemented after a trigger is realised and the associated actions, defined in the Implementation Plan, have been undertaken. There are four possible outcome categories:

- 1) No intervention.
- 2) Enhance natural features.
- 3) Protect.
- 4) Create Space.

These Categories however are general, and nuances and variations may result upon completion of any more detailed study.

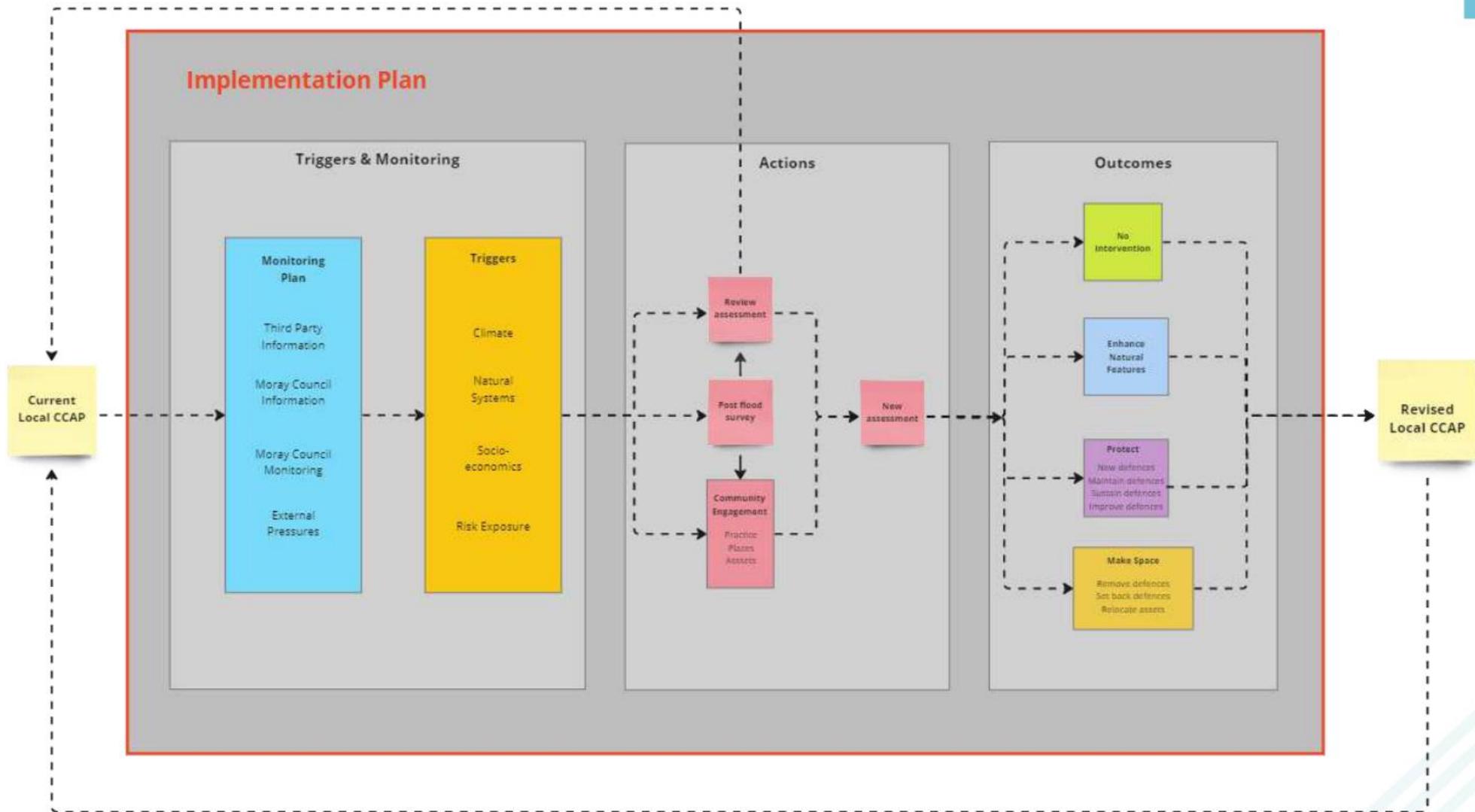
As the Implementation Plan is applied at CMU level, the ultimate outcome is dependent on the CMU and the associated Adaptation Pathway. Table 4-6 summarises the general and specific CMU outcomes for the Cullen to Muckle Hythe Coast CA.

**Table 4-6: Cullen to Muckle Hythe Coast CA Outcomes**

Outcome Category	Outcome	CMU
No intervention	No intervention	All
Enhance natural features	Enhance natural features	CMU 1 CMU 2 CMU 5 CMU 6
Protect	Maintain defences	CMU 2 CMU 3 CMU 4 CMU 5
	Sustain* defences	CMU 2 CMU 3 CMU 4 CMU 5
	Improve** defences	All
Create space	Remove defences	CMU 2 CMU 3 CMU 4 CMU 5
	Set back defences	CMU 2 CMU 3 CMU 4 CMU 5
	Relocate assets	CMU 1 CMU 2 CMU 3 CMU 4 CMU 5
*standard of performance is sustained into the future in response to climate change		
**standard of performance is improved beyond the current and then maintained in response to climate change		

The complete Implementation Plan for Cullen to Muckle Hythe Coast is shown in (

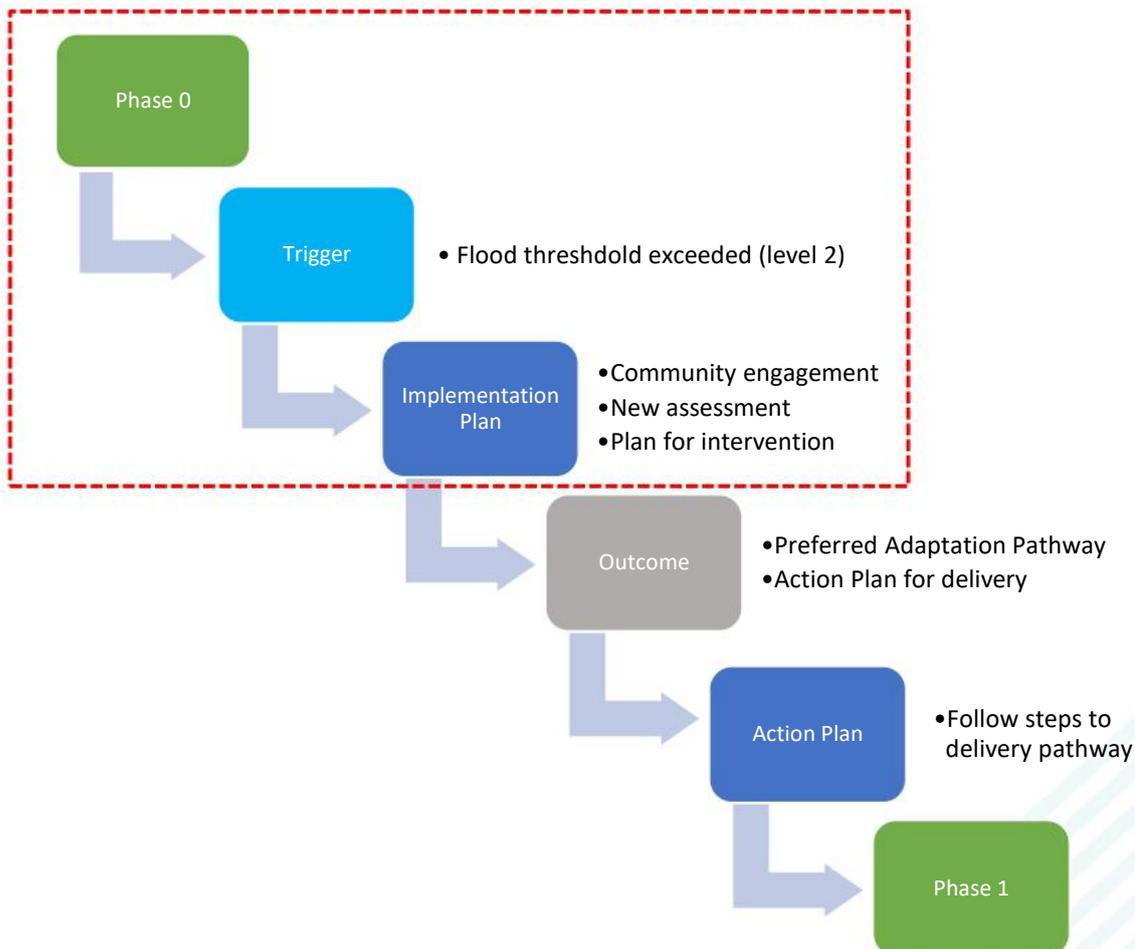
Figure 4-3); structured using the three stages: 1) Monitoring and Triggers, 2) Actions, and 3) Outcomes.



