REPORT

Fishbourne Footpath, Chichester Harbour

Feasibility Study

Client: Chichester Harbour Conservancy

Reference: PC4445-RHD-XX-XX-RP-X-0001

Status: P05

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P04	12/05/2023	Updated costs	RB	CLM	NJC
P05	16/06/2023	Final issued	CLM	DB	NJC

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Glossary

Apuldram Meadow	The area of land to the east of the embankment and Footpath 3059
Borrow ditch	A ditch adjacent to an embankment created during the construction of the embankment by “borrowing” soil for use in the construction
Brackish	Water than has more salinity than freshwater, but not as much as seawater
Chainage	Distance along an elevation profile
Coastal and floodplain grazing marsh	Periodically inundated pasture or meadow
Coastal defence	Measures to protect the land from flooding or erosion
Coastal erosion	Wearing away or removing of land or structures due to coastal processes
Coastal squeeze	The loss of natural habitats or deterioration of their quality arising from human-made structures or actions, preventing the landward transgression of those habitats that would otherwise naturally occur in response to sea-level rise in conjunction with other coastal processes
Embankment	A raised bank made of earth or building material
Embayment	A bay in the coastline
Enforced embankment	An embankment that is enforced with masonry, concrete, or other building material
Estuary	The tidal mouth of a river
Floodplain	Generally flat area of land next to a body of water that is susceptible to flooding
Footpath 3059	The footpath that runs along the outer edge of the site on top of the embankment
Footpath 555	The footpath that runs diagonally through the site
Habitat	The preferred environment of a plant, animal, or organism
Habitat creation	Creating ecosystems in areas where that ecosystem doesn’t currently exist
Highest astronomical tide	The highest level of water that can be predicted to occur under average meteorological and any combination of astronomical conditions
Intertidal	The area between high and low tides
Land reclamation	Creating new land from the sea
Managed realignment	Managed removal of coastal protection to allow coastal flooding to occur in a controlled manner
Mean high water neap	The average of the high water heights of two successive tides during the neap tide
Mean high water spring	The average of the high water heights of two successive tides during the spring tide
Mean low water neap	The average of the low water heights of two successive tides during the neap tide

Mean low water spring	The average of the low water heights of two successive tides during the spring tide
Mudflat	An area of mud in the intertidal zone
Natural flood and coastal erosion management	When natural processes are used to reduce the risk of flooding and coastal erosion
Nature based solutions	Solutions that are inspired and supported by nature, which are cost-effective, provide environmental, social, and economic benefits and help build resilience
Neap tide	A tide that occurs when there is the smallest height difference between high and low water
Optimism bias	Provides a contingency on costs that accounts for a tendency to underestimate costs/time during the early stages of projects
Ramsar	A wetland site designated to be of international importance under the Ramsar Convention
Reedbed	An area of water or marshland dominated by reeds
Return period	An average or estimated time between events of the same magnitude
Saltmarsh	A vegetated area of wetland that is flooded and drained by the tide
Seawall	A wall or embankment that prevents the sea flooding or eroding the land
Sediment supply	The amount of sediment that is supplied to a coastal environment by coastal processes
Spring tide	A tide that occurs when there is the greatest height difference between high and low water
Still Water Level	The average water level at any given time, excluding local variation due to waves
Tidal surge	A rise in water levels due to the combination of the astronomical tide and storm surges

Acronyms

AONB	Area of Outstanding Natural Beauty
BAP	UK Biodiversity Action Plan
CFBD	Coastal Flood Boundary Dataset
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
FCERM	Flood and Coastal Erosion Risk Management
HAT	Highest Astronomical Tide
LiDAR	Light detection and ranging
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
OD	Ordnance Datum
PLC	Permits, licences and consents
RCP	Representative Concentration Pathway
RHCP	Habitat Compensation and Restoration Programme
SAC	Special Area of Conservation
SFRA	Strategic Flood Risk Assessment
SGN	Southern Gas Network
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
UKCP18	United Kingdom Climate Projections 2018

Executive Summary

Chichester Harbour is in an 'unfavourable declining' condition due to a long-term loss of saltmarsh. This trend is predicted to continue as the presence of hard defences along much of the harbour's coastline are physically restricting the landward movement of the coastline and associated saltmarsh habitats. At the same time, the condition of the harbour's coastal defences are deteriorating creating weak spots that are likely to be breached in the near future, allowing coastal waters to flood low-lying land, putting properties and infrastructure at risk. The challenge for any future coastal management strategies is to maintain a level of flood defence whilst supporting nature and habitat recovery.

At Fishbourne, the coastal defences fronting Apuldram Meadow are in poor condition and were damaged during Storm Eunice in February 2021. This led to the closure of the footpath running along the embankment. Loss of the footpath, alongside ongoing ecosystem and flood risk challenges was a trigger point and Royal HaskoningDHV were commissioned by Chichester Harbour Conservancy, with funding provided by the Environment Agency, to undertake a feasibility study at Apuldram Meadow to evaluate the condition of the existing defences, and propose a range of potential solutions for their future management that aim to maximise environmental and recreational benefits.

The existing defence was inspected by a coastal engineer, and it was determined that the section running along the southern and western boundary of Apuldram Meadow was in poor condition and had a high potential of failing, particularly at the south-west corner where storm damage had removed blockwork allowing waves to erode the inner core of the embankment. Using predictions of future water levels that account for rising sea levels, a flood risk assessment was undertaken that showed if the embankment was breached, flooding would extend inland and effect a range of assets, including existing footpaths, a freshwater stream, a gas pipe buried below the site, existing grassland habitats, the Apuldram Wastewater Treatment Works, residential housing, Apuldram Lane and surrounding agricultural land.

To determine if the site would develop into saltmarsh if the embankment was breached, an assessment of coastal setting was undertaken to establish the existing land levels, habitats, tidal regime and site history. The results showed that saltmarsh could be created and develop to cover an area of up to 5 hectares over the next 100 years.

A long list of options was considered and after a high-level review of the opportunities and constraints of each, three options were shortlisted for a more detailed appraisal and costing exercise. Option 1 is a "Do Nothing" approach which sets out what will happen to the site without intervention. This is not a recommended option due to the unmanaged flood risk to local infrastructure and important habitats but was included as a baseline to assess other options against.

Option 2 proposes repairing the existing embankment to maintain the defence in its current configuration. The cost implication of this option is estimated to be of the order of £458,000 if an in situ concrete cast solution is used. If implemented, this will maintain the level of flood defence and reinstate access to the existing footpath. This approach provides a solution for weak spots but due to the overall deteriorating condition of the defence, continued repair (and funding) will be required as other sections of the embankment degrade. This option will not address the 'unfavourable declining' condition of saltmarsh across Chichester Harbour and if the current rate of loss continues, there will be no saltmarsh at Apuldram within the next 25 years. Loss of saltmarsh habitat will have a knock-on effect on local bird and wildlife, changing the local ecosystems and natural beauty.

Option 3 proposes managed realignment of the site which would allow inundation of the coast in a controlled manner. Considering the flood risk, a new defence would be required, located further inland to protect key assets. The configuration of this defence can tie into the natural topography of the site, creating a more

sinuous, natural structure. Locating a new footpath on top of the defence will maintain the footpath length across the site and provide a similar view across the Fishbourne Channel. The area of land directly in front of the defence can be flooded in a controlled manner either by breaching the existing defence at the weak points, or by removing the embankment completely allowing the saltmarsh to develop unconstrained. This option leaves the northern embankment in place for the short-term creating a causeway and lookout into the Fishbourne Channel. A managed realignment solution aligns with the ambitions of various Government policies and will provide a nature-based solution that improves biodiversity.

The cost estimate for a managed realignment scheme at Fishbourne is in the region of £605,000 (including 60% optimism bias) which is a potential financial constraint. The presence of a high-pressure gas pipe below the site is a significant constraint and engagement with Southern Gas Network is required at an early stage to determine the feasibility of constructing the new defence as additional measures may be required to divert or protect the pipeline.

Considering the opportunities and constraints of all options, managed realignment is the preferred approach to manage the challenges at Apuldram Meadow as it provides an opportunity to be proactive and prepare for future change by creating new habitats and space for the coast to adapt sustainably and naturally.

The information and findings presented in this report are based on work undertaken by Royal HaskoningDHV.

1 Introduction

Royal HaskoningDHV (RHDHV) was commissioned by Chichester Harbour Conservancy to undertake a Feasibility Study to assess options for future management of Footpath 3059 and adjacent land at Apuldram Meadow, located to the south of Fishbourne Parish. This study was commissioned following damage to the embankment underpinning Footpath 3059 during Storm Eunice in February 2022 which resulted in closure of the footpath for safety reasons.

1.1 Study Area

Chichester Harbour is nationally and internationally recognised for the complexity of its marine and estuarine habitats. At the eastern margin of Chichester Harbour is the Fishbourne Channel which is separated in several locations from adjacent land to the east by a series of embankments. Footpath 3059 is located to the south of Fishbourne Parish and sits on top of one of these embankments (Figure 1-1). The embankment encloses an area of low-lying land to the east that is referred to here as the Apuldram Meadow. The study area covered by this Feasibility Study includes the land at Apuldram Meadow and parts of Footpath 3059 that run along the western boundary of the meadow. The land is owned by Chichester Harbour Trust and managed by Chichester Harbour Conservancy.

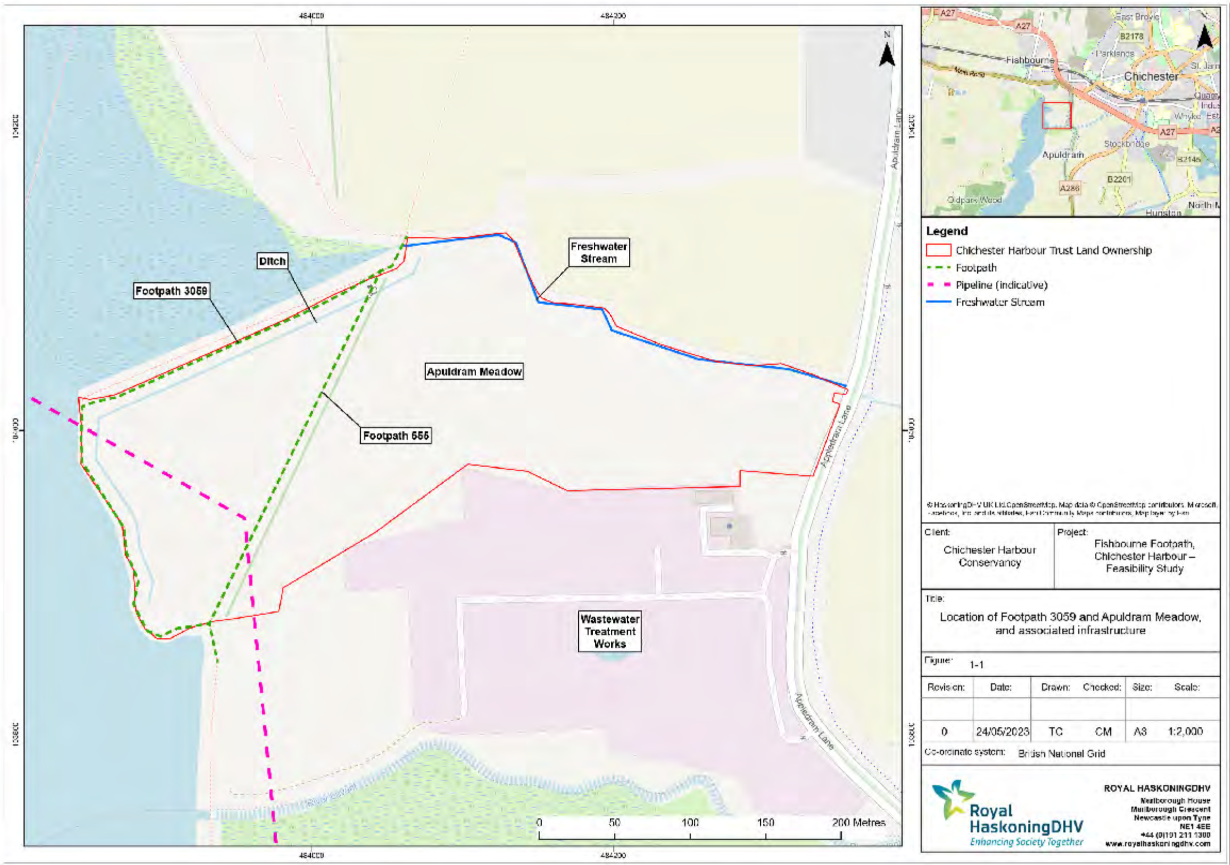


Figure 1-1 Location of Footpath 3059 and Apuldram Meadow, and associated infrastructure

1.2 Background and context

Chichester Harbour is located on the south coast of England and is the largest designated area within National Character Area 126, the South Coast Plain, (Natural England 2014). The following nationally and internationally important and locally designated sites overlap with Chichester Harbour, demonstrating its importance both nationally and globally for its coastal ecosystems and the services they provide:

- Chichester Harbour Area of Outstanding Natural Beauty (AONB)
- Chichester Harbour Site of Special Scientific Interest (SSSI)
- Chichester and Langstone Harbours Special Protection Area (SPA)
- Chichester and Langstone Harbours Ramsar site
- Solent Maritime Special Area of Conservation (SAC)
- Chichester Harbour Amenity Area – designated under the 1971 Chichester Harbour Conservancy Act
- Nutbourne Marshes, Pilsey Island and Thorney Deeps Local Nature Reserves
- West Wittering Bathing Water
- Chichester Harbour Shellfish Waters (Chichester Channel, Thornham Channel and Emsworth Channel).

In February 2021, Natural England published its Condition Review of the Chichester Harbour SSSI (NERR090) (Bardsley et al. 2021) and through a combination of desk-based evidence reviews and field surveys, they assessed the condition of the harbour's special habitats and species (known as notified features). Overall, the main intertidal habitat features were assessed as being in 'unfavourable declining' condition largely due to the continued loss of the extent of saltmarsh and the poor quality of saltmarsh and mudflat habitat. The Condition Review highlighted the need to remove barriers to coastal change caused by inappropriate coastal management which are resulting in saltmarsh erosion due to coastal squeeze and the interruption of sediment supply.

Considering the ambitions of Defra's 25-year plan for the Environment (Defra 2018), any plans for restoration of Chichester Harbour AONB should include reducing risks from flooding and coastal erosion by expanding the use of natural flood management solutions, and nature recovery through protection, conservation and enhancing natural beauty.

The National Character Area Profile for the South Coast Plain (including Chichester Harbour) (Natural England 2014) also recognised the need to manage the effects of coastal change by allowing the operation of natural coastal processes and improving the sustainability of current management practices along the coastline to successfully integrate the needs of the natural environment, landscape, local communities, agriculture, tourism, and recreation.

Damage to the already deteriorating embankment underpinning Footpath 3059 during Storm Eunice in February 2022 has prompted a review of the coastal management options for the embankment and Apuldram Meadow considering the ambitions and policies governing the future of Chichester Harbour AONB.

1.3 Scope

This Feasibility Study provides a high-level investigation of the potential engineering options for the future management of the embankment underpinning Footpath 3059 and the adjacent land at Apuldram Meadow. The suitability of different options depends on the physical, ecological, cultural, and socio-economic factors at the site. As such, a baseline environmental characterisation has been undertaken which forms the basis to assess the opportunities and constraints for each option.