**Figure 4-3: Complete Implementation Plan for Cullen to Muckle Hythe Coast CA.**

### 4.7 Example application

Figure 4-4 provides a schematic describing an example application of the Implementation Plan and how it fits in with the wider Adaptation Framework for Cullen to Muckle Hythe Coast. The red box highlights the processes described in this first iteration of the CCAP.



**Figure 4-4: Example application of Phase 0 to Phase 1 of the adaptation process and how the Implementation Plan works with Adaptation Pathways and Action Plans.**

## 5 Summary and Next Steps

### 5.1 Approach

This document presents the local CCAP for Cullen to Muckle Hythe Coast. It is the first iteration and will be subject to ongoing review and update to effectively guide the adaptation process. The approach for developing the plan makes use of available, national information on coastal flood and erosion risk and combines these with relevant local datasets.

Adaptation in Moray has been steered by relevant published documentation and the Scottish Governments interim guidance on CCAPs. These have been used to develop a Regional CCAP. This has been simplified into four key pillars of adaptation:

1. **Working with Natural Processes**
2. **Monitoring Change**
3. **Community and Engagement**
4. **Climate Resilient Placemaking**

This local Plan builds on the Regional Plan by focusing on these pillars to develop an Adaptation Framework that can effectively prepare Cullen to Muckle Hythe Coast to the impact climate change will have on the coast. This will be delivered by following the Implementation Plan, presented here, that outlines Triggers and associated actions to develop detailed Adaptation Pathways and an Action Plan for the Cullen to Muckle Hythe Coast CA.

The following sections provide summaries of the key findings of this initial stage of the adaptation planning process.

### 5.2 Coastal Management Units and Risks

The Cullen to Muckle Hythe Coast CA was subdivided into six CMUs. For each of these a refined assessment was undertaken to determine coastal type and associated current and future flood and erosion risk. These are summarised as:

- CMU1 – Natural with Risk and Hazard
- CMU2 – Hybrid with Risk and Hazard
- CMU3 – Built Structures with Risk and Hazard
- CMU4 – Built Structures with Risk and unknown Hazard
- CMU5 – Hybrid with Risk and Hazard
- CMU6 – Natural with No Risk and Hazard

These were then taken forward to develop Adaptation Pathways and an Implementation Plan with Triggers and Actions associated with each CMU.

### 5.3 Adaptation Pathways

To enable effective implementation of the CCAP across the Cullen to Muckle Hythe Coast CA, each CMU has been assigned a generic Adaptation Pathway. This is specific to the CMU classification.

The adaptation journey is a multiphase, multiyear process and aims to transition communities into a more sustainable and resilient future. We are currently at **Phase 0**, meaning that no definitive preferred Adaptation Pathway and associated Action Plan have been developed.

To move to Phase 1 of the Adaptation Pathway, a trigger must be realised that results in New Assessment, which is the case for CMUs 1, 2 and 5 (section 4.4). During Phase 1 a preferred pathway and associated Action Plan will be identified at these CMUs:

1. **Phase 0:**
  - Development of the Implementation Plan
  - Delivery of Phase 0 Actions (Appendix C)
  - Delivery of Phase 0 Proactive Actions (Appendix B)
2. **Phase 1:**
  - Implementation Plan outcomes:
    - Preferred Adaptation Pathway
    - Action Plan for delivery
  - Delivery of Phase 1 Proactive Actions
3. **Phase 2+:**
  - Implementation Plan outcomes:
    - Preferred Adaptation Pathway (Continue or revise Phase 1)
    - Action Plan for delivery (Continue or revise Phase 1)
  - Delivery of Phase 2 Proactive Actions

While ultimately the Adaptation Pathways have a desired outcome, what that looks like and how it will be reached cannot be defined at this stage. Effective monitoring against the set triggers will enable the CCAP to evolve through Phases and support Moray Council decision making to aim to achieve this end-outcome.

#### 5.4 Implementation Plan

The Implementation Plan was developed by defining Triggers and setting Actions against these. Implementation of the Plan will result in end outcomes that will ultimately influence the direction of the Adaptation Pathways in the Cullen to Muckle Hythe Coast CA.

At this stage the pathways do not result in definitive end points. Triggers, while tangible, provide markers whereby Moray Council will undertake actions, guided by the Implementation Plan. The Outcomes of these however, are unknown and the direction of the pathway in the future therefore cannot be defined.

Triggers focus on the updates to the data and documentation that has underpinned the development of the plan, and bespoke flooding or erosion thresholds being exceeded, through monitoring of physical processes.

As well as Actions that rely on Triggers being realised. This initial stage of the adaptation planning process has identified several knowledge gaps and opportunities for activities to be undertaken upfront. These are defined as Proactive Actions, whereby undertaking these will only benefit and support Moray's adaptation to coastal change.

In total, four Proactive Actions have been set.

#### 5.5 Next Steps

Adaptation to coastal change will be a continual journey and it is therefore important that the process is ongoing. Here, the following key steps require implementing by Moray Council to support this journey and follow CCAP:

- Implement internal governance processes to review and monitor Triggers.
- Deliver local Phase 0 Actions.
- Deliver local Proactive Actions.

# Appendices

## A CMU Risk Assessment

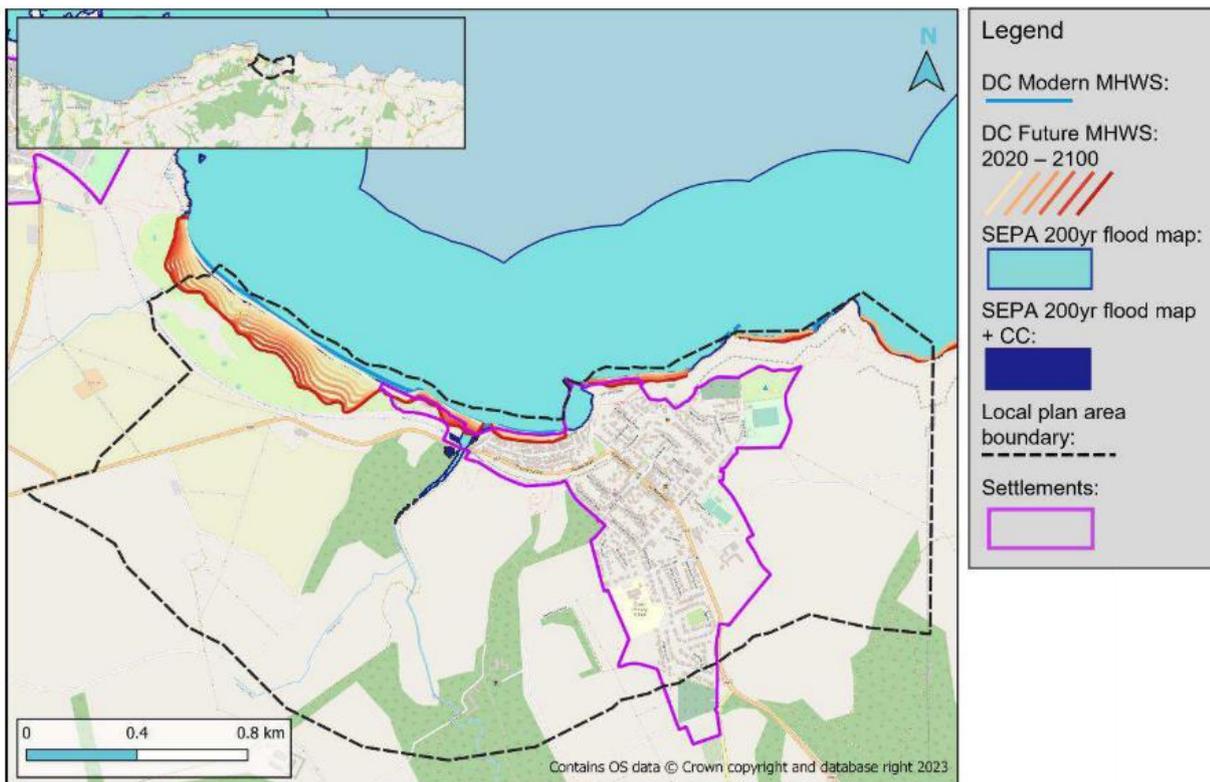
### A.1 Data and overview

Coastal parameters and associated datasets for Cullen to Muckle Hythe Coast are summarised in Table A-1.