Royal HaskoningDHV

2 Site Walkover

A site walkover was undertaken on 27th January 2023 to assess the condition of the embankment and provide an overview of the environmental setting. The Apuldram Meadow covers an area of approximately 0.065 km^2 (6.5 ha) and the embankment running along the northern and western boundaries of the site is 0.45 km long (Figure 1-1). The land in Apuldram Meadow to the east of the embankment is low lying and a ditch (flooded during the site walkover) runs alongside the embankment on the landward side. The land gently rises towards the east and is partially compartmentalised by a row of trees and hedges that run alongside Footpath 555 (Figure 2-1). At the time of the site walkover, the main vegetation across the site was grassland.

Infrastructure and environmental features in or immediately adjacent to the site include:

- Wastewater treatment works immediately south of the site;
- A concrete outfall through the embankment (Figure 2-2);
- A public footpath which crosses the centre of the site (Footpath 555);
- A freshwater stream (Fishbourne Stream) which runs along the northern boundary of the site and enters the Fishbourne Channel via a sluice;
- A buried gas pipe which runs under part of the site (location given in Figure 1-1); and,
- A minor road which runs parallel to the eastern margin of the site.

Figure 2-1 Treeline running alongside Footpath 555 and coastal grazing marsh in Apuldram Meadow

Figure 2-2 Embankment along the northern boundary of the site

3 Condition of Existing Coastal Defences

During the site walkover a visual inspection of the coastal defences along the embankment was undertaken to appraise the current condition and identify sections that have failed and sections that appear to be at risk of failing, potentially during the next large storm or through ongoing deterioration. A summary of the findings is presented below.

3.1 Visual inspection

The condition of the defences was assessed in line with the Environment Agency Condition Assessment Manual (2012). The condition grading and descriptions are presented in Table 3-1 and are the standards adopted by the Environment Agency for visual inspections of coastal defences. The condition grades range from 'very good' to 'very poor', and the descriptions reflect the condition according to flood defence performance.

Table 3-1: Visual Inspection Condition Grades, Environment Agency Condition Assessment Manual, 2012.

Grade	Rating	Description
1	Very Good	Cosmetic defects that will have no effect on performance.
2	Good	Minor defects that will not reduce the overall performance of the asset.
3	Fair	Defects that could reduce performance of the asset.
4	Poor	Defects that would significantly reduce the performance of the asset. Further investigation needed.
5	Very Poor	Severe defects resulting in complete performance failure.

Based on the findings of the visual inspection the defences have been divided into four sub-sections as indicated on Figure 3-1. A summary of the inspection is presented in Table 3-2**.**

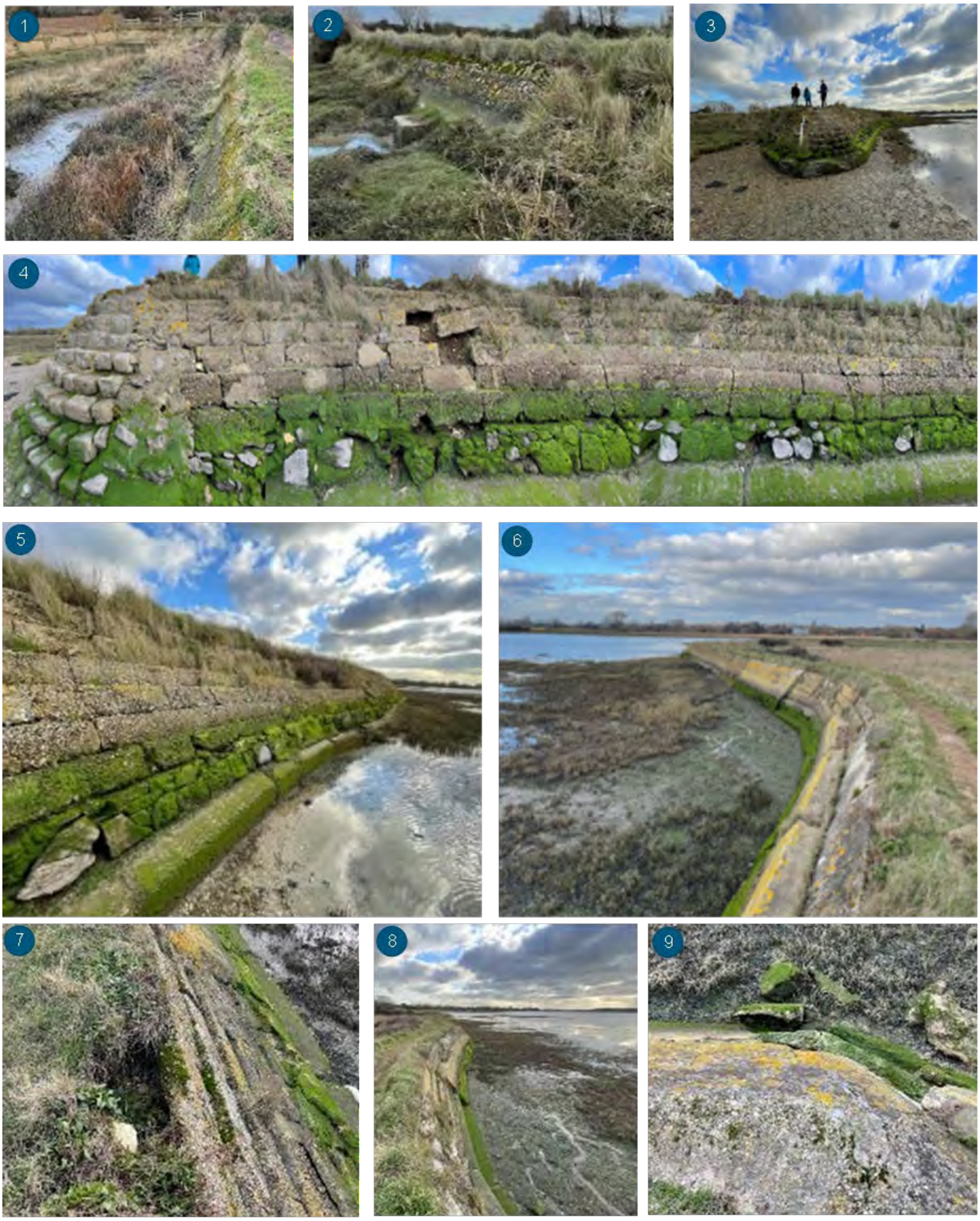
Figure 3-1: Embankment condition assessment, numbers link to photographs shown below

Table 3-2: Summary of condition survey on 27th January 2023

Section	Description of defence and general observations	Defence condition
1	The embankment is 'encased' with concrete and is heavily vegetated along the top and the base (photos 1 & 2). Vertical cracks are present along with some localised scour at the base but generally the wall appears to be relatively stable with no signs of imminent failure.	2 – Good
2	The embankment is faced with a mixture of concrete and stone blockwork forming a transition in form from Section 1 (photo 3). A concrete apron runs along the base of the embankment holding up the blockwork. There are clear signs of patch repair works along the section using what appears to be concrete where blockwork has failed and boulders of various sizes to fill voids. Cracks are present along most of the section and blockwork has slumped and in some places is missing altogether (photos 4 & 5) exposing the earth fill material behind. Large voids are present along the apron in multiple locations. These voids sit within the intertidal zone leaving them susceptible to scour.	4 – Poor
3	The embankment is faced with a mixture of concrete and stone blockwork like Section 2. The concrete apron also continues. Voids are starting to form along the crest of the embankment (photo 7). At the corner, the embankment changes form again to what appears to be concrete 'encasement' like Section 1 (photo 8). The encasement has failed in some locations (photo 9) and vertical cracks are present.	4 – Poor

Section	Description of defence and general observations	Defence condition
4	The embankment in this section transitions back to a predominantly concrete blockwork wall with a couple of concrete ‘encasement’ areas which appear to be previous repair works. The blockwork wall has failed at the corner exposing the earth fill material behind. There are signs of voids along the crest of the embankment and the blockwork is missing in places. Towards the eastern end of this section is another failed section which has exposed the earth fill material behind (photo 14). The blockwork on either side of this section is loose and in placed failed (photo 13).	4 - Poor

3.2 Photographs



4.1 Deterioration

Damage to the coastal defences has not been caused solely by large storms such as Storm Eunice; gradual degradation of the defence was also observed. The images in Figure 4-1 show the same section of defence. The image to the left was taken in November 2022 (courtesy of Uwe Dornbusch) and the image to the right was taken during the site visit in January 2023. Over a period of a few months, the upper blockwork has collapsed exposing the inner core of the embankment which comprises soil and sediment that will be more susceptible to erosion by normal tidal conditions, increasing the rate of deterioration.

There are several smaller areas along the coastal defence where the external blockwork has been removed (Figure 4-2). These areas will likely degrade rapidly over a period of months to years, compromising the overall function of the coastal defence.

Figure 4-1 Left image shows condition of the coastal defence in November 2022 and right image is the same section of defence in January 2023

Figure 4-2 Emerging zones of weakness along the coastal defence that are more susceptible to deterioration (courtesy of Uwe Dornbusch)

4.2 Legal Owners and Maintainers of Defences

The legal responsibilities for the coastal defences holding the line around Chichester Harbour are difficult to define. The Environment Agency's Asset Information and Maintenance System (AIMS) (Environment Agency 2023) provides partial coverage of coastal defences around Chichester Harbour that are currently owned, managed or inspected by the Environment Agency and other organisations (JBA Consulting, 2022) (Figure 4-3). According to the AIMS dataset, the Environment Agency are responsible for maintaining the coastal defences running along the boundaries of Apuldram Meadow.

Figure 4-3 Asset maintainer as defined by the AIMS data around the Chichester Harbour coast (source: Environment Agency)

5 Site Characteristics

This section provides a high-level overview of the baseline functions and natural characteristics of the site providing the physical context for potential future management options.

5.1 Coastal Setting

Chichester Harbour is a sheltered embayment comprising multiple estuarine channels. The Fishbourne Channel is the most eastern channel within Chichester Harbour and extends approximately 6.5 km south from Fishbourne to West Itchenor where it joins the Chichester Channel and wider harbour.

The site is located adjacent to the upper Fishbourne Channel which is dominated by mudflats fringed by narrow stretches of saltmarsh with some areas of reedbed. The shorelines along the eastern and western side of the channel are classified by Dornbusch (2022) as “protected” by embankments. At the northern limit of the channel, there are no hard coastal defences, and the shoreline is classified as “unprotected” and backed by the rising elevation of the land in the vicinity of Fishbourne parish. The channel is confined by embankments on both sides (restricting any tendency for lateral movement) and is approximately 0.5 km wide at the site.

The elevation of the land at Apuldram Meadow lies below 6 m above Ordnance Datum (OD) and the topography gently rises towards the east (Figure 5-1). There are a series of straight ditches that run adjacent to the embankment and crosscut the meadow extending into the land occupied by the Wastewater Treatment Works to the south. Within the lower parts of the site, there are some subtle sinuous drainage channels that may be relict former intertidal channels that existed before the land was reclaimed. Along the northern boundary of the site, the elevation is lower along the margins of the freshwater chalk stream. If the site was inundated, the drainage ditches and relict channels would be the first to flood creating pathways for the drainage system to evolve.

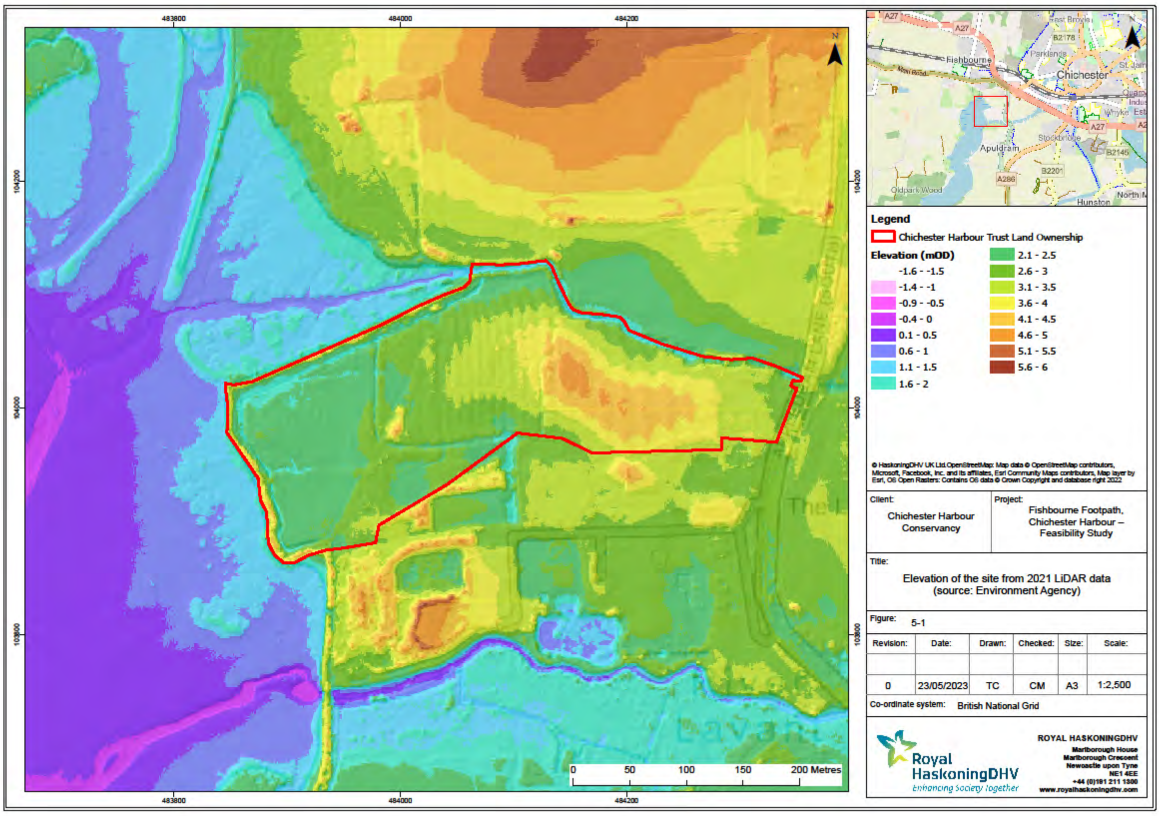


Figure 5-1 Elevation of the site from 2021 LiDAR data (source: Environment Agency)

5.2 Tidal levels and tidal range

The spring and neap tidal datums around Chichester Harbour are presented in Table 5-1 (Admiralty Tide Tables, 2022). Mean high water spring (MHWS) elevation is approximately 2.16 m above OD around most the harbour with mean high water neap (MHWN) at an elevation of about 1.16 m above OD. Highest astronomical tide (HAT) is approximately 2.56 m above OD at the entrance to the harbour. The nearest tidal datum to the Fishbourne Channel is at Dell Quay.

Table 5-1 Tidal datums relative to OD in Chichester Harbour (Admiralty Tide Tables, 2022)

Location	HAT	MHWS	MHWN	MLWN	MLWS
Entrance	2.56	2.16	1.26	-0.84	-1.84
Northney	No data	2.16	1.06	-1.04	-2.24
Bosham	No data	2.16	1.16	No data	No data
Itchenor	No data	2.06	1.06	-1.04	-2.14
Dell Quay	No data	2.16	1.16	No data	No data

5.3 Existing land use and habitats

The land at Apuldram Meadow is grassland and is classified according to the UK Biodiversity Action Plan (BAP) Priority Habitat Descriptions as Coastal and Floodplain Grazing Marsh which is a priority habitat. (Figure 5-2). The defining features of coastal grazing marshes are typically hydrological and topographical rather than botanical. Grazing marsh is defined as periodically inundated pasture or meadow, typically with ditches containing standing brackish water or freshwater, behind a primary embankment or seawall (Rees et al., 2010). Despite the embankments, the ditches and ponds may still be affected by tidal influence and contain standing brackish water or freshwater. The embankments may also be overtopped by waves during large storm events which was the case during Storm Eunice in 2022. The coastal grazing marsh at Apuldram Meadow occupies elevations generally between 2.4 and 4.6 m OD with the lowest elevations of 1.7 m OD in the base of ditches. Coastal grazing marsh can support a diverse range of plants, although agricultural management tends to lower diversity. They also support breeding and wintering birds, as well as birds on passage.