**Table A-1: Coastal dataset summary for Cullen to Muckle Hythe Coast CA.**

Coastal Data		Details	Data source
Hindcast wave height (m)	0.72	50th percentile	CMEMS (Point 4)
	1.12	75th percentile	
	3.03	99th percentile	
Tide levels (m OD)	HAT	2.5	TotalTide (Buckie)
	MHWS	2.0	
	MHWN	1.1	
	MSL	0.31	
	MLWN	-0.5	
	MLWS	-1.6	
	LAT	-2.0	
Extreme Sea Levels (m OD)	2.00	MHWS	CFB (Cullen: 3094)
	2.62	2-year	
	2.92	50-year	
	2.98	100-year	
	3.04	200-year	
	3.18	1000-year	
Sea level rise projections (m)	0.15	2050 70 <sup>th</sup> percentile	UKCP18
	0.20	2050 95 <sup>th</sup> percentile	
	0.59	2100 70 <sup>th</sup> percentile	
	0.84	2100 95 <sup>th</sup> percentile	

An overview of coastal flood and erosion hazards is provided for Cullen to Muckle Hythe Coast CA (Figure A-1). This has been produced using SEPA flood mapping for 1 in 200-year and 1 in 200-year plus climate change flood events as well as Dynamic Coast erosion projections for 2020 to 2100. The data has been analysed for each CMU individually and has been used to identify receptors at risk.



**Figure A-1: Cullen to Muckle Hythe Coast CA coastal flood and erosion hazard overview.**

**A.2 CMU 1: Beach West - natural**

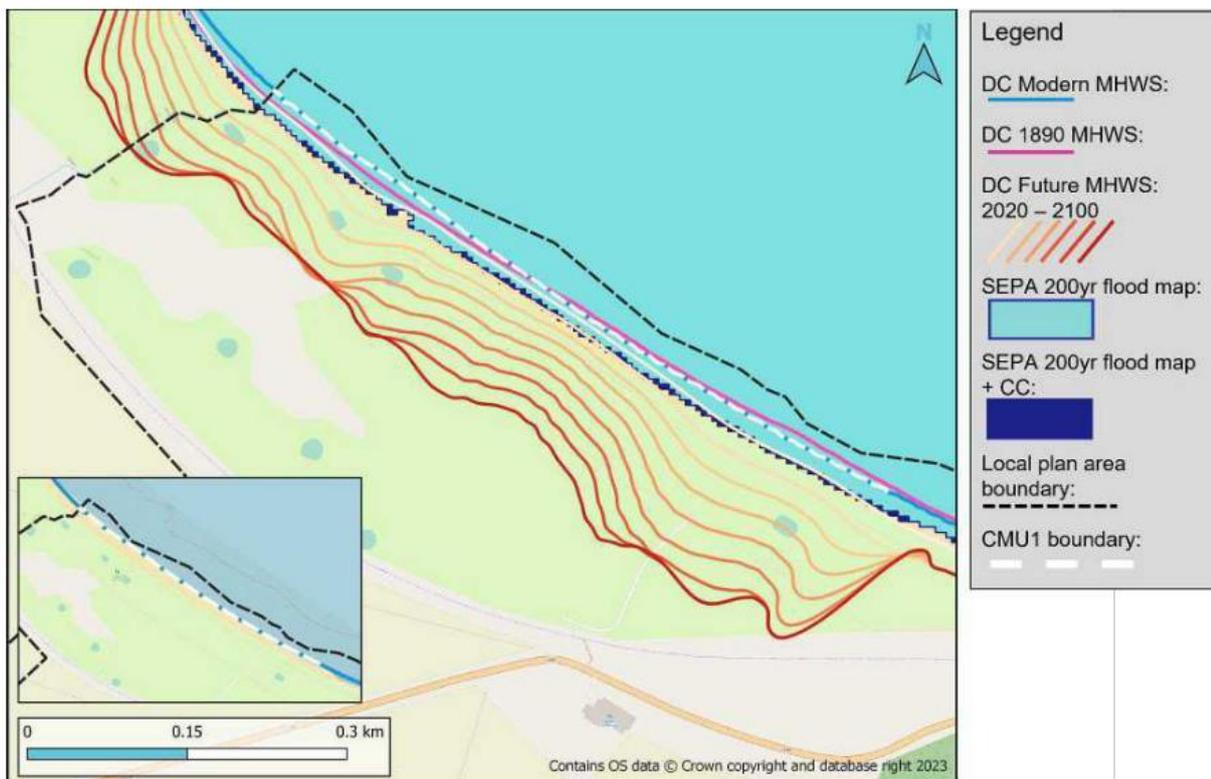
This CMU is natural, with no engineered structures present. It is fronted by a natural sandy beach and backed by vegetated dunes and grassland. SEPA flood maps and NFRA data show negligible risk from coastal flooding to land and assets.

Results from Dynamic Coast show this CMU is at risk from coastal erosion. Dynamic Coast data shows that, historically (from ca. 2011 to 2016), this coast has eroded at a maximum rate of 2.6 m/yr. Maximum future erosion rates are expected to increase to 2.4 m/yr by 2100. This would result in a maximum of ca. 170 m of shoreline retreat by 2100. Table A-2 summarises Dynamic Coast data for CMU 1 within Cullen to Muckle Hythe Coast CA.

Assets in this CMU which lie within the Dynamic Coast erosion extent under the RCP8.5 scenario are summarised below:

- Vegetated dunes and grassland.
- Cullen Links Golf Club – golf course.

There is no erosion risk to infrastructure, residential properties, or non-residential properties currently predicted.



**Figure A-2: CMU 1 (Beach West Natural) coastal hazards map showing SEPA flooding extents and Dynamic Coast (DC) past and future erosion. Inset shows unit without coastal hazards.**

**Table A-2: CMU 1 Dynamic Coast erosion data summary.**

Dynamic Coast calculation		Results	
Historical rate (m/yr)	rate	2.6	Maximum
		1.4	Median
2050 rate (m/yr)	rate	2.9	Maximum
		1.8	Median
2050 distance (m)	distance	84.1	Maximum
		49.0	Median
2100 rate (m/yr)	rate	2.4	Maximum
		0.0	Median
2100 distance (m)	distance	168.8	Maximum
		124.1	Median

### A.3 CMU 2: Beach West - hybrid

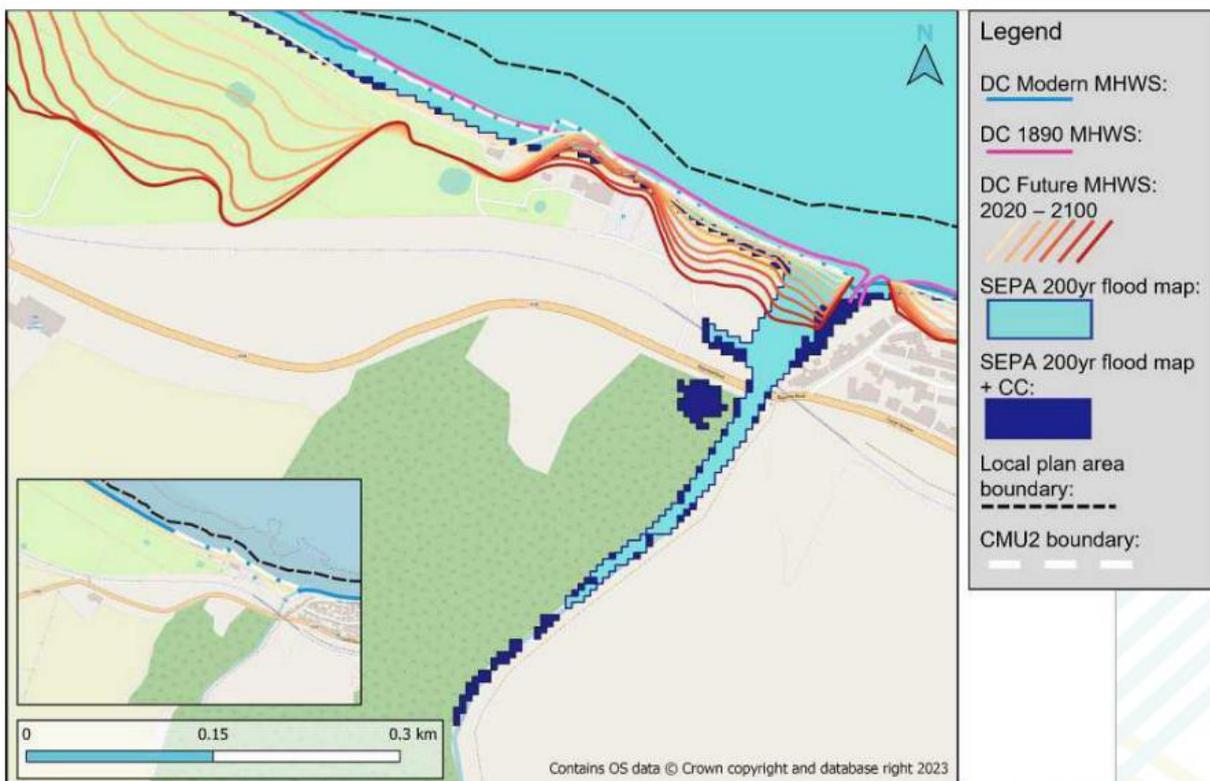
The majority of this CMU consists of a concrete wall, fronted by a natural sandy beach. In the west, a section of rock armour spans approximately 50 m in length. In the east there are no structures at the confluence of the Burn of Cullen.

SEPA flood maps and NFRA datasets show only very minor flooding to grassland either side of the A98 road and therefore the risk from coastal flooding to land and assets in this unit is negligible.

Results from Dynamic coast show this CMU is at risk from coastal erosion. Dynamic Coast data shows that, historically (from ca. 2011 to 2016), this part of the Cullen to Muckle Hythe Coast CA has eroded at a maximum rate of 2.7 m/yr. Maximum future erosion rates are expected to increase to 3.1 m/yr by 2050 before decreasing to 1.2 m/yr by 2100. This would result in a maximum of ca. 160 m shoreline retreat by 2100. Table A-3 summarises Dynamic Coast data for CMU 2.

Assets in this CMU which lie within the Dynamic Coast erosion extent under the RCP8.5 scenario are summarised below:

- Two NRP at risk from erosion: minimum of 20 m from present-day shoreline.
- Footbridge over Burn of Cullen and access path both sides (~100 m at risk): ~50 m from present-day shoreline.
- Two car parks at risk from erosion: Cullen Links Golf Club and beach.
- Secondary road providing access to Cullen Links Golf Club from A98 (~20m at risk): minimum of 50 m from present-day shoreline.



**Figure A-3: CMU 2 (Beach West Hybrid) coastal hazards map showing SEPA flooding extents and Dynamic Coast (DC) past and future erosion. Inset shows unit without coastal hazards.**

**Table A-3: CMU 2 Dynamic Coast erosion data summary.**

Dynamic Coast calculation		Results	
Historical rate (m/yr)	rate	2.7	Maximum
		0.3	Median
2050 rate (m/yr)		3.1	Maximum
		0.2	Median
2050 distance (m)		88.0	Maximum
		13.9	Median
2100 rate (m/yr)		1.2	Maximum
		0.2	Median
2100 distance (m)		157.1	Maximum
		30.4	Median

#### **A.4 CMU 3: Beach West – built structures**

##### **A.4.1 Dynamic Coast and SEPA**

This CMU consists of a concrete revetment with recurve sea wall, fronted by a sandy beach. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding to land and assets in this unit. **However, these do not account for wave overtopping risk.**

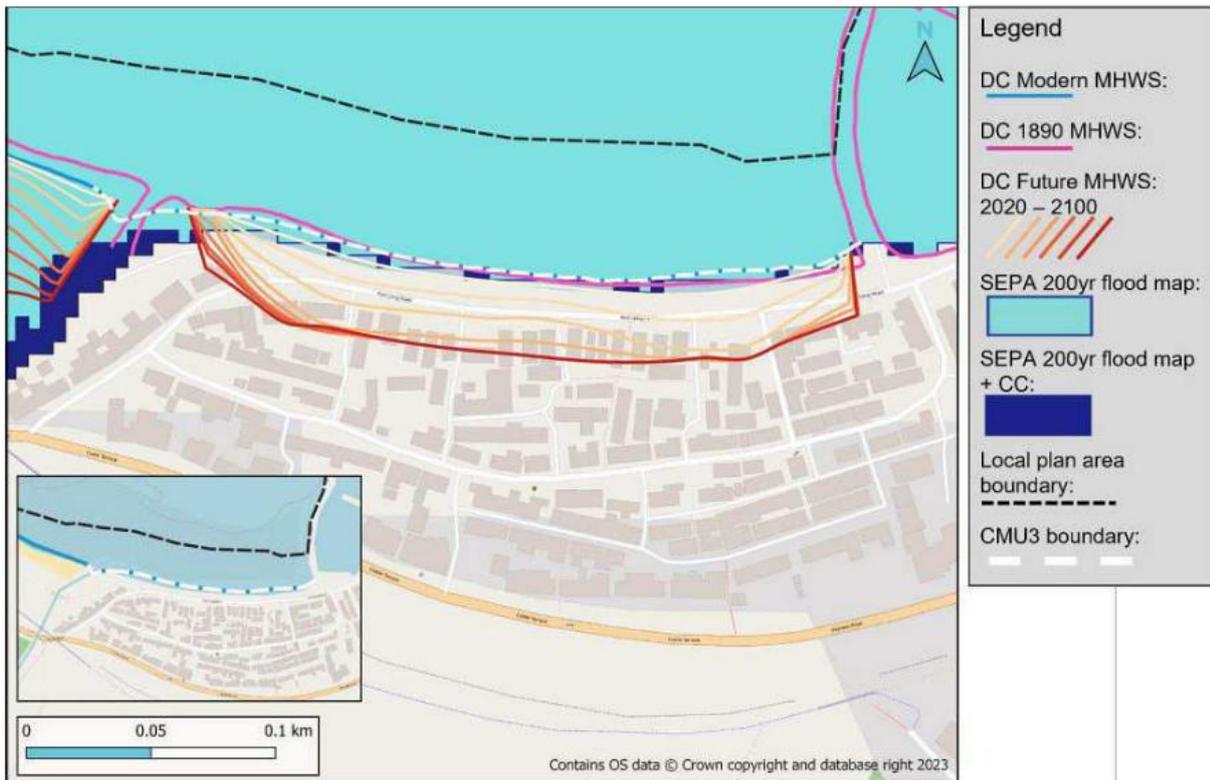
Results from Dynamic Coast show this CMU is at risk from coastal erosion. Dynamic Coast data shows that, historically (from ca. 2011 to 2016), this part of the Cullen to Muckle Hythe Coast CA has eroded at a maximum rate of 1.1 m/yr. Maximum future erosion rates are expected to remain stable at 1.1 m/yr by 2050 and 1.0 m/yr by 2100. This would result in a maximum of ca. 45 m of shoreline retreat by 2100.

**This however does not account for the presence of the coastal defences with future erosion risk ultimately being controlled by their integrity.**

Table A-4 summarises Dynamic Coast data for CMU 3.