The land at Apuldram Meadow is compartmentalised by a row of trees that run alongside Footpath 555 (Figure 5-3). These trees are a relatively recent addition to the landscape as they are not present in an aerial photograph taken in 1974 (Figure 5-4).

A spring-fed freshwater chalk stream runs along the northern boundary of Apuldram Meadow (Figure 5-3). Chalk streams are rare and have high conservation value for wildlife, water supply, recreation, and culture (WWF 2014). The River Lavant, another important chalk stream is located approximately 150 m to the south of Apuldram Meadow, to the south of the Wastewater Treatment Works. The River Lavant is a Water Framework Directive water body whereas the chalk stream along the northern boundary of the site is classed as a transitional water body, most likely due to its relatively small size.

The Environment Agency's 2013 Water Framework Directive classification shows that the chalk streams running into the Fishbourne Channel are in poor to bad condition. The chalk streams at Fishbourne have been recognised as a Biodiversity Opportunity Area which is a priority area for the delivery of BAP targets with opportunities for wetland habitat management, restoration, and creation (Sussex Biodiversity Partnership 2008).

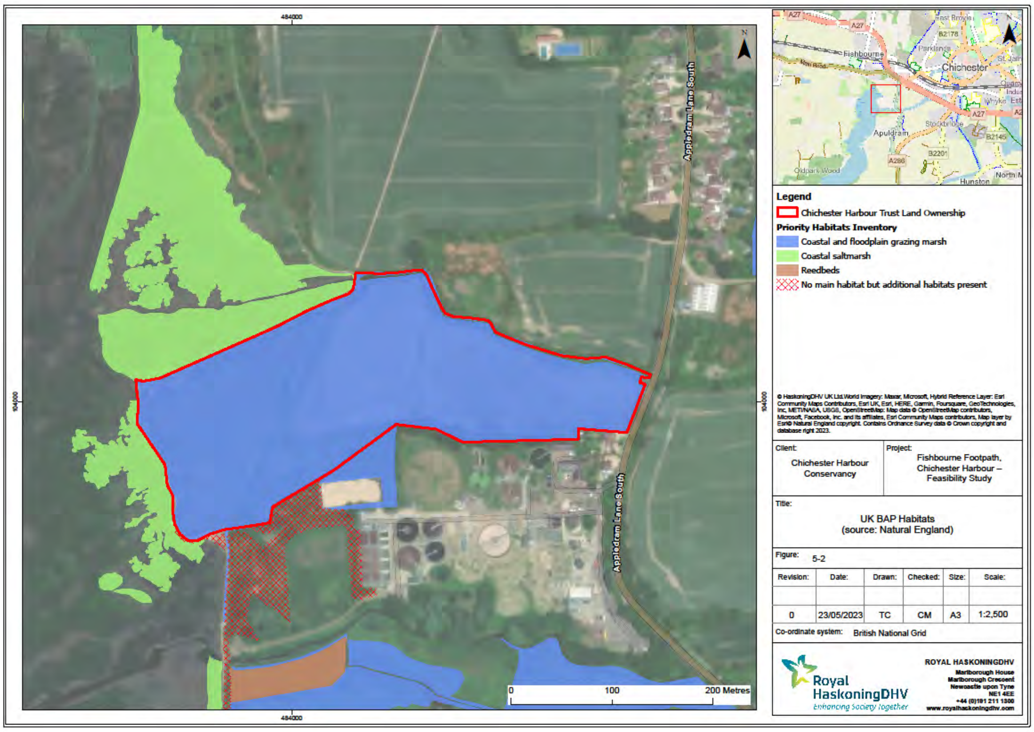


Figure 5-2 UK BAP Habitats at Fishbourne

Figure 5-3 Top left and bottom left shows grassland at Apuldram Meadow; top right shows the freshwater stream to the north; bottom right shows the treeline running across the land (site walkover photographs taken in January 2023).

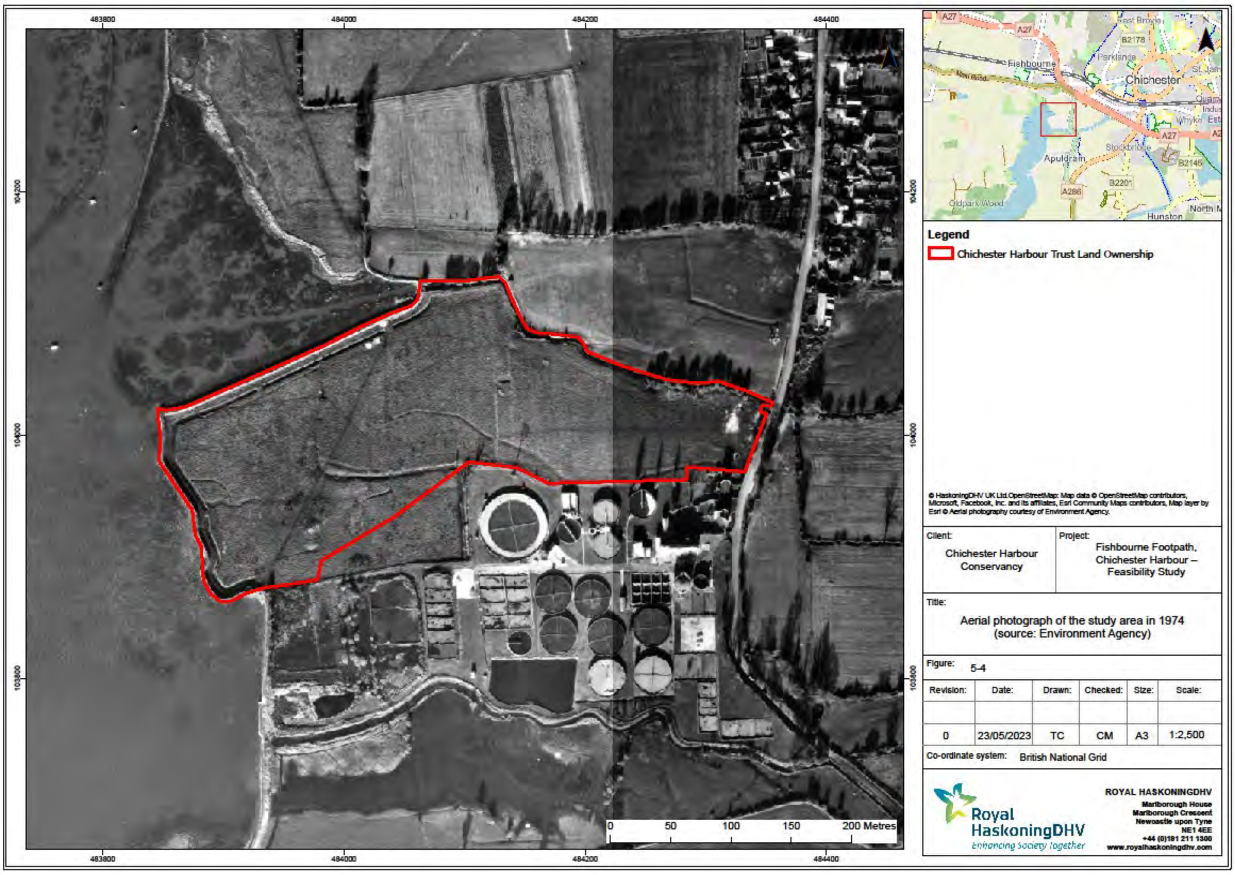


Figure 5-4 Aerial photograph of the study area in 1974 (source: Environment Agency)

The Fishbourne Channel is fringed by saltmarsh (Figure 5-5). The saltmarsh habitat across Chichester Harbour is declining and over the period 1946 to 2018, the extent of saltmarsh habitat has reduced by 60.6% (Lockwood and Drakeford 2021). This decline has occurred adjacent to the site with loss of 1,965 m^2 of saltmarsh between 2008 and 2016 based on Environment Agency data on saltmarsh extent and zonation (Environment Agency 2023)(Table 5-2; Figure 5-6) which is an average rate of 245 m^2 per year. If this rate continues, then the saltmarsh next to the Apuldram Meadow will disappear within the next 30 years, likely sooner due to rising sea levels. This decline is in part due to the presence of fixed structures such as the embankment underpinning Footpath 3059 that causes coastal squeeze which prevents the saltmarsh from rolling back landward as it would do naturally if the structures were not present. The saltmarsh habitat directly adjacent to the site occupies elevations between 0.5 and 2.4 m above OD.

Table 5-2 Area of saltmarsh adjacent to Apuldram Meadow

Year	Saltmarsh Area (m^2)
2008	9,500
2016	7,535

Figure 5-5 Narrow saltmarsh adjacent to the site

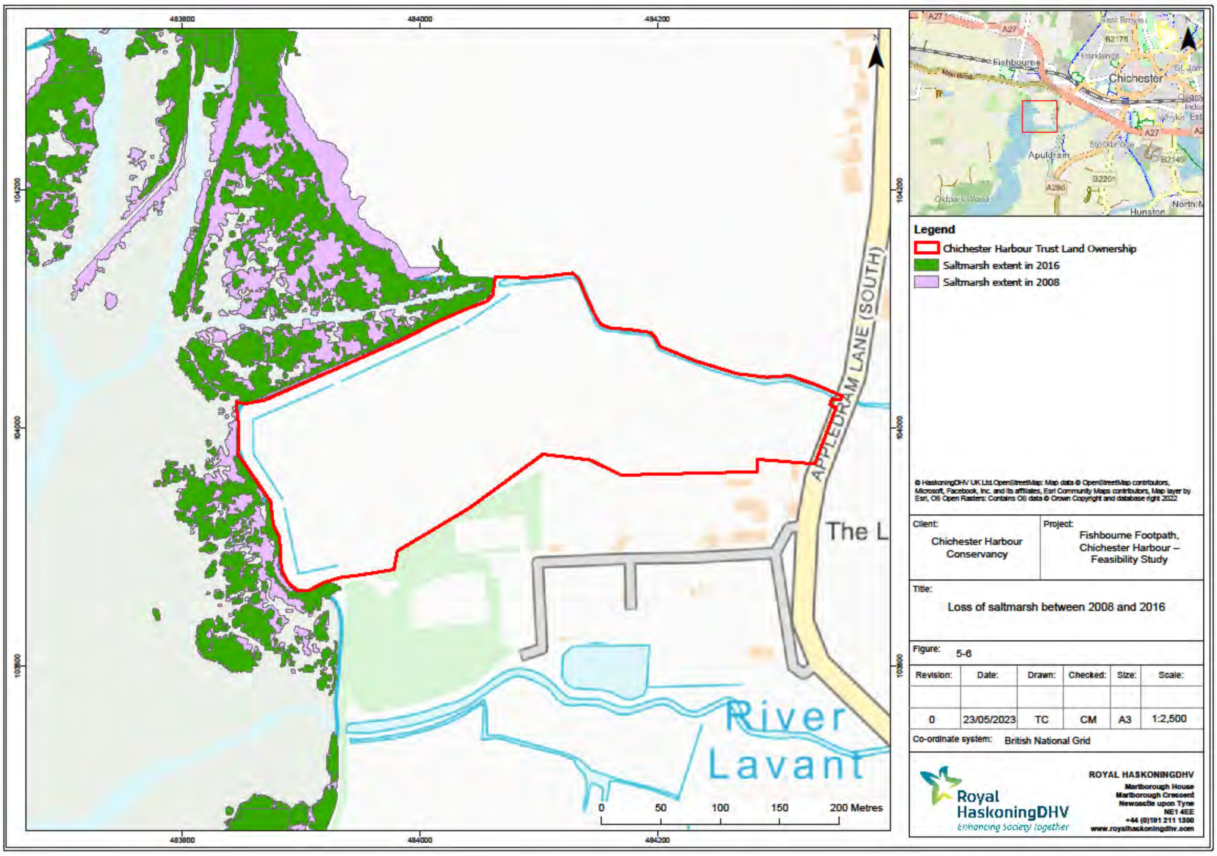


Figure 5-6 Loss of saltmarsh habitat between 2008 and 2016 (Environment Agency 2023)

5.4 Site history and cultural heritage

The known history and heritage assets within the surrounding area of the Fishbourne Channel largely reflect the presence of the saltmarsh. From the excavated Roman tools, found in nearby Chidham and likely used to produce salt, to the medieval purpose-built salt mills built on the Fishbourne channel itself (Figure 5-7), there is strong evidence of the centrality of the saltmarsh to longstanding activity within Chichester Harbour. However, the area's connection to industry-focused activity more broadly is observable from the Mesolithic period onwards supported by the evidence of the flint working site and excavated Roman agricultural buildings at the eastern margin of Chichester Harbour.

Figure 5-7 Location of listed heritage assets and 1982 excavation in relation to the site

5.4.1 Listed heritage assets

- Grade II listed Fishbourne Manor (320 m from site), this building is located to the east of the earliest part of building with 18th and 19th Century additions (Historic England, 2023);
- Grade II Listed Manor Barn (330 m from site), located next to the Grade II listed Fishbourne Manor, this structure dating to the 18th century – or earlier – is the current site of a nursing home. It was previously listed with Fishbourne Manor as Fishbourne Manor Barn;

- Grade II listed Church of St Peter and St Mary (395 m from site), parts of this listed church, specifically the chancel and potentially the roof, date to the 13th Century. Restorations and additions were predominantly made in the 19th Century (Historic England, 2023);
- Grade II listed Salt Mill House (400 m from site), this 18th Century redbrick house with gables (SU 83810 04445) was listed in July 1950 (Historic England, 2023);
- Grade II listed Wall (370 m from site), this wall is within the grounds of the Salt Mill estate located on the same site as the listed barn and house (Historic England, 2023);
- Grade II listed Barn (410 m from site), situated next to the salt mill house, this listed building is a gabled single storey barn; and
- Grade II listed Pendrills (480m from site), this building is a thatched 18th century house (Historic England, 2023).

5.4.2 Mesolithic

Knowledge of Mesolithic activity is limited to the scattered finds that have been noted within the area. Within Apuldram, a selection of flint tools has been recovered including the head of a Mesolithic flint axe as well as microliths, scrapers and blades. Research into neighbouring Langstone Harbour would suggest that the landscape of Chichester Harbour was comparatively very different to the current formation of the coastline with the area likely consisting of valleys within open grassland (CITiZAN, 2016).

5.4.3 Neolithic

Fieldwalking of the Apuldram side of the Fishbourne foreshore, completed as part of a field survey of Chichester Harbour in 1982, revealed the presence of flint flakes dating to the Neolithic period. This included retouched flint, waste flint and fire-cracked flint (Cartwright, 1984). Amongst the individual scattered finds dating to the Neolithic period include a flint axe head. This is suggestive of the area being used as a working site for Neolithic flint with the flakes likely deposited on the beach due to coastal erosion. However, there is a limited potential of further remains of this specific flint working site due to ongoing coastal erosion. However, there is potential for similar finds to be preserved within the salt marsh or Apuldram Meadow that could be impacted by future coastal erosion.

5.4.4 Bronze Age

Limited Bronze Age finds have been noted within Fishbourne, amongst these include a palstave with a midrib but no loop. During this period, the landscape of Chichester Harbour would have likely resembled the present landscape with the separation of Hayling Island to the mainland (CITiZAN, 2016).

5.4.5 Iron Age

The presence of multiple Iron Age artefacts found within the Fishbourne area – alongside a hillfort on Hayling Island - is indicative of the site’s Iron Age activity. Finds dating to the period include an Iron Age coin found in 1979. Fragments of Iron Age pottery were also found during the 1982 excavation and its subsequent monitoring (1992) suggesting Iron Age occupation of the site (Kenny, 1992; Rudkin, 1986).

Excavation finds within Chichester Harbour more broadly highlight the likely engagement of the area with salt production. This is particularly the case at Chidham, 4.5km to the west of Fishbourne, where excavations within the area revealed strong evidence of a salt production site with briquetage, burnt pottery and flint as well as a deep trench which has been attributed to being a potential source of salt water. However, this area has been affected by coastal erosion with the locations of original salt production sites lost to its impact (CITiZAN, 2016).

5.4.6 Roman

Prior research indicates that the salt marsh within Chichester Harbour was in its most expansive form during the Roman period (MoLAS, 2007). Evidence suggests this was utilised as part of continued salt production within the area. This is especially the case in the area surrounding Hayling Island where the site was named in literature by St Augustine of Hippo who credited the area’s salt as ‘superior’ in comparison to other areas producing salt in Britain (Allen & Gardiner, 2000).

Romano-British finds were noted around Apuldram prior to the 1982 excavations (Cartwright, 1992), however, evidence of Roman activity surrounding Fishbourne Channel, largely centres on its close proximity to the Roman Palace. Excavations on the west side of the salt flats taking place in 1982 revealed the remains of two forms of a Romano-British farming building. The original building was a timber structure highlighted by remains of sill beam slots, charred timber and burnt daub (Rudkin, 1986). It is estimated - given the dating of pottery found within the remains of the building - that this structure dates to the 1st Century. The presence of pottery would suggest that the building was occupied, however, the exact function of this building is debated. Its use for agriculture is plausible given the aisled formation the foundations, a prevalent design for agricultural buildings within the time period.

This structure was rebuilt following a fire during the middle of the 2nd Century. Excavations revealed the multiple stages of the building’s development with extensions added over multiple years. The agricultural nature of part of this building is also suggested from the coarse gravel floor of some of the rooms to the layout of the ‘T-shaped flue and furnace’ forming a familiar corn drier structure (Rudkin, 1986).

5.4.7 Medieval

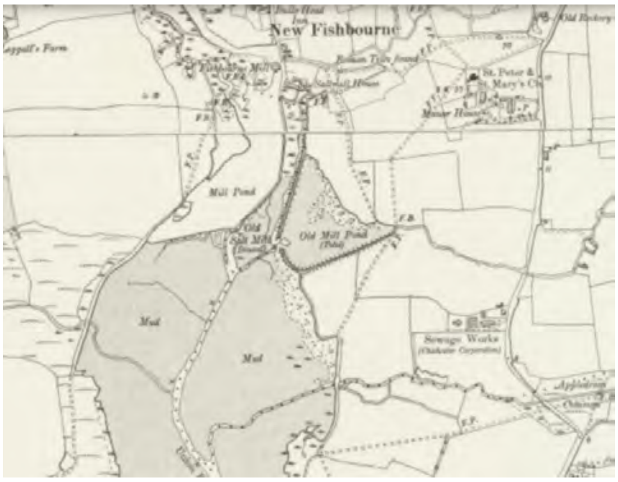
The settlement of Fishbourne is noted within the Domesday Book in 1086. Over this period, there is evidence of multiple industrial-focused infrastructural developments. The growth of salt production within the area is apparent over the medieval period highlighted by the appearance of two mills (Sea or Salt Mylls) by the 1582 record. There is evidence to suggest that pottery was also produced within the area. A Medieval pottery kiln has also been attributed to Fishbourne through research by Le Patourel (1986). The construction of the Wadeway, a connecting causeway between the mainland and Hayling Island also dates to the Medieval period.

5.4.8 Post Medieval to Modern

The mills built towards the end of the Medieval period remained into the nineteenth century. As can be seen on the 1875 and 1896 Ordnance Survey maps of the harbour, Fishbourne housed two mills on its channel (Ordnance Survey, 1880; 1899). One was situated at the head of Fishbourne Channel marked as ‘Fishbourne Mill’ with the other a tidal mill situated further south in the channel, marked on the map as a disused salt mill (Salzman, 1953). Fishbourne Mill was a water powered corn mill sometimes referred to as Fresh Mill or Fresshemyll (Salzman, 1953). It remained standing until about 1959 when it was converted into flats. Alongside the watermills, as is illustrated on the 1875 map, Fishbourne also housed two flour mills (Ordnance Survey, 1880) (Figure 5-8).

A comparison between the two historic maps indicates there is a distinction between the land to the west of Appledram. The earlier 1875 map marks this land adjacent to the channel as being marshland. However, the land appears as grassland in the later map. With the earlier map marking the sea wall, this could be evidence of the land reclamation from this sea defence. This was something that occurred in Britain during the medieval period - there are records of reclaimed land from salt marshes being used for agriculture - but as has been noted within a prior archaeological report on the area, there is little evidence of this occurring during the medieval period within Chichester Harbour (MoLAS, 2007).

The establishment of related mill buildings is also apparent in the eighteenth century, to the North of the site is the Grade II listed Salt Mill House and its adjacent Barn, also Grade II listed.



Map of Fishbourne surveyed in 1875, reproduced with the permission of the National Library of Scotland (Ordnance Survey 1880).

Map of Fishbourne surveyed in 1896, reproduced with the permission of the National Library of Scotland (Ordnance Survey 1899).

Figure 5-8 Historic maps of the site

5.4.9 Land reclamation

The earliest historical maps indicate the land at Apuldram Meadow was reclaimed at some point before 1875 with modification to the embankment between 1875 and 1896 (Figure 5-8). In 1875, parts of the site were saltmarsh, but this had disappeared by 1896 suggesting the land was fully enclosed and not influenced by brackish water by the end of the century. The construction of embankments and reclamation of land along the Fishbourne Channel likely commenced alongside the salt industry which was active from as early as 1582.

5.1 Existing infrastructure

Any changes to future management of Apuldram Meadow may potentially affect local infrastructure. The following key assets are located directly within (or under) Apuldram Meadow:

- Footpath 555 (and associated treeline);
- Footpath 3059 (and underlying embankment); and
- Gas pipe running under the site.

There are also several assets located directly adjacent to the site:

- Wastewater Treatment Works to the south of the site;
- Residential housing (two properties) adjacent to the Wastewater Treatment Works; and
- Minor road adjacent to the eastern boundary of the site (Apuldram Lane).

5.1.1 Gas pipe

A high-pressure gas pipe runs from the south-western boundary of the site, under Footpath 555 where it deviates towards the north-west, running across the meadow, exiting the site along the western boundary, and thereafter running under the Fishbourne Channel (Figure 1-1). The asset is owned and managed by Southern Gas Network (SGN).

Based on initial communications with SGN, the gas pipe is buried to a depth of approximately 2 m and there is a legal requirement to ensure the pipe is buried by a minimum of 1 m of sediment. SNG's representative indicated that if the land was to flood and become intertidal, there may be concerns with saltwater causing corrosion of the pipe. Initial communications have not included the inclusion of any major construction or earthworks associated with future management of the site and these would need to be discussed in detail with SGN to understand safety requirements.

If the gas pipe is impacted by any future changes to the management of the site, detailed consultation with SGN will be required to understand constraints. If any earthworks are planned that would directly impact the pipe, the pipe may need to be diverted (at significant cost) to mitigate the risk to the infrastructure. If works are undertaken in close proximity, additional monitoring may be required (e.g. for vibration) under supervision of an SGN representative. Mitigation in relation to changes in land use, in particular saltwater intrusion, cannot be defined at this stage and should be investigated further through consultation with SGN.

5.1.2 Wastewater Treatment Works

The Wastewater Treatment Works located immediately to the south of Apuldram Meadow is on land at elevations between 2.0 and 4.5 m OD. The land gently slopes down towards the River Lavant which runs along its southern boundary. Along the northern boundary adjacent to Apuldram Meadow, there are stretches of higher ground covered with trees that were planted after 1974 (see Figure 5-4).

The existing embankment at Apuldram Meadow currently protects the land directly north of the Wastewater Treatment Works and if this embankment was breached, it could increase the risk of flooding to the works (see Section 6 below). While the embankment immediately adjacent to the Wastewater Treatment Works would offer some protection from flooding, ingress of flood waters from the north may occur which would require additional mitigation in the form of a secondary embankment or other coastal defences to protect the northern fringes of the works.

5.1.3 Embankment

Construction of the embankment may have started as early as mid-19th century, likely associated with growth of the salt industry across Chichester Harbour. This embankment may be considered a heritage asset, although it is not a designated feature. If allowed to deteriorate naturally without removal, the blockwork and structures fronting the embankment would likely break off and become deposited in the intertidal zone which would change the landscape setting locally.

5.2 Agricultural Land Valuation

Any changes to the management of the site may lead to changes in land-use which could affect the value of the land. The land at Apuldram Meadow is owned by Chichester Harbour Trust and the boundaries of the land were defined according to the Land Registry Title Plans as shown in Figure 1-1. A selection of different sources have been used here to derive a range of land values and provide a higher level of confidence that the valuation is realistic. These sources included:

- Agricultural land classification dataset (Natural England);
- Multi-Coloured Handbook land values at 2018 prices;
- Farmland values (Savills at 2021 prices); and

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- Average farmland prices (Farmers Weekly at 2021 prices).

The Agricultural Land Classification dataset (Figure 5-9) classifies the land use within the study area as Grade 1 – excellent quality agricultural land defined as ‘Land with no or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown and commonly include top fruit, soft fruit, salad crops and winter harvested vegetables. Yields are high and less variable than on land of lower quality.’

However, a review of the area using Google Earth/Street View suggests the land is more likely grassland rather than arable. The classification of grassland, in particular coastal grazing marsh, was confirmed during the site visit on 27th January 2023. The land was relatively poorly drained, although it is acknowledged that the site visit was undertaken in winter following a period of prolonged heavy rainfall. Adjacent land to the north and east of the site was ploughed arable land and more representative of the Agricultural Land Classification.

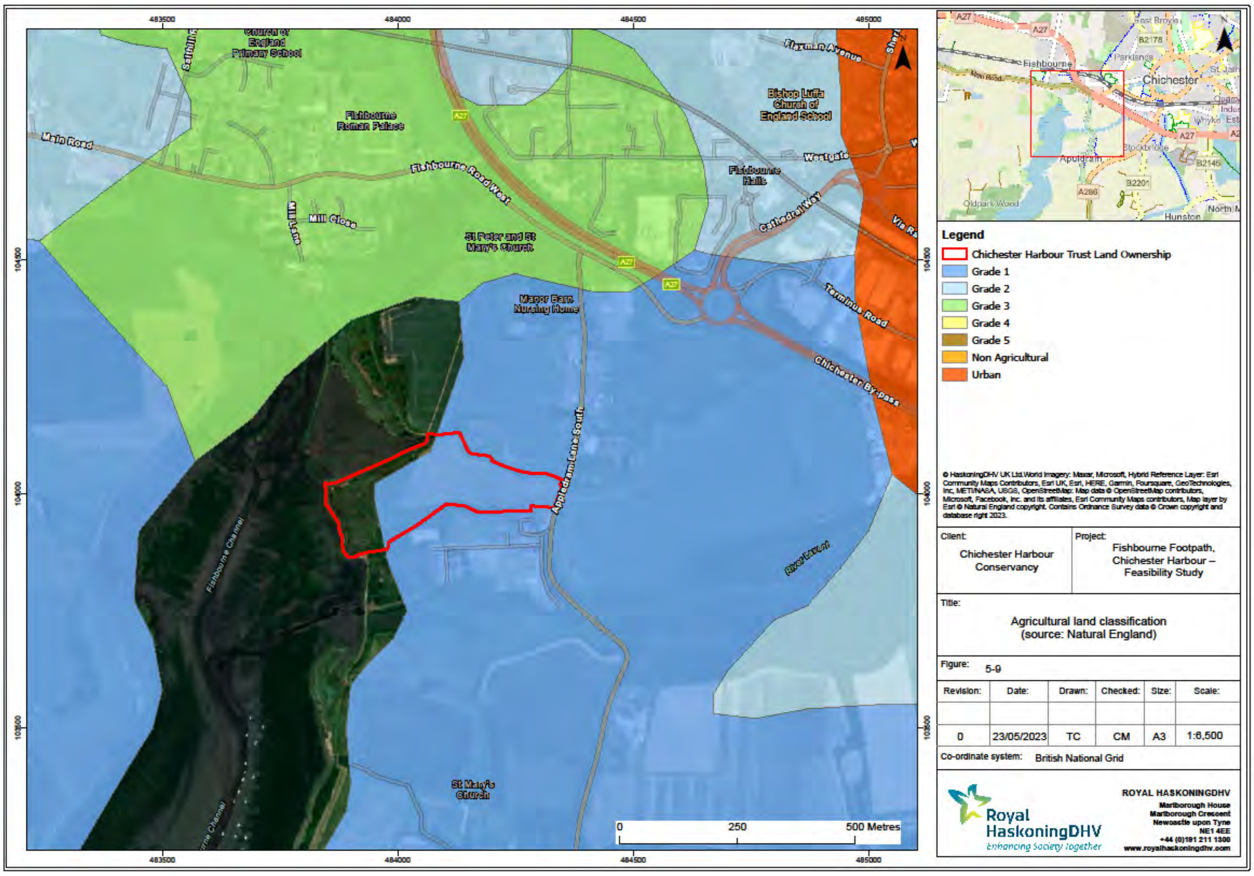

Figure 5-9 Agricultural land classification

The Multi-Coloured Handbook 2022 (Penning-Rowsell et al, 2022) provides the industry standard methodologies for carrying out economic appraisals for Flood and Coastal Erosion Risk Management projects. This includes guidance on valuing different types of losses to agricultural land.

Following the advice in the Multi-Coloured Handbook 2022 the change at the site would equate to Scenario I: Permanent loss of agricultural land. The guidance states that land permanently lost to agriculture should in most cases be valued at its market value (£11,000/ha - £14,000/ha for grazing land) less £600/ha to reflect the subsidy effect of farm income support. These are national average values and both upper and lower values have been calculated in Table 5-1 to account for variations in land quality.

Savills is a property agent providing a range of specialist management and consultancy services to food and farming businesses, including carrying out industry research into farmland valuation trends. Based on their latest published data the most appropriate land-use type for this site would be 'poor livestock (grassland rate)' with a rate of £4,500/acre.

Average farmland prices are drawn from Knight Frank's opinion-based survey of its agents across the country and cover the last six months of 2021. Knight Frank is an independent real estate consultancy, with specialised Rural Valuation and Advisory team. They carry out industry research into farmland valuation trends. The data is regionally based and may better represent local values.

Using the range of sources above, a comparison of land value estimates for the full 6.4 ha area covered by the land registry title boundary is summarised in Table 5-3. The range of values is between £76,000 and £120,000.