Assets in this CMU which lie within the Dynamic Coast erosion extent under the RCP8.5 scenario are summarised below:

- 32 NRP at risk from erosion: minimum of 20 m from present-day shoreline.
- 203 RP at risk from erosion: minimum of 20 m from present-day shoreline.
- Port Long Road (~250 m at risk): minimum of 15 m from present-day shoreline.
- Six unnamed side roads in Seatown off Port Long Road (~20 m at risk): minimum of 20 m from present-day shoreline.
- Unnamed road/path leading to footbridge over Burn of Cullen (~30 m at risk): minimum of 16 m from present-day shoreline.



**Figure A-4: CMU 3 (Beach East built structures) coastal hazards map showing SEPA flooding extents and Dynamic Coast (DC) past and future erosion. Inset shows unit without coastal hazards.**

**Table A-4: CMU 3 Dynamic Coast erosion data summary.**

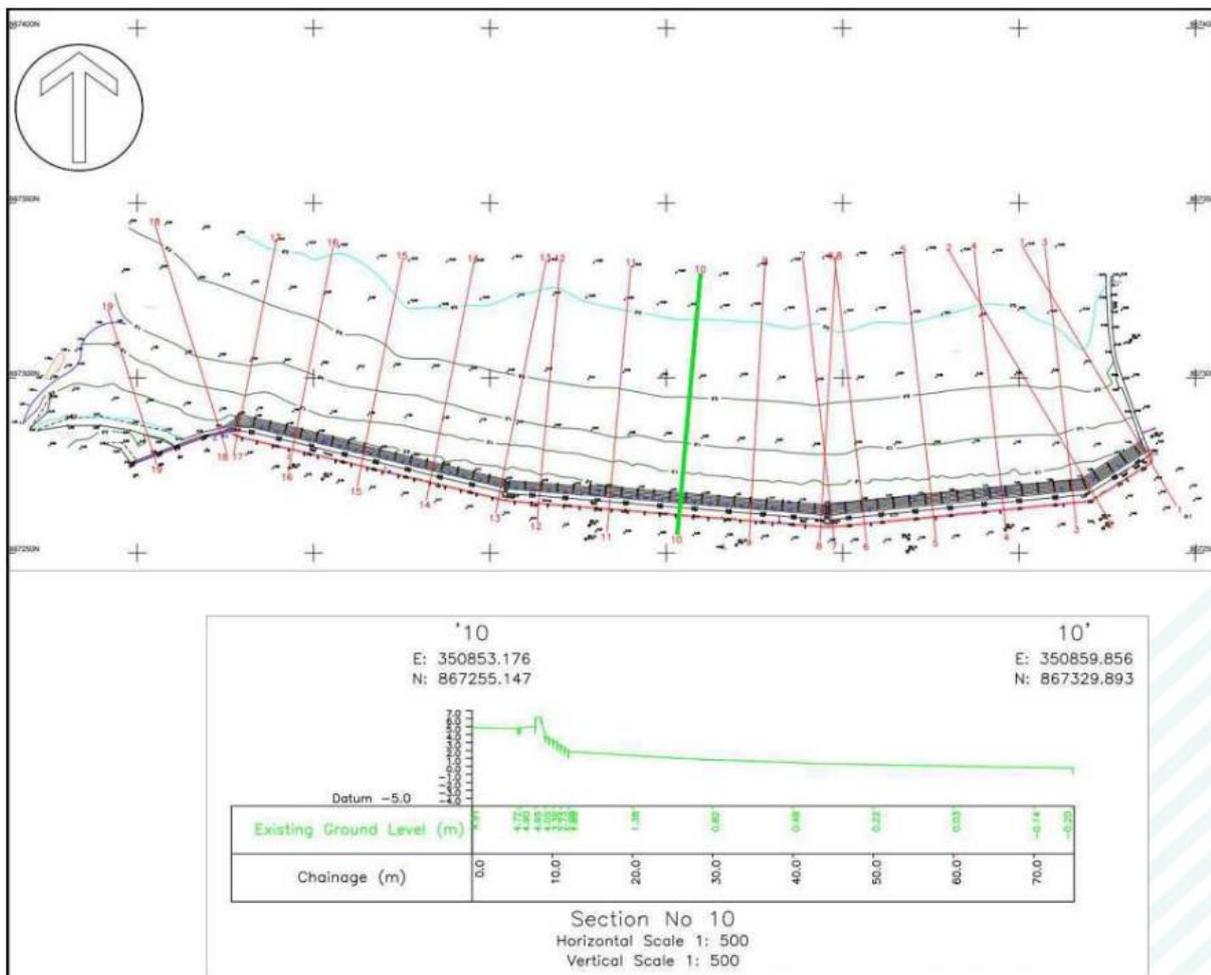
Dynamic Coast calculation	Results	
Historical rate (m/yr)	1.1	Maximum
	0.6	Median
2050 rate (m/yr)	1.1	Maximum
	0.9	Median
2050 distance (m)	29.1	Maximum
	25.3	Median
2100 rate (m/yr)	1.0	Maximum
	0.0	Median
2100 distance (m)	43.4	Maximum
	26.0	Median

#### **A.4.2 CMU 3 seawall overtopping assessment**

The overtopping assessment has been undertaken for the seawall with a stepped revetment in CMU 3. At this location, overtopping volumes have been calculated based on the following cross-shore profile survey, undertaken by Moray Council in November 2022 (Figure A-5).

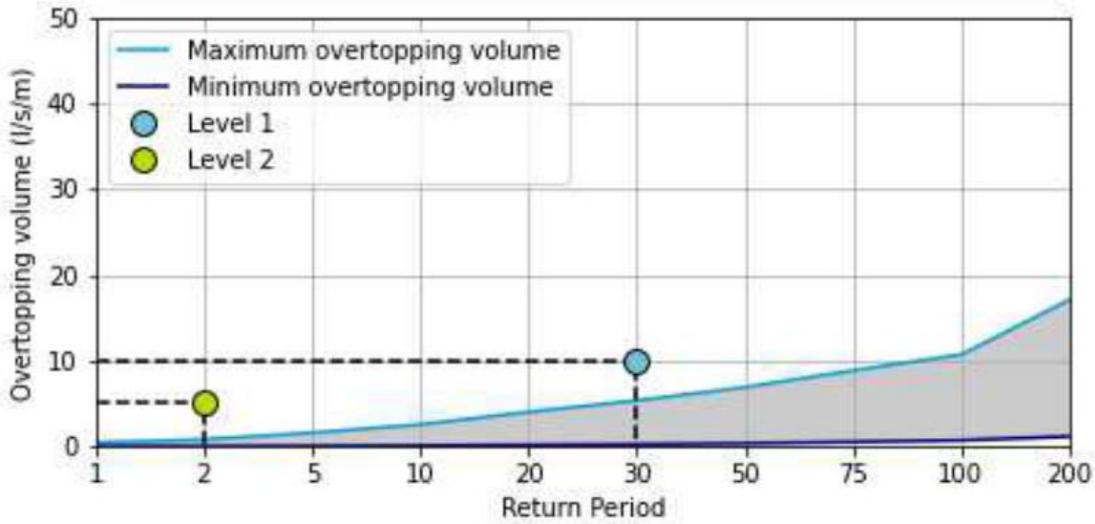
Several schematic representations were tested to understand the potential variability in overtopping predictions. These were:

- Cross-sectional profile no. 10 (6.2 mAOD crest level, 1.0 mAOD toe level).
- Cross-sectional profile no. 10 with no return (recurve) wall (6.2 mAOD crest level, 1.0 mAOD toe level).
- Cross-sectional profile no. 10 with lower toe to account for beach variability (6.2 mAOD crest level, 0.0 mAOD toe level).