Table 5-3 Land value comparison

Source	Scale	Valuation (base price)	Base price date	Valuation (2023 price)
Multi-Coloured Handbook	National Lower	£65,520	2018	£76,632
	National Upper	£84,420	2018	£98,737
Savilles	National	£66,276	2021	£71,642
Farmers Weekly	Regional	£110,955	2021	£119,939

* values inflated to 2023 prices using Gross Domestic Product deflator

6 Coastal flood risk

The land fringing Chichester Harbour has been reclaimed over the years, resulting in low-lying land with significant areas at risk of tidal flooding from tidal surges. Typically, coastal flooding can be caused by either Still Water Level flooding, wave overtopping, or a combination of the two. In the context of coastal management, the dominant source of coastal flooding around Chichester Harbour is due to Still Water Level flooding, which is the average water level at any given time, excluding local variation due to waves.

An understanding of the elevation and topography of the study area relative to water levels is important for predicting the extent of flooding if the existing embankment is breached (naturally or artificially). It is also important to understand changes in water levels resulting from climate change and extreme storm events.

6.1.1 Water levels

Baseline extreme water levels were obtained from the Environment Agency (EA) Coastal Flood Boundary Dataset (CFBD; Environment Agency, 2018). This dataset provides extreme water levels for a variety of return periods along the coastline of England and Wales and within estuaries and harbours (Figure 6-1, left). Extreme water levels were taken from the output point closest to the site rather than at the entrance of the harbour. These levels are generally 0.15 m higher than levels at the entrance of the harbour.

Sea-level rise projections have been taken from Chichester Harbour entrance (Figure 6-1, right) using UKCP18 RCP 8.5 70th percentile projections in line with EA guidance[1]. Using this scenario, sea levels within Chichester Harbour are predicted to rise by approximately 1.06 m over the next 100 years. Sea-level rise projections have been applied to the EA CFBD water levels to derive future extreme water levels for present day (taken as 2025 being closer to the likely year of any scheme implementation) and year 2050 (+25 years), 2075 (+50 years) and 2125 (+100 years). Table 6-1 summarises the extreme water levels for a variety of return period events and Table 6-2 summarises the changes to tide levels at Itchenor due to sea-level rise.

Figure 6-1: EA CFBD output point and UKCP18 sea-level rise output area.

Table 6-1: Extreme water levels in future years including sea-level rise (RCP 8.5 70th percentile).

Return Period (1 in x)	Base water levels from EA CFBD (chainage 4604_5) (mOD)	2025 (mOD)	2050 (mOD)	2075 (mOD)	2125 (mOD)
1	2.86	2.91	3.09	3.34	3.97
10	3.10	3.15	3.33	3.58	4.21
20	3.17	3.22	3.40	3.65	4.28
50	3.26	3.31	3.49	3.74	4.37
75	3.30	3.35	3.53	3.78	4.41
100	3.33	3.38	3.56	3.81	4.44
200	3.40	3.45	3.63	3.88	4.51
1000	3.57	3.62	3.80	4.05	4.68

[1] *https://www.gov.uk/guidance/flood-and-coastal-risk-projects-schemes-and-strategies-climate-change-allowances*

Table 6-2: Changes to tide levels at Itchenor over time due to sea-level rise (RCP 8.5 70th percentile).

Tide	2025	2050	2075	2125
HAT	2.47	2.65	2.91	3.54
MHWS	2.07	2.25	2.51	3.14
MHWN	1.07	1.25	1.51	2.14
MLWN	-1.03	-0.85	-0.59	0.04
MLWS	-2.13	-1.95	-1.69	-1.06

6.1.2 Existing ground levels

Existing ground levels have been determined using LiDAR data (2021) as shown on Figure 6-2 with an elevation profile across the site shown on Figure 6-3. The LiDAR is filtered which means the elevations should represent true ground elevations rather than artefacts created by vertical structures such as trees and buildings. However, there is some uncertainty in the levels in and around the Waste Water Treatment Works as the elevations appear stepped within an area of trees.

The existing embankment crest level is approximately +3.75 m OD (at chainage 30 m), the foreshore level is approximately +1.25 m OD (at chainage 0 m) and the backing land is approximately +1.7 m OD within the borrow ditch adjacent to the embankment (at chainage 50 m) and rises to approximately +3.5 m OD further inland (at chainage 400 m). The adjacent defence to the south of the site also has a crest level +3.75 m OD and ground levels behind this defence are higher at approximately +3.6 m OD to +4.9 m OD.

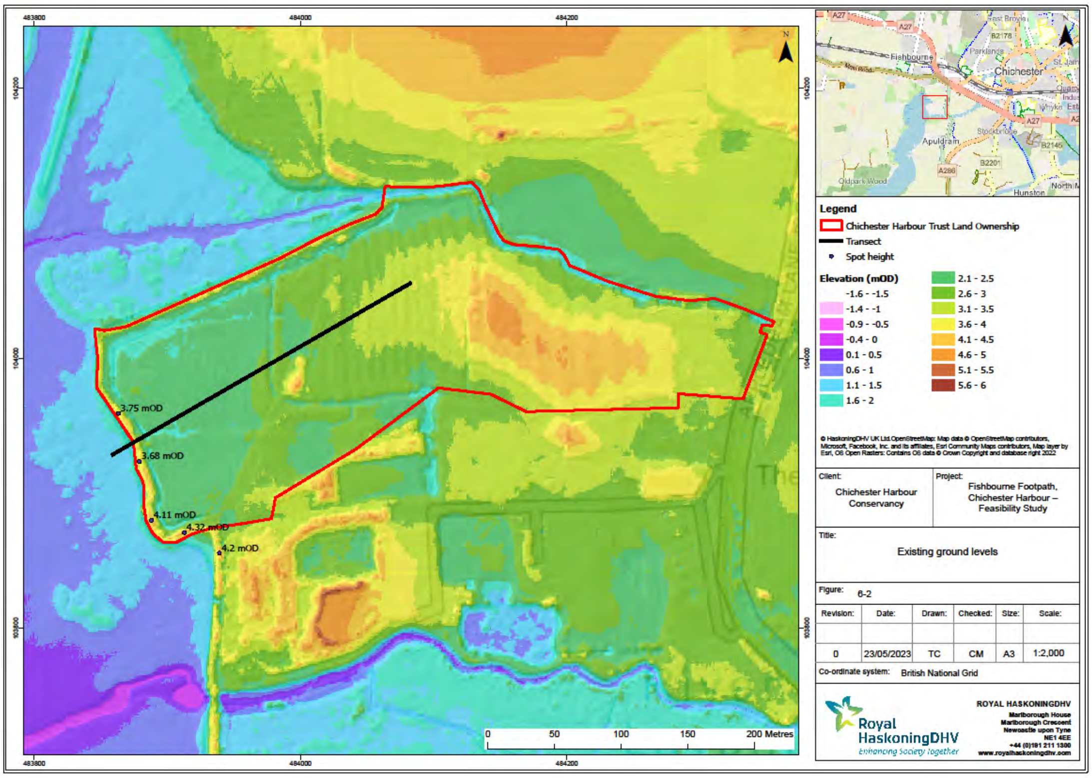

Figure 6-2: Existing ground levels at Fisbourne

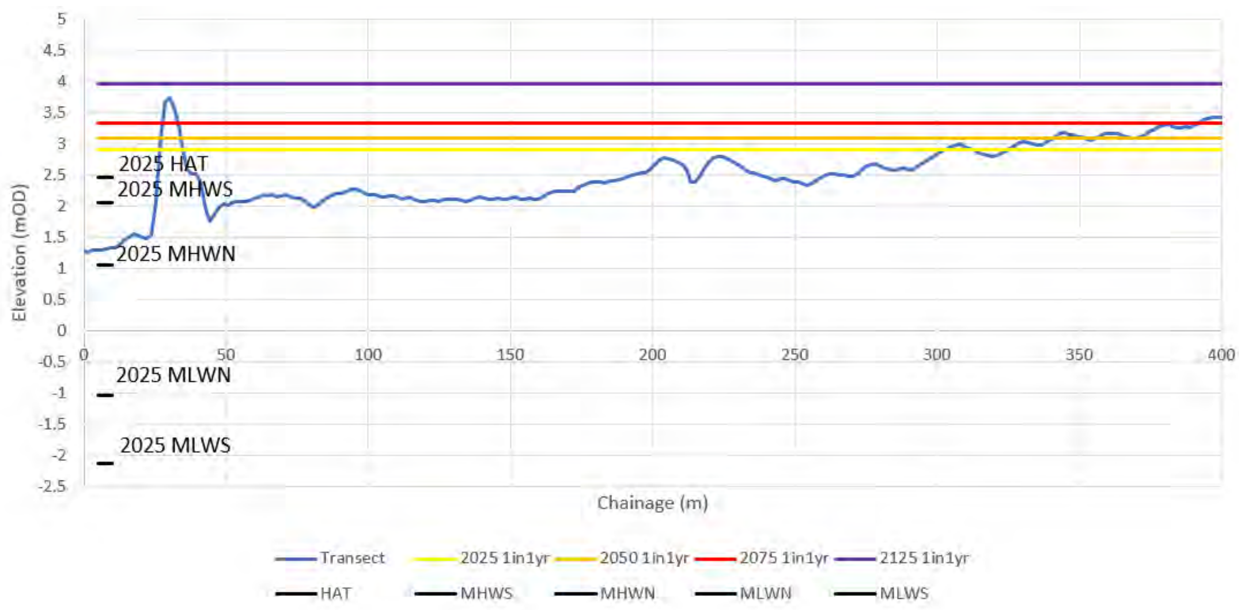

Figure 6-3: Transect showing elevations of the site relative to predicted tide levels in 2025 and water levels over the next 100 years.

6.1.3 Extent and depth of inland flooding

Without the existing defence, a 2025 1 in 1 year return period extreme water level would inundate a significant area behind the existing defence as shown in Figure 6-4. The area at risk to inundation during a 1 in 1 year return period extreme water level naturally extends further inland over time. The area of inundation is even greater during a 1 in 200 year return period extreme water level as shown in Figure 6-5 noting the existing defences at their current elevation would be overtopped during an event of this magnitude. As a result, any future management option that allows water to inundate the land behind the defence will need to take the flood risk area into consideration.

An independent Strategic Flood Risk Assessment (SFRA) has been undertaken for Chichester Harbour (JBA Consulting 2022). The assessment created maps showing flood zones that show the land that would flood if no defences were present. The land at Apuldram Meadow falls into Flood Zone 2 which is defined as having medium probability of between 0.5% and 0.1% chance of flooding in any given year (Figure 6-6).

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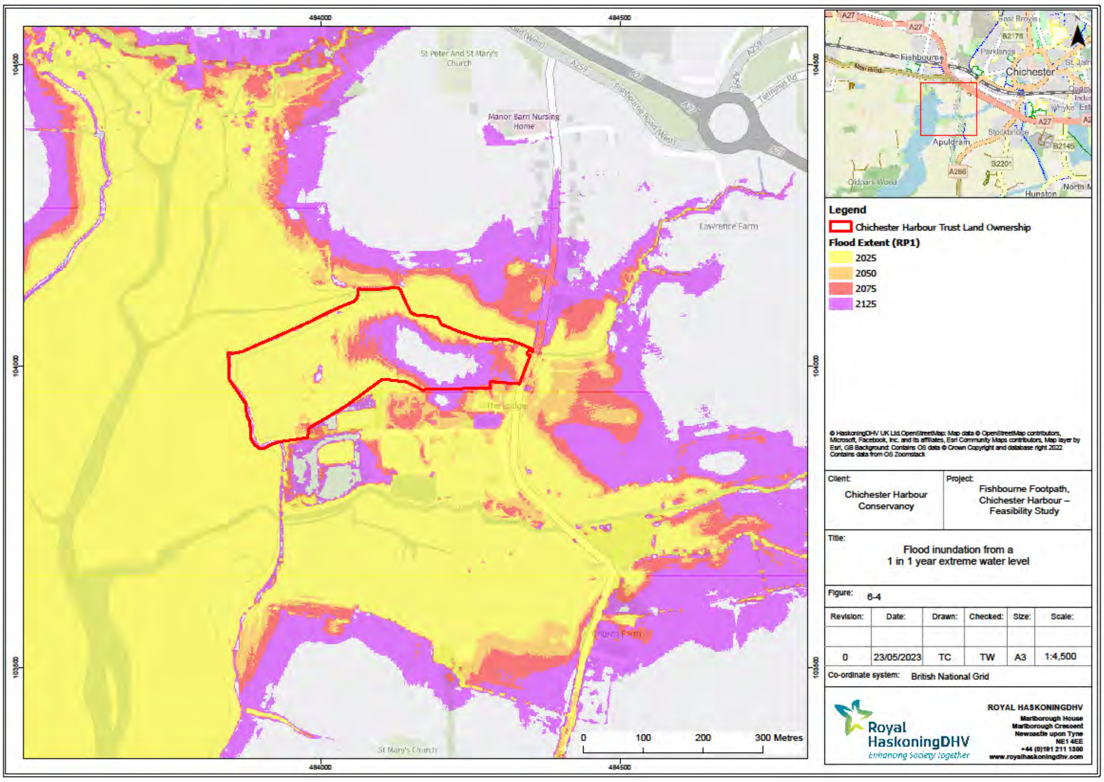

Figure 6-4: Flood inundation from a 1 in 1 year extreme water level

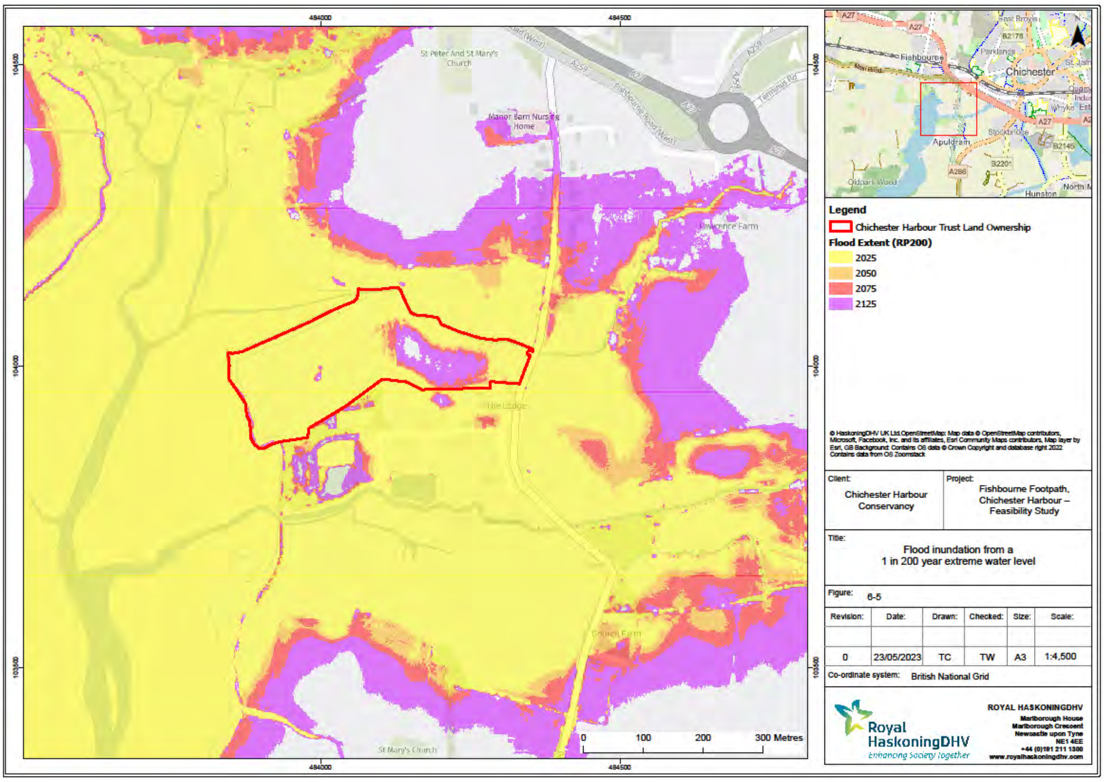

Figure 6-5: Flood inundation from a 1 in 200 year extreme water level

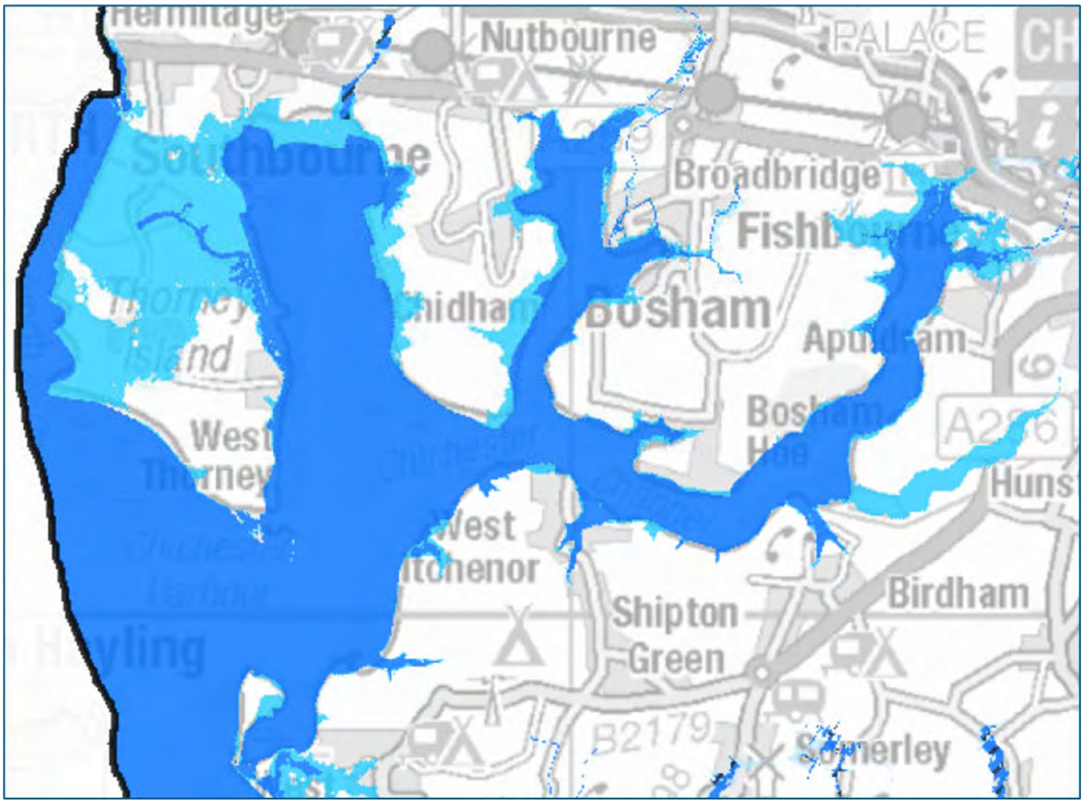

Figure 6-6 Present-day undefended flood zones around Chichester Harbour (excluding Hayling Island) (JBA Consulting, 2022)

6.1.4 Assets affected

If the eastern coastal defences were breached (naturally or artificially), most of the site would be flooded during a 1 in 1 year water level with the exception of high ground in the central eastern part of the site (Figure 6-4). Under this flood scenario the following assets within the site boundary would be affected by inundation of brackish water into the site:

- Footpath 555 (and associated treeline);
- Footpath 3059 (and underlying embankment);
- Freshwater stream running along northern boundary of the site;
- Gas pipe running under the site; and
- Grassland habitats within the site.

Several assets located directly adjacent to the site may also be affected:

- Wastewater treatment works to the south of the site;
- Residential housing (two properties) adjacent to the Wastewater Treatment Works;
- Minor road adjacent to the western boundary of the site (Apuldram Lane);
- Adjacent agricultural land; and
- Residential properties along Apuldram Lane to the north and south of the site.

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6.1.5 National Flood and Coastal Erosion Risk Management Strategy (FCERM)

The Environment Agency (2020) FCERM Strategy for England up to 2100, includes using the Habitat Compensation and Restoration Programme (HCRP) as the agreed strategic mechanism for delivering the necessary compensation requirements to support the ambitions of the FCERM strategy. The new strategy places a greater emphasis on the environment and nature-based solutions/natural flood management including (of most relevance to this project, amongst others):

- Plan all flood and coastal defence projects and programmes to deliver biodiversity net gain, in line with the Government's mandate, and seek to encourage other environmental benefits.
- Use nature-based solutions and improve the environment through their investments in flood and coastal resilience.
- Encourage farmers and land managers to adopt land use and land management practices that help contribute to greater resilience to both floods and droughts.

Development of actions to reduce flood risk through managed realignment around Chichester Harbour integrate with the national strategy, which calls for a broad range of resilience actions in the face of a changing climate. Alongside flood and coastal defences, a broader range of actions for achieving climate resilient places is recommended. These include avoiding inappropriate development in the floodplain and using nature-based solutions, which would include managed realignment, to protect and enhance the environment.

7 Habitat creation

The extent and type of coastal habitat that exists is closely tied to tidal levels. In the UK (and elsewhere), saltmarsh initially colonises areas between approximately MHWN tide and MHWS tide, with areas lower than this down to mean low water spring (MLWS) tide forming mudflat (Allen, 2000) (Figure 7-1). Another important aspect is the availability of suitable plant species for colonisation; different plants can colonise at lower levels than others. However, in general terms, the elevation of a site relative to the varying tidal range is used as an initial indicator of the habitats that could evolve (Table 7-1). Hence, the topography of the site and the tidal heights adjacent to it are one of the principal issues to be considered at the planning stage of a managed realignment site (Leggett et al., 2004).

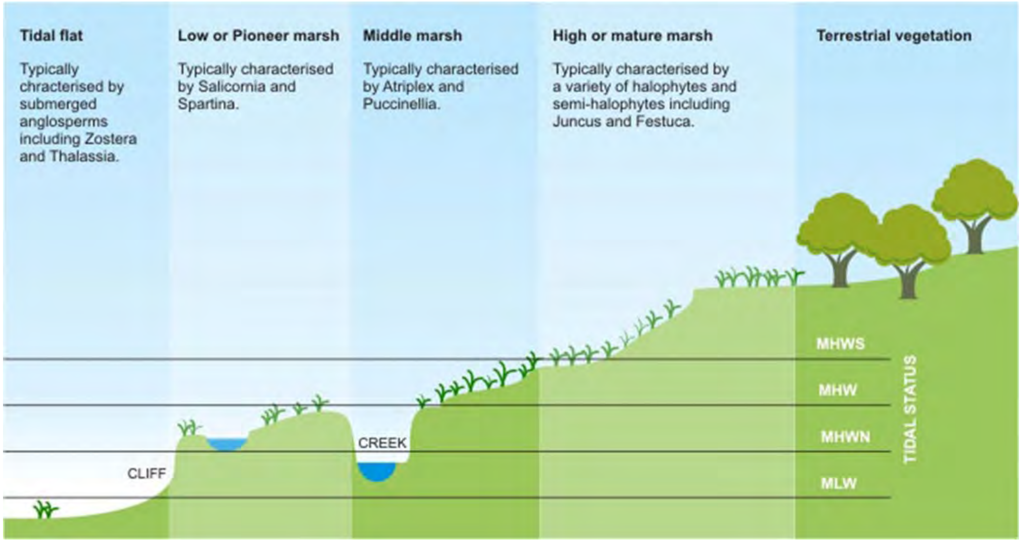


Figure 7-1 Approximate relationship between habitat and tidal datums

Table 7-1 Coastal habitat types

From	To	Primary habitat
MLWS	MLWN	Intertidal mudflats and sandflats
MLWN	MHWN	Pioneer saltmarsh
MHWN	MHWS	Saltmarsh
MHWS	HAT	Transitional saltmarsh (high marsh transitioning to fresh marsh)

7.1 Habitat types

Using the LiDAR data as a topographic base map, and future water levels (Section 6) predicted habitat type maps were created for 2025, 2050, 2075 and 2125 as shown in Figures 7-2 to 7-5. If the embankment is breached at Apuldram Meadow, and the site is inundated and flooded by brackish water, the initial area of saltmarsh creation would be limited to the low-lying area along the northern boundary of the site (Figure 7-2). Brackish water would likely enter the freshwater stream and change this ecologically important habitat, with saltmarsh forming along the margins of the stream. Transitional saltmarsh would be created across most of the area between the existing embankment and Footpath 555. Land to the east of Footpath 555 would not be affected by brackish water under the prevailing tidal regime because it is too high, although it could be affected by a 1 in 1 year extreme water level event (see Figure 6-4). As sea levels rise, the extent of saltmarsh would increase gradually (as long as sediment accretion keeps pace) and by 2075, much of the site to the east of Footpath 555 would be saltmarsh (Figure 7-3, Figure 7-4 and Figure 7-5). Predictions of the types and extent of habitats created are given in Table 7-2.

Table 7-2 Predictions of the type and area of habitat that would be created

Year	Transitional saltmarsh (ha) (MHWS to HAT)	Saltmarsh (ha) (MHWN to MHWS)	Pioneer saltmarsh (ha) (MLWN to MHWN)	Intertidal mudflats and sandflats (ha) (MLWS to MLWN)	Total saltmarsh created (ha)
2025	1.62	0.45	0	0	1.62
2050	1.38	1.30	0	0	1.38
2075	1.44	2.19	0.03	0	3.66
2125	0.97	3.49	0.77	0	5.23