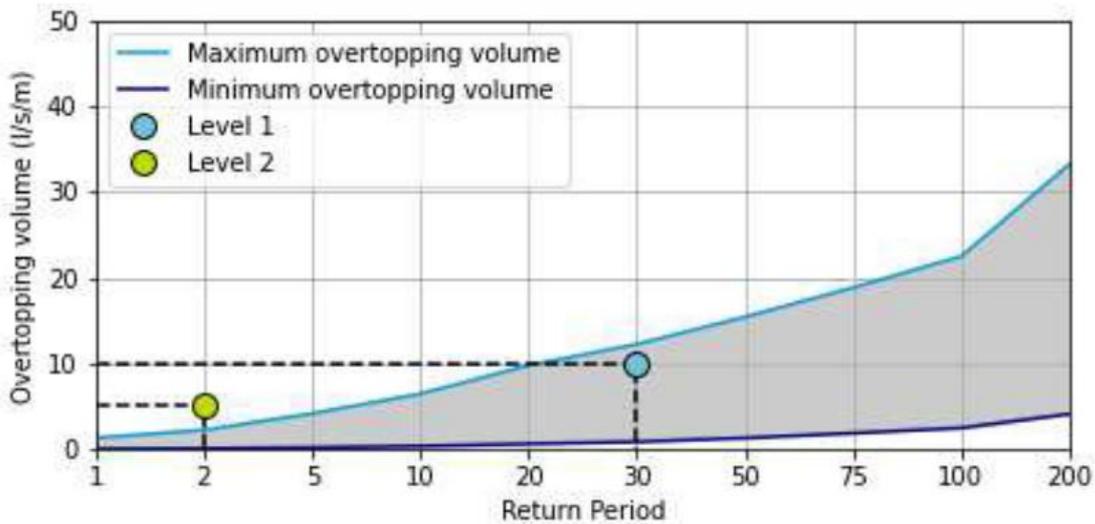


**Figure A-5: Overtopping profile location at Cullen.**

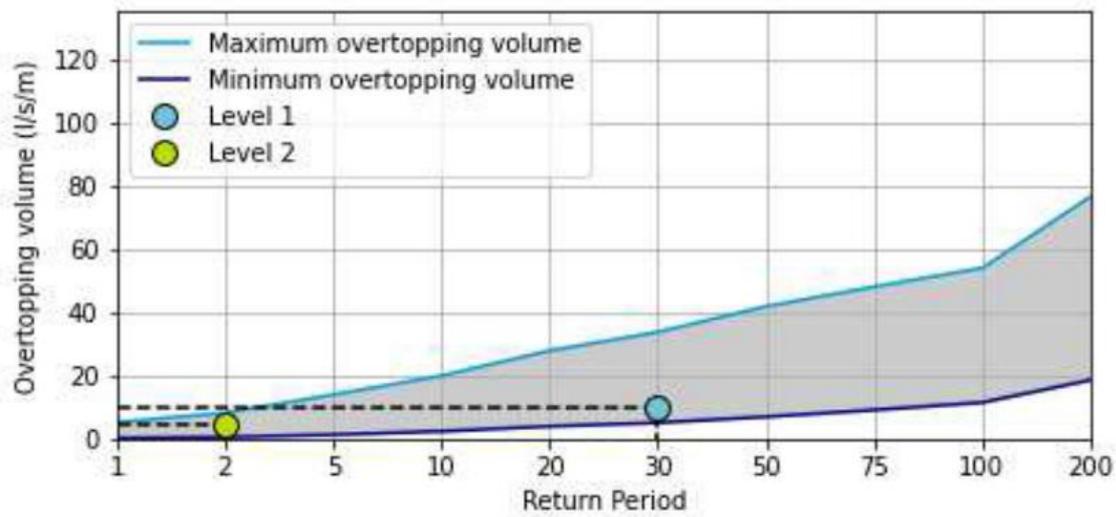
Results from the overtopping assessment for all four sea level rise scenarios are shown in Figure A-6 to Figure A-9 and correspond to Table 4-1 in the main report.



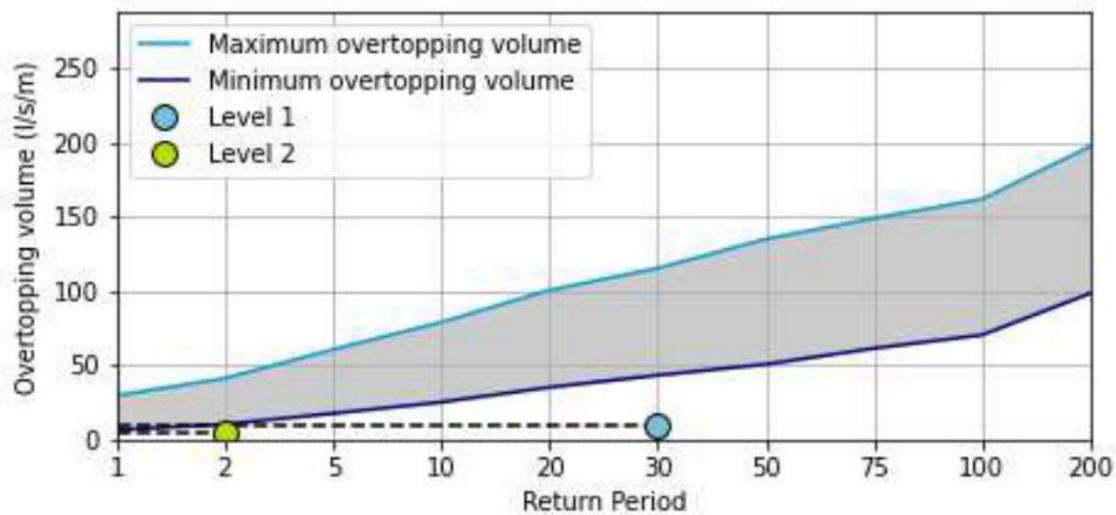
**Figure A-6: Upper and lower overtopping volume estimates for the seawall with stepped revetment in CMU 3 with a 0 m sea level rise projection (present-day). Overtopping triggers plotted for 1 in 30-year and 1 in 2-year return period events.**



**Figure A-7: Upper and lower overtopping volume estimates for the seawall with stepped revetment in CMU 3 with a 0.2 m sea level rise projection. Overtopping triggers plotted for 1 in 30-year and 1 in 2-year return period events.**



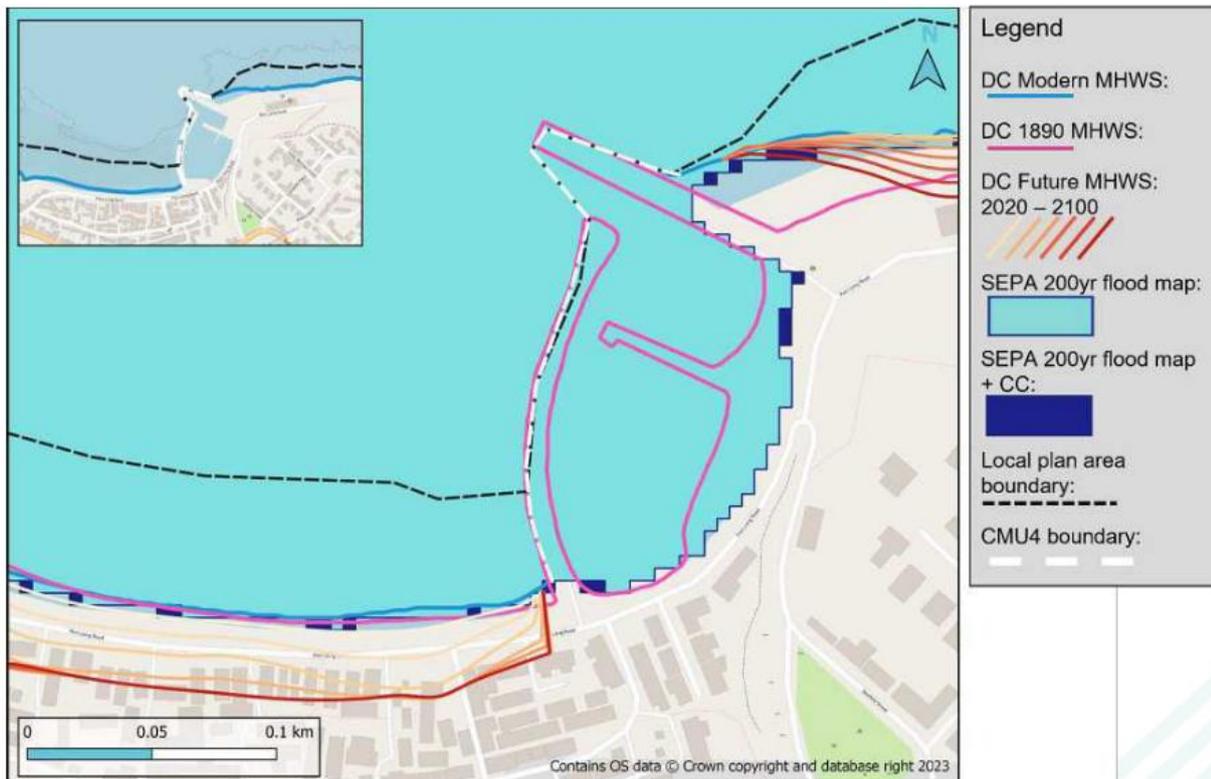
**Figure A-8: Upper and lower overtopping volume estimates for the seawall with stepped revetment in CMU 3 with a 0.5 m sea level rise projection. Overtopping triggers plotted for 1 in 30-year and 1 in 2-year return period events.**



**Figure A-9: Upper and lower overtopping volume estimates for the seawall with stepped revetment in CMU 3 with a 1 m sea level rise projection. Overtopping triggers plotted for 1 in 30-year and 1 in 2-year return period events.**

### A.5 CMU 4: Cullen Harbour - built structures

CMU 4 consists of Cullen Harbour which is a mix of concrete and stone walls. It provides flood and erosion protection to the properties and roads behind. Due to the built structures, there is no data available from Dynamic Coast. As a result, the hazard is unknown from coastal erosion in this unit, to the land and to assets. SEPA flood maps show there is currently no identified risk from flooding at CMU 4.



**Figure A-10: CMU 4 (Cullen Harbour) coastal hazards map showing SEPA flooding extents and Dynamic Coast (DC) past and future erosion. Inset shows unit without coastal hazards.**

### A.6 CMU 5: Beach East - hybrid

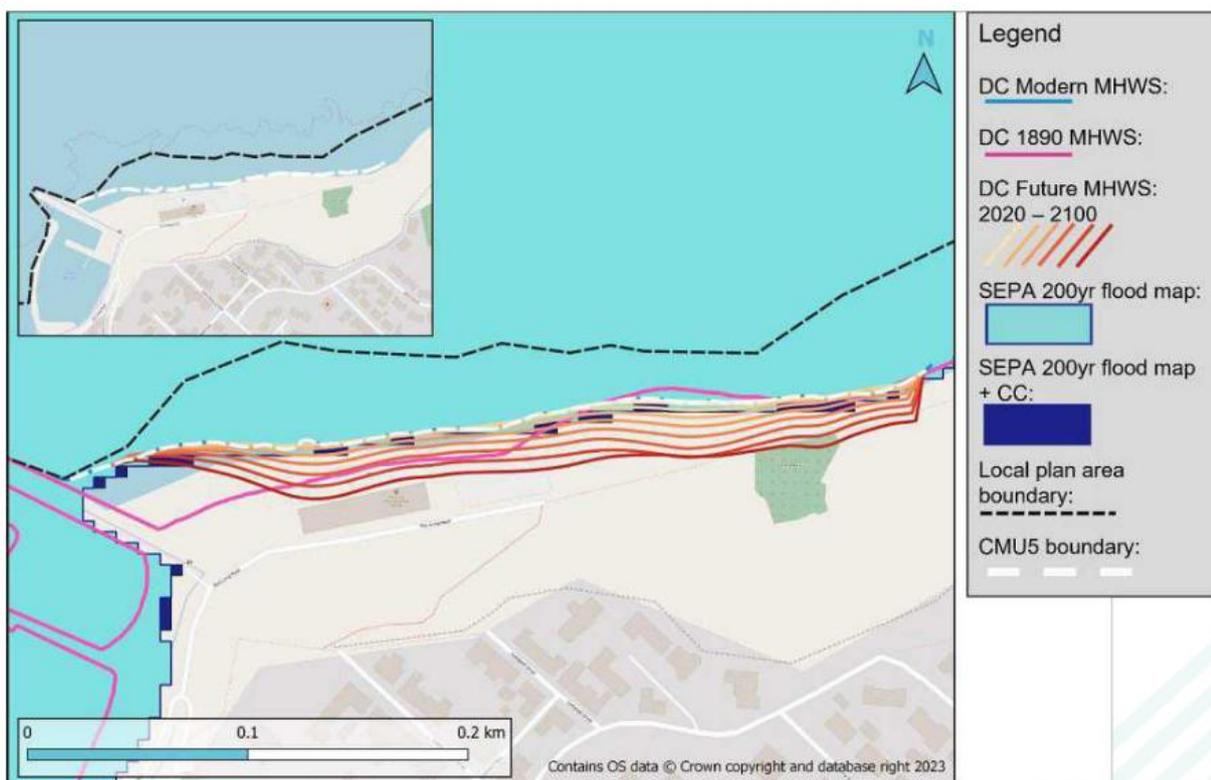
The coast along CMU 5 is mostly natural and formed of shingle beaches and exposed rocky shore platforms. There is a carpark defended with rock revetment in the eastern end of CMU 5. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding. Most properties are located on top of a cliff, at an elevation at least 20 m higher than present-day sea level and situated, at minimum, 80 m inland from the present-day-coastal edge. Port Long Road, the pet’s cemetery, a carpark, and some non-residential properties including a recycling centre sit at a lower elevation, seaward of the cliff.

Results from Dynamic Coast show this CMU is at risk from coastal erosion. Dynamic Coast data shows that, historically (from ca. 1964 to 2011), this part of the Cullen to Muckle Hythe Coast CA has experienced a maximum erosion rate of only 0.1 m/yr. Maximum future erosion rates are expected to increase to 0.4 m/yr by 2050 and 0.6 m/yr by 2100. This would result in a maximum of ca. 30 m of shoreline retreat causing land loss by 2100. Table A-5 summarises Dynamic Coast data for CMU 5.

Assets in this CMU which lie within the Dynamic Coast erosion extent under the RCP8.5 scenario are summarised below:

- Two RP at risk from erosion: minimum of 20 m from present-day shoreline.
- 20 NRP at risk from erosion: minimum of 26 m from present-day shoreline.
- Car park: minimum of 10 m from present-day shoreline
- Coastal path at eastern end of Port Long Road (~95 m at risk): minimum of 13 m from present-day shoreline

There is no erosion risk to residential and non-residential properties.



**Figure A-11: CMU 5 (Beach East Hybrid) coastal hazards map showing SEPA flooding extents and Dynamic Coast (DC) past and future erosion. Inset shows unit without coastal hazards.**