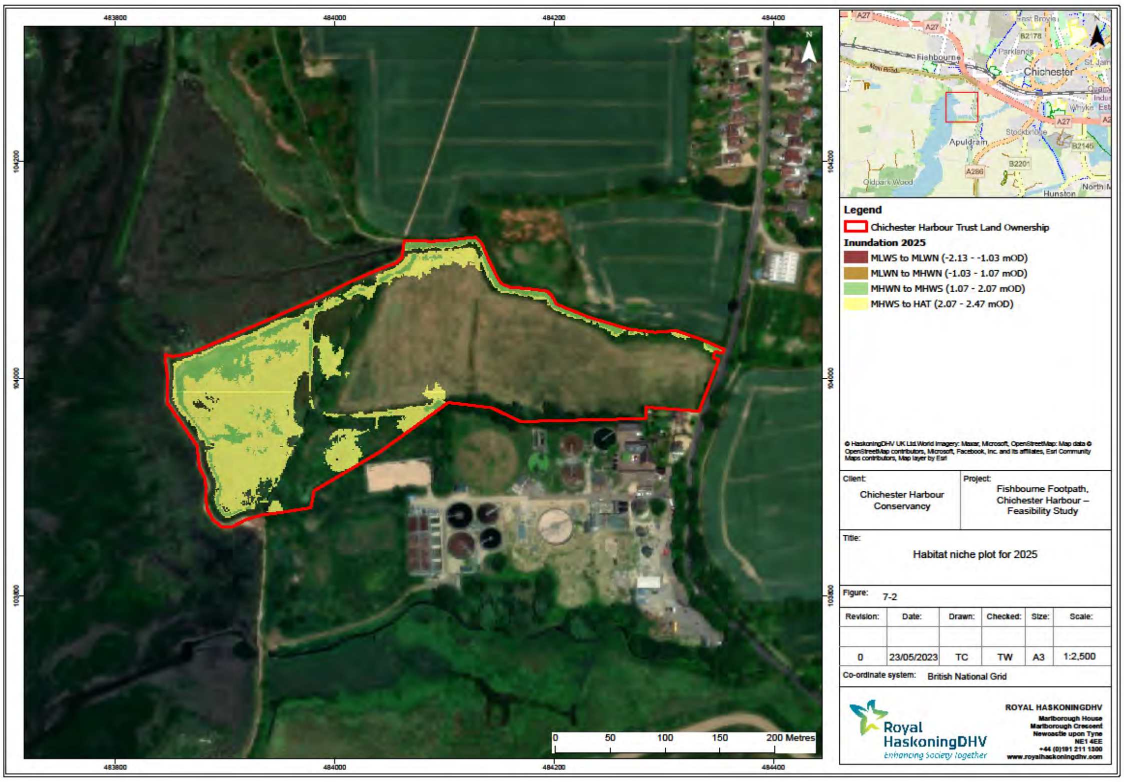


Figure 7-2 Predicted habitat in 2025

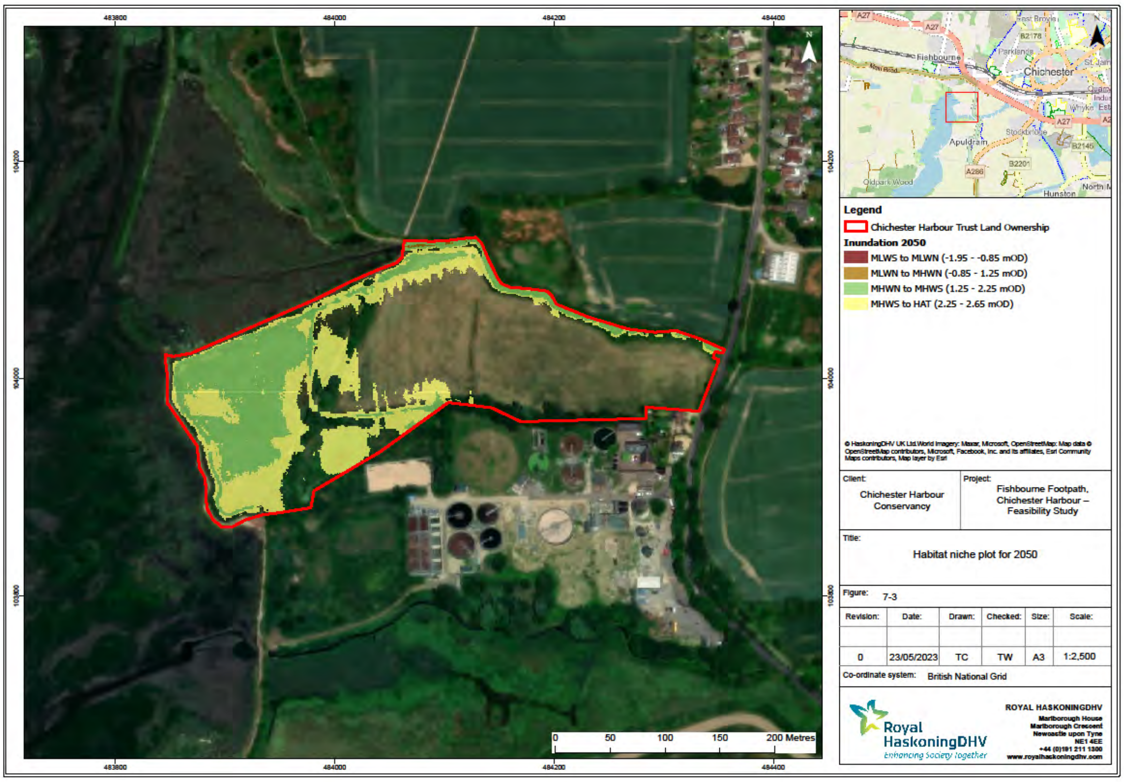


Figure 7-3 Predicted habitat in 2050

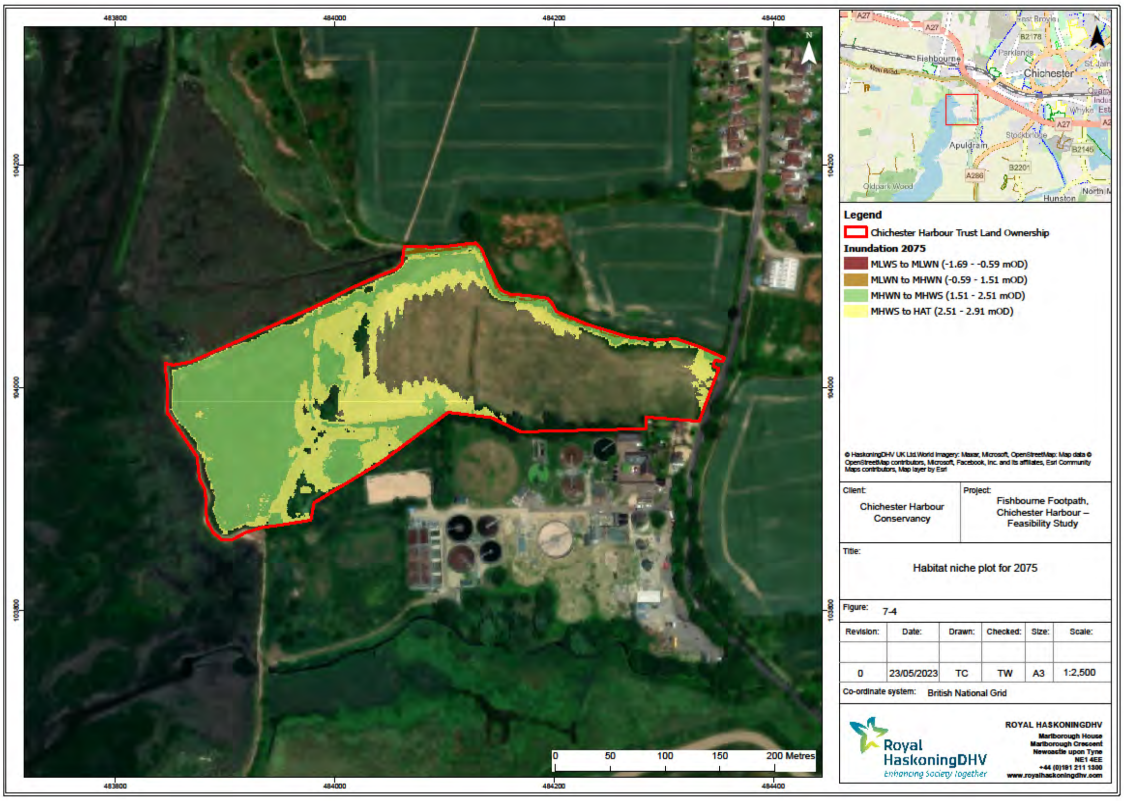


Figure 7-4 Predicted habitat in 2075

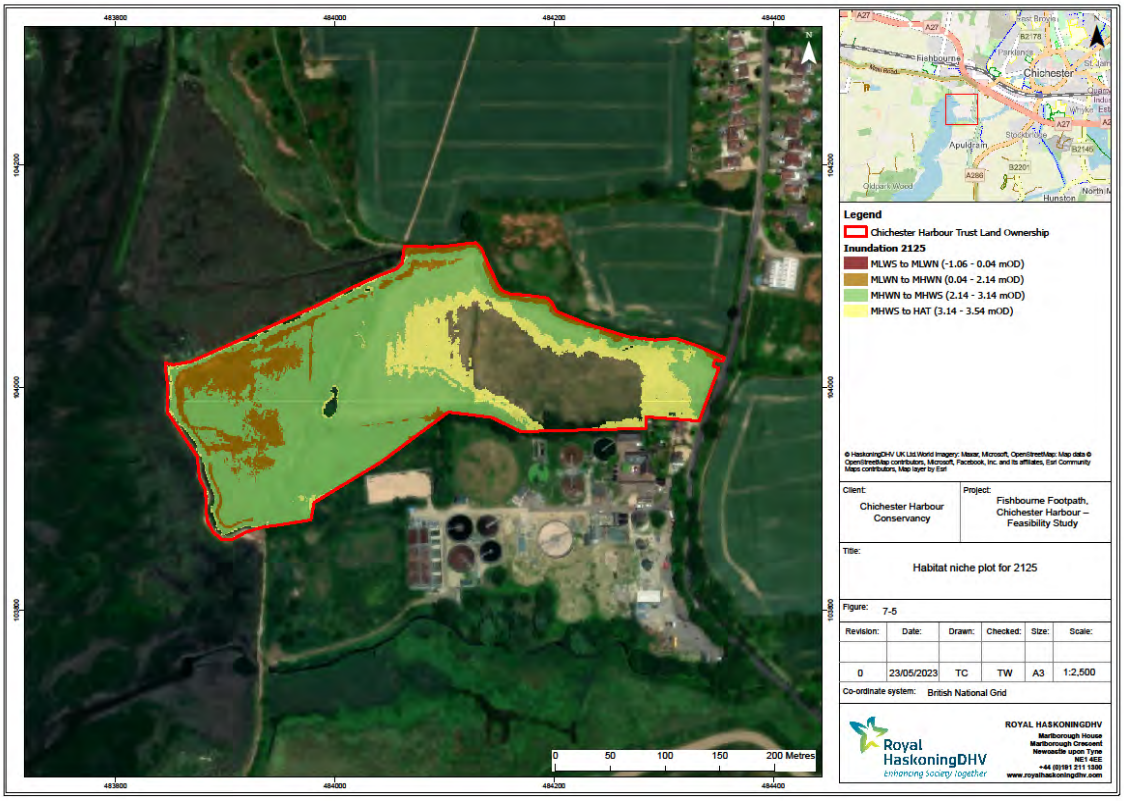


Figure 7-5 Predicted habitat in 2125

7.2 Habitat Compensation and Restoration Programme

The North Solent Shoreline Management Plan covers the Chichester Harbour and the policy at Fishbourne is “Hold the Line (No Public Funding Available)” (Environment Agency 2010) which means the continued provision of defences along the coastline to protect coastal communities, agricultural land, environmentally important and designated coastal and freshwater grazing marsh habitats, roads, and heritage features. However, continued maintenance of these coastal defences will also result in continued loss of seaward intertidal habitats through coastal squeeze with sea-level rise into the future.

The Solent and South Downs Habitat Compensation and Restoration Programme (HCRP) is responsible for providing the required compensatory habitat because of the hold the line policies. The HCRP is a strategic programme, established in 2009, and managed by the Environment Agency. It is the Government’s agreed mechanism for delivering strategic habitat compensation for FCERM schemes to ensure compliance with the Habitats Regulations.

In 2017 a strategic update on the progress of the HCRP was published which showed there were no completed compensation schemes in Chichester Harbour. However, a list of potential habitat compensation opportunities was developed and Fishbourne and Apuldram were named as a potential site for compensation. A recent strategic review of Chichester Harbour seawalls and management practices commissioned by Natural England identified Fishbourne as a potential opportunity area that warrants a short-term adaptation plan (to meet a 2030 target) to manage the current risk of, and compensate for, further loss of intertidal (saltmarsh) habitat around Chichester Harbour.

8 Potential Engineering Design Options

Considering the condition of the embankment outlined in Section 4 and the potential the site offers to create new intertidal habitat, this section provides a high-level assessment of the potential engineering design options in relation to the site characteristics, local infrastructure, and future flood risk scenarios.

8.1 Long list of options considered

A long list of potential options has been considered in the context of assessing future management of the coastal defence and Footpath 3059, and the unfavourable declining condition of the intertidal habitat features. A high-level screening / appraisal of these options has been undertaken, assessing the opportunities and constraints of each, in order to develop a short list of options to consider in further detail. Table 8-1 provides a summary of the long list and the high-level screening / appraisal. The long list of options can be categorised as follows:

- Do Nothing Options.
- Repair Options.
- Improve Options.
- Breaching Options.
- Lowering Options.
- Tidal Exchange Options.

Table 8-1: Long list of potential options

Option No.	Option Description	Opportunities	Constraints	Short Listed (Y/N)
Do Nothing Options				
1	Do Nothing Allow continued natural deterioration of defences.	• No capital cost. • No PLC requirements.	• No control over timing of breach / failure of defences. • No control over location(s) of breach / failure. • No control over inland consequences (flooding) of breach / failure. This could lead to tidal inundation behind the defences during a present day extreme 1 in 1 year return period event, Figure 6-4. Inundation is likely to include the waste water treatment works and freshwater stream. • No control over foreshore consequence of breach / failure (i.e. spill of material including blockwork armouring). • Eventual loss of footpath.	Y (baseline option)
2a	Allow continued natural deterioration of defences but with wider awareness and site preparedness.	• Relatively low capital cost • No marine licence requirements (possible planning requirements for inland works)	• Largely similar to the above but with control over inland consequences (flooding) through local earthworks. • Requires diversion of existing footpath.	N
2b	Allow continued natural deterioration of defences but with wider awareness and site preparedness + removal of concrete blockwork from seaward face of embankment.	• Relatively low capital cost • No marine licence requirements (possible planning requirements for inland works) • Removes material that could become foreshore waste / debris in advance of breaching • Accelerates change (less protection) towards habitat creation	• Largely similar to the above but with control over inland consequences (flooding) through local earthworks and control over some foreshore consequences through removal of material that would otherwise become waste/debris. • Requires diversion of existing footpath	N
Repair Options				
3	Repair damages sections of defences.	• No adverse effects on inland receptors (other than through ongoing sea-level rise) • Maintains existing footpath.	• Unlikely to attain Natural England support in light of its stance on works within SSSI • Repeated damage returning to present day situation in relatively short timescale (5-10 years). • May require PLCs.	Y

Option No.	Option Description	Opportunities	Constraints	Short Listed (Y/N)
4	Repair damaged sections of defences + maintain into the future	• No adverse effects on inland receptors (other than through ongoing sea-level rise). • Maintains existing footpath	• Unlikely to attain Natural England support in light of its stance on works within SSSI • Whole life costs over future decades not inconsiderable • Lose ability to sustain standard of service due to sea level rise, leading to increased overtopping and storm damage. • May require PLCs	N
Improve Options				
5	Improve existing defences by increasing width and level.	• No adverse effects on inland receptors (ongoing sea-level rise managed through improved defences) • Maintains existing footpath. • Implementation could be delayed until a future epoch if Option 4 implemented in short term.	• Likely adverse effects on foreshore receptors • Unlikely to attain Natural England support in light of its stance on works within SSSI • Whole life costs over future decades not inconsiderable. • Requires PLCs	N
Breaching Options				
6	Habitat creation through breaching with inland footpath diversion	• Creation of intertidal habitat on backing land. • The above is likely to attain Natural England support in light of its stance on works within SSSI. • Maintains footpath via new diversion. • Control over timing of breaching • Control over location(s) of breaching • Control over inland consequences (flooding) of breaching through drainage creeks and local earthworks (re-grading, banks, bunds) • Control over foreshore consequences of breaching (remove and re-use materials to avoid waste and debris) • Re-use of material in earthworks for banks/bunds reduces off-site waste	• Requires control over inland consequences (flooding) through local earthworks (internal drainage creeks, re-grading, on-site re-use of material to create banks, bunds) • Requires control over foreshore consequences of breaching (removal of waste and formation of external creek) • Requires re-diversion of existing footpath • Requires PLCs • Large sections of embankment remain with facing concrete blockwork (which will become loose over time and remain as debris on the foreshore in the longer term)	Y
6b	Habitat creation through breaching with inland footpath diversion + Removing concrete blockwork from seaward face of embankment prior to breaching	• As above but with the additional benefit of removal of material that would otherwise become foreshore waste / debris in the longer term	• As above but without the constraint of material becoming foreshore waste/debris in the longer term. • The above could lead to accelerated deterioration of the defences.	N

Option No.	Option Description	Opportunities	Constraints	Short Listed (Y/N)
7	Habitat creation through breaching with bridges	• As Option 6 but with maintenance of existing footpath to connect bridges.	• As above. • In addition, bridges would need maintenance and repair. There is still a risk of defence failures elsewhere as defences are not being maintained.	N
7b	Habitat creation through breaching with bridges + removing concrete blockwork from seaward face of embankment prior to breaching	• As above but with the additional benefit of removal of material that would otherwise become foreshore waste/debris in the longer term	• As above but without the constraint of material becoming foreshore waste/debris in the longer term.	N
Lowering				
8	Habitat creation through embankment lowering	• Creation of intertidal habitat on backing land • Control over timing of embankment lowering • Control over inland consequences (flooding) of lowering through local earthworks (re-grading, banks, bunds) • Less (or no) internal creek network required • Low risk of foreshore consequences of breaching (remove and re-use materials to avoid waste and debris, no larger external creeks through breaches) • Re-use of material in earthworks for infilling borrow dykes to create a smooth morphological transition and reduces off-site waste • Re-use of material in earthworks for local banks/bunds reduces off-site waste • Removal of material that would otherwise become foreshore waste/debris in the longer term – can be re-used elsewhere on site or crushed for aggregate	• More extensive earthworks involved and so higher cost • Requires re-diversion of existing footpath • Requires PLCs • Risk to manage during construction at point of final lowering	N
Tidal Exchange				
9	Habitat creation through regulated tidal exchange (spillway and one-way pipes)	• Creation of intertidal habitat on backing land • Control over timing and extent of inland flooding through design	• Control over timing and extent of inland flooding through design may limit habitat creation potential • Less material liberated from earthworks for re-use on inland areas, may necessitate importation of subsoil and topsoil	N

Option No.	Option Description	Opportunities	Constraints	Short Listed (Y/N)
		• Control over inland consequences (flooding) of works through local earthworks (re-grading, banks, bunds) • Less and lower risk earthworks required for installation	• Large sections of embankment remain with facing concrete blockwork (which will become lose over time and remain as debris on the foreshore in the longer term) • Pipework requires ongoing maintenance (debris and sediment clearance) and repair/replacement as part of whole life costs	
9b	Habitat creation through regulated tidal exchange (spillway and one-way pipes) + removing concrete blockwork from seaward face of embankment prior to works	• As above but with the additional benefit of removal of material that would otherwise become foreshore waste/debris in the longer term	• As above but without the constraint of material becoming foreshore waste/debris in the longer term • Requirement to continue to maintain and improve the embankment	N
10	Habitat creation through regulated tidal exchange (two-way pipes)	• Largely as Option 9 but with potentially less earthworks	• Largely as Option 9 but with potentially even less material liberated for on-site re-use by earthworks (and therefore likely more material importation)	N
10b	As above but removing concrete blockwork from seaward face of embankment prior to works	• As above but with the additional benefit of removal of material that would otherwise become foreshore waste/debris in the longer term	• As above but without the constraint of material becoming foreshore waste/debris in the longer term	N

8.2 Short list

8.2.1 Option 1: Do nothing

Without intervention the defences will continue to deteriorate until they are compromised allowing tidal waters to inundate the site at Apuldram Meadow. It is difficult to predict exactly when this will occur. However, there are two vulnerable points on the southwest corner of the defence that have degraded significantly over a period of months (Figure 4-1). If the current rate of deterioration occurs, the defences may become breached within the next 2-5 years. Considering the number of emerging points of weakness along the western defence, these will continue to degrade creating new vulnerable points with time.