**Table A-5: CMU 5 Dynamic Coast erosion data summary.**

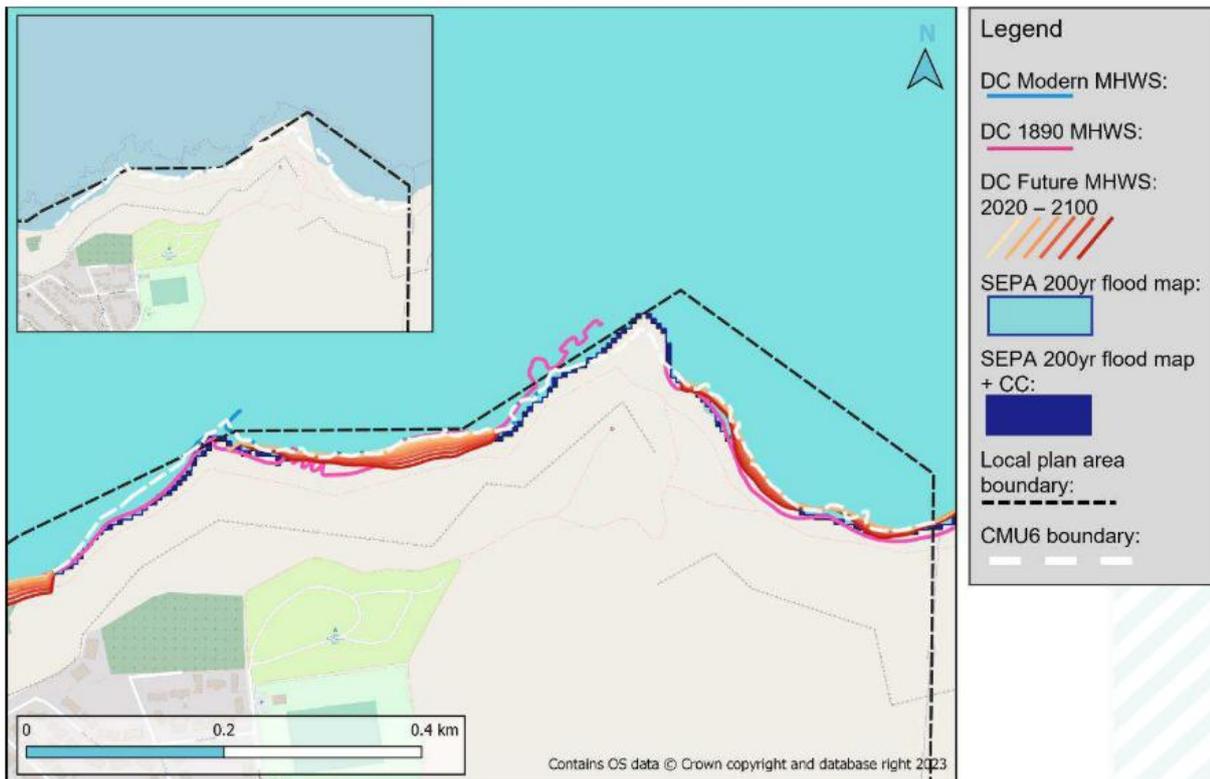
Dynamic Coast calculation		Results	
Historical rate (m/yr)	rate	0.1	Maximum
		0.0	Median
2050 rate (m/yr)	rate	0.4	Maximum
		0.2	Median
2050 distance (m)	rate	8.9	Maximum
		4.0	Median
2100 rate (m/yr)	rate	0.6	Maximum
		0.5	Median
2100 distance (m)	rate	28.4	Maximum
		25.5	Median

### A.7 CMU 6: Beach East - natural

The coast along CMU 6 is formed of shingle beaches and exposed rocky shore platforms. There are also areas of vegetated shingle. This unit is natural, with no engineered structures in place. SEPA flood maps and NFRA datasets show negligible risk from coastal flooding to land and assets.

Like CMU 5, at CMU 6 most properties, including Cullen Bay Caravan Park, are located on top of an ancient cliff, at an elevation at least 40 m higher than present-day sea level and situated, at minimum, 100 m inland from the present-day-coast. There are no assets sat seaward of the cliff at CMU 6.

Results from Dynamic Coast show this CMU is at risk from coastal erosion. Dynamic Coast data shows that, historically (from ca. 1964 to 2011), this part of the Cullen to Muckle Hythe Coast CA has experienced a maximum erosion rate of only 0.1 m/yr. Maximum future erosion rates are expected to increase to 0.3 m/yr by 2050 and 0.5 m/yr by 2100. This would result in a maximum of ca. 26 m of shoreline retreat by 2100. Table A-6 summarises Dynamic Coast data for CMU 6. Despite the retreating shoreline, there is no erosion risk in this CMU as no assets lie within the Dynamic Coast future erosion extent under the RCP8.5 scenario.



**Figure A-12: CMU 6 (Beach East Natural) coastal hazards map showing SEPA flooding extents and Dynamic Coast (DC) past and future erosion. Inset shows unit without coastal hazards.**

**Table A-6: CMU 6 Dynamic Coast erosion data summary.**

Dynamic Coast calculation	Results	
Historical rate (m/yr)	0.1	Maximum
	0.1 (accretion)	Median
2050 rate (m/yr)	0.3	Maximum
	0.1	Median
2050 distance (m)	6.2	Maximum
	0.6	Median
2100 rate (m/yr)	0.5	Maximum
	0.3	Median
2100 distance (m)	25.7	Maximum
	12.6	Median

## B Proactive Actions

### Action 1 – Develop modelling framework to support future assessments.

Implementation of effective future risk assessments will require investment in numerical (or similar) modelling tools that can effectively and efficiently quantify flood and erosion risk. A modelling framework should be developed that includes:

- Statistical extremes
- Wave transformation
- Morphodynamics and erosion
- Flood inundation



### Action 2 – Establish coordinated and consistent beach monitoring plan for CMUs 1, 2, 3, 5.

The requirements for monitoring the beach systems in the CA should be reviewed in the context of a wider Regional monitoring plan. Information should be collected through monitoring that is specific to support future risk assessments and compared to CMU specific erosion triggers.



### Action 3 – Adaptation and resilience workshop with local community and stakeholders.

Adaptation to coastal change is not solely about physical interventions in coastal communities. Community and individual responsibility to increase resilience and adapt to coastal hazards is of paramount importance.

The outcomes of this initial phase of the CCAP should be presented to the community and stakeholders alongside consideration for wider support and education around climate awareness and flood resilience.



**Action 4 – Identify landownership and safeguarding.**

To work with natural processes and make space for coastal change it is inevitable that existing land will be lost. To adapt effectively it is therefore important that land and asset ownership within the CA is fully understood to enable safeguarding of areas. This should feed into revisions of the wider Moray Council Local Development Plan.



## C Trigger and Action Database

Table C-1: Phase 0 Trigger and Action database for Cullen to Muckle Hythe Coast.

Community Area (CA)	CMU	Coast Type	Trigger Type	Asset Affected	Asset Description	Trigger Level	Trigger Exceeded?	Trigger Buffer Flooding (Freq/10 yr)	Trigger Buffer Overtopping (SLR m)	Trigger Buffer Erosion (m)	Action	Owner	Delivery Partners	Timescale	Cost
Cullen to Muckle Hythe Coast	1	Natural	Erosion	Other	Golf Course	1	Y			-13	Increase monitoring and plan for assessment.	Moray Council	Cullen Golf Club	Short	Low
						2	Y			-5	Undertake assessment and plan for intervention.	Moray Council	Scot. Gov.	Medium	Medium
	2	Hybrid	Erosion	Property		1	Y			-43	Increase monitoring and plan for assessment.	Moray Council	None	Short	Low
						2	Y			-16	Undertake assessment and plan for intervention.	Moray Council	Scot. Gov.	Medium	Medium
				Other	Carpark	1	Y			-12	Increase monitoring and plan for assessment.	Moray Council	None	Short	Low
						2	Y			-3	Undertake assessment and plan for intervention.	Moray Council	Scot. Gov.	Medium	Medium
			Condition	Defence	Sea wall	1	N				None	NA	NA	NA	NA
						2	N				None	NA	NA	NA	NA
	3	Built Structures	Erosion	Defence	Sea wall	1	N			1.4	None	NA	NA	NA	NA
						2	N			1.4	None	NA	NA	NA	NA
			Overtopping	Defence	Sea wall	1	N			0.2	None	NA	NA	NA	NA
						2	N			0.5	None	NA	NA	NA	NA
			Condition	Defence	Sea wall	1	N				None	NA	NA	NA	NA
						2	N				None	NA	NA	NA	NA
	4	Built Structures	Condition	Defence	Harbour	1	N				None	NA	NA	NA	NA
						2	N				None	NA	NA	NA	NA
	5	Hybrid	Erosion	Property		1	Y			-12	Increase monitoring and plan for assessment.	Moray Council	None	Short	Low
						2	Y			-2	Undertake assessment and plan for intervention.	Moray Council	Scot. Gov.	Medium	Medium
				Other	Carpark	1	Y			-2	Increase monitoring and plan for assessment.	Moray Council	None	Short	Low
						2	N			1	None	NA	NA	NA	NA
			Condition	Defence	Rock revetment	1	N				None	NA	NA	NA	NA
						2	N				None	NA	NA	NA	NA
	6	Natural					N				None	NA	NA	NA	NA

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