The coastal defences at Southmoor, near Langstone Harbour, started to deteriorate in 2017-2018 and there was no planned intervention. By 2020, the defences were breached during a storm allowing tidal waters to flood the site in an uncontrolled manner. The site is currently adapting to the breach which is becoming wider and deeper. The eroded material is being washed onto the land creating a sediment fan and blockwork has become stranded on the shoreline (Figure 8-1).

If the “Do nothing” option is adopted at Apuldram Meadow, a similar situation to that at Southmoor is expected. The potential opportunities, constraints and costs of this option are presented below in Table 8-4, Table 8-5 and Table 8-6.

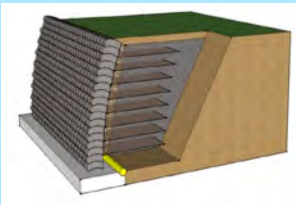
Figure 8-1 Left: Aerial photography of the unmanaged breach at Southmoor (Coastal Partners 2021). Right: Photograph of breach taken during January 2023 (courtesy of David Brew)

8.2.2 Option 2: Repair/maintain the existing embankment

The condition assessment highlighted the weakest spots in the existing embankment are within Sections 2 to 4, in particularly in the south-west corner of the site (Figure 3-1). Blocks have been dislodged and sediment has been lost, reducing the cross-sectional area of the defence, and promoting further failure. To prevent uncontrolled breaching (see section 8.2.1 “Do Nothing”), these sections could be strengthened. There are multiple options to repair these defences; all involving removal of the current blockwork, backfilling and reshaping the seaward slope using earth-moving equipment, and then placing a form of erosion protection. Table 8-2 provides an overview of possible solutions that could be considered. All these options do not include modifying the defence to conform with modern standards: such works would require a significantly higher number of earth-moving activities when compared to the repairs alone. It should also be mentioned that all these solutions require road-access for heavy vehicles (the exception being the concrete bag solution). This will require a temporary access road to be put in place. For the cost indications in Section 8.2.6, the current approach of concrete encasing is used.

It should be kept in mind that whilst repairing the defences would remedy the current risk of breaching, more works are likely to be required in future. Other parts of the defence could fail as well, which would then need to be repaired, and it is clear that these defences are not robust enough to accommodate future sea level rise. The latter would require the defences to be bolstered at a future date. These whole life costs were not taken into account for the cost indications in Section 8.2.6.

Table 8-2: Suggestions for potential solutions for repairing sections 2 and 4.

Solution	Impression	Comments
Repair using similar blocks as original		This solution would fit in well with the visual appearance of the original defence. However, based on the failure of the current embankment, the design should be adapted to cope better with loading.
Concrete encasement / slab		This is the current, pragmatic, method of repair, which seems to work sufficiently. This would involve encasing existing sections that have not yet failed but are damaged with in-situ concrete and replacing failed sections of blockwork with a concrete slab.
Porcupine Wall		An example of a retaining wall solution that consists of interlocking units, backed by soil stabilisation. This solution is non-standard for coastal defences and would need to be tested against wave loading, but could provide increased stability compared to the original blockwork. Image from RetainingWall Solutions.
Concrete Bags		(Bio-degradable) bags filled with a dry concrete mix are stacked into the required shape before being wetted to start the curing process. Placing this type of solution will require less plant to access and move around the site. However, this solution is non-standard for coastal defences and would need to be tested for hydraulic loading. Image from SoluForm.

8.2.3 Option 3: Managed realignment

Managed realignment can be defined as setting back the line of actively maintained defence to a new line inland of the original, or preferably to rising ground, and promoting the creation of habitat on the land between the old and new defences (or rising ground). Removal of the front-line defence is typically achieved in two ways; bank realignment where the defence is totally removed or breach realignment where a section of the defence is either lowered or removed. The tide can then inundate the exposed land during each tidal cycle allowing the floodplain to expand until it meets the new inland line. Depending on many factors, the flooded land will over time be occupied by intertidal habitats including mudflat and saltmarsh.

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There are currently four managed realignment schemes across Chichester Harbour, at Thornham Point, Cobnor Point, Chalkdock Marsh, and West Wittering, each with different characteristics, design features and rationale. Breach realignment was the preferred option at Thornham Point and Cobnor Point. Existing defences were breached by cutting channels through the embankments and allowing tidal waters to ingress. They have both been successful at creating new saltmarsh (Figure 8-2).

Figure 8-2 Bridge over one of the Cobnor Point managed realignment scheme breaches. Photograph taken 26th May 2021 courtesy of Uwe Dornbusch

The managed realignment option for Apuldram Meadow considers both a new earth embankment and different options for the existing frontline defence, as discussed in detail below.

8.2.3.1 Conceptual model of site evolution following managed realignment

When tidal action is restored through managed realignment, physical processes are set in motion that dictate the rate and the way a site will evolve. If the site is sheltered from significant wind-wave action and is at the appropriate elevations, it will evolve in response to coastal sedimentation processes, from intertidal mudflat (and potentially sandflat) to initial mudflat colonisation by salt-tolerant marsh plants, to ultimately a fully vegetated saltmarsh plain. Subtidal (lagoon) habitats could also form across lower parts of the site if the site is low relative to the tidal frame. Apuldram Meadow is located at the head of Fishbourne Channel and is relatively sheltered from waves. The LiDAR assessment also shows the land is of a suitable elevation for saltmarsh habitat creation, and the gentle rising slope of the land will allow a mix of habitats to form increasing the biodiversity of the site.

Flood tides carry in suspended sediments that deposit in the wave-protected slack waters of the flooded site. As sediment accumulates, intertidal mudflats are formed. As they build to higher elevations, the period of tidal-water inundation decreases, and the rate of sedimentation decreases. Once the mudflats reach a high enough elevation relative to the tidal frame, pioneer vegetation colonisation can occur. Sites that have relatively high initial elevations will reach colonisation elevation more quickly than those that are more deeply subsided. After vegetation colonisation has occurred, build-up of the saltmarsh continues through sediment trapping and organic accumulation. As the saltmarsh rises within the tidal frame, sediment accretion slows until a saltmarsh plain develops at an elevation around high water.

Concurrently with the physical evolution of the mudflat and saltmarsh, the tidal drainage system starts to form. Tidal creeks first form in the mudflat, and as vegetation becomes established, they become imprinted in the saltmarsh, eventually forming a tidal channel system. The rate of sedimentation is influenced by the development of channel networks across the site. The channels serve three principal functions: introduction and dispersal of fine-grained sediment, surface drainage and substrate dewatering, and dissipation of tidal energy. Sedimentation rates on intertidal areas generally increase in relation to higher density channel networks. Within this system, the tidal prism of the saltmarsh 'watershed' upstream mainly dictates the size and shape of the tidal channel at any given point. There is some evidence of former tidal creeks within the LiDAR data. Depending on how the site is breached, these former channels systems may reactivate and govern initial development of the tidal creek network.

8.2.3.2 New earth embankment

Considering the existing flood risk to local infrastructure (in particular the Wastewater Treatment Works), any managed realignment scheme would need to ensure infrastructure remains protected. In this case, this could be achieved by enhancing the natural land levels of the area to provide a sufficient level of protection. The location of these to-be-enhanced natural topographic features will determine the type and extent of habitat creation, whilst the continuous elevation of these features will manage the flood risk to the hinterland.

In terms of flood risk, the objective is to maintain at least the same level of protection as is currently provided. Part of the direct protection of this area is the embankment to the west of the Wastewater Treatment Works, which is directly south of the existing defence. As a starting point, it is assumed that the crest level of the enhanced topographic features would not need to be higher than the existing Wastewater Treatment Works defences, as this all forms part of the same flood cell. The enhanced land level is therefore assumed to be 3.75 m OD. If there is a need to upgrade the current approach in future to a flood defence conform with modern (Environment Agency) standards, enough space should be left around existing and planned assets to allow for the footprint of these future defences. This will require additional funding not accounted for here as any increase in crest height would need to be aligned with increases in the defence to the south of the site as if these are not maintained, their remains a flood risk to the Wasterwater Treatment Works from the south.

The approach to enhancing the natural land levels to provide a continuous level of protection is two-fold, and is further clarified in Figure 8-3:

1 Along the southern boundary of the site, the LiDAR data suggests there is a liner ridge feature where elevations are higher than the surrounding land. Whilst, the LiDAR in Figure 5-1 shows land elevations above 3.75m OD, a review of the data in detail indicates these elevations are due to the presence of vegetation and they do not represent the ground level. In this area, the land elevation is expected to be approximately 3m OD but will need to be surveyed to confirm this. The level of the fields on the seaward side of this crest is estimated to be 2.3m OD. Figure 8-4 presents a typical LIDAR cross-section of this crest (including vegetation) and the estimated land elevations based on the principles set out above. To enhance the lower parts of this crest to 3.75 m OD, 235 m of earth embankment would need to be constructed from local clay on the seaward slope of the crest (to reduce the volume that will need to be placed and to minimise the effect on the existing vegetation). This embankment would have a crest width of 1.5 m to allow for the realignment of Footpath 3059, and both slopes would be 1V:3H. This is visualised in Figure 8-5. A backfilled trench is included along the length of this enhancement (also indicated on Figure 8-5) to control the seepage of sea water beneath the enhancement. It should be noted that a topographic survey and Ground Investigation of this area are needed to determine the actual land elevation levels, before any further design works could commence.

2 Along the northern boundary of the site, land levels are relatively low when compared to the higher ground in the central part of the site. Here, construction of an earth embankment is proposed (Figure 8-3; Sections 2 and 3 with a total length of approximately 157 m), to connect those higher ground elevations levels with the existing sea defences to the north and to the south. Such an embankment would exist out of locally sourced clay, would have a crest height of 3.75m OD and a crest width of 1.5m to accommodate the realignment of Footpath 3059. The front and back slopes of the embankment would be 1V:3H. Figure 8-5 shows a typical cross-section of this embankment, whilst Figure 8-6 shows a comparison between existing land elevation along this section and the proposed height of the embankment (which indicates where the embankment would be constructed). This embankment would have a similar seepage control as the southern section in the form of a backfilled trench.

The clay needed for these enhancement works is expected to be sourced from the realignment preparation works (i.e. the sediment that becomes available from creating tidal creeks and/or local lagoons; Section 8.2.3.3) and the removal of (parts of) the existing defence (Section 8.2.3.4). The availability of a suitable quantity of clay would need to be confirmed through Ground Investigation.

Figure 8-3 Schematic showing a proposed location and configuration of a new earth embankment, tying-in to areas of natural higher ground. Dashed lines indicate sections where it is expected that such an embankment is needed, but cannot be confirmed at this moment due to the uncertainty in the LiDAR levels.

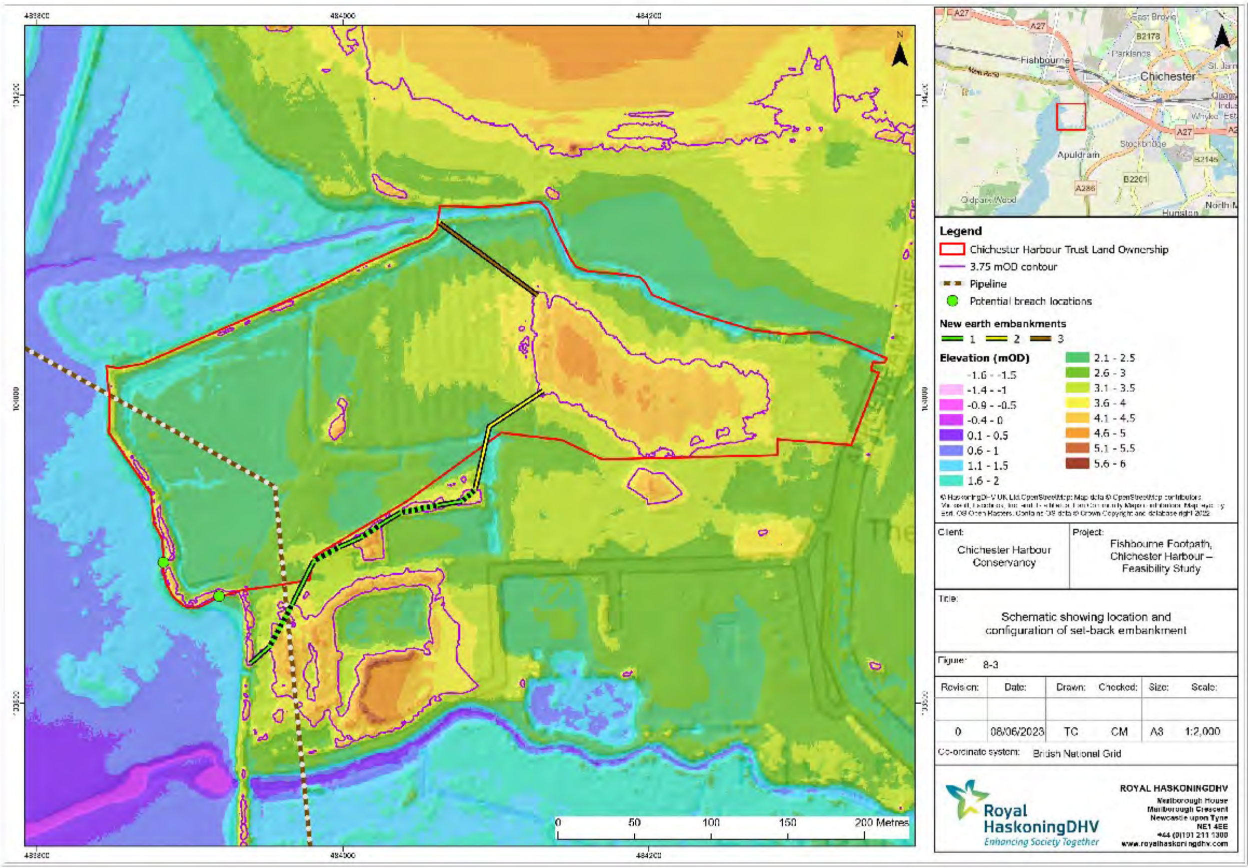


Figure 8-4 Cross section showing land elevation and new embankment along Section 1.

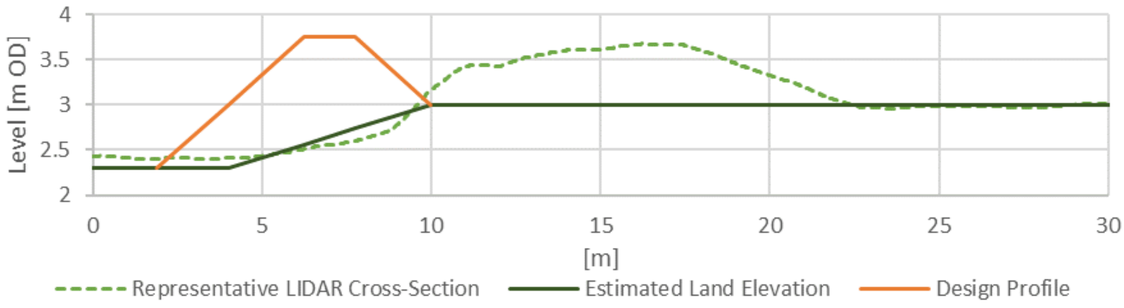


Figure 8-5 Schematic showing new embankment design along Sections 2 and 3.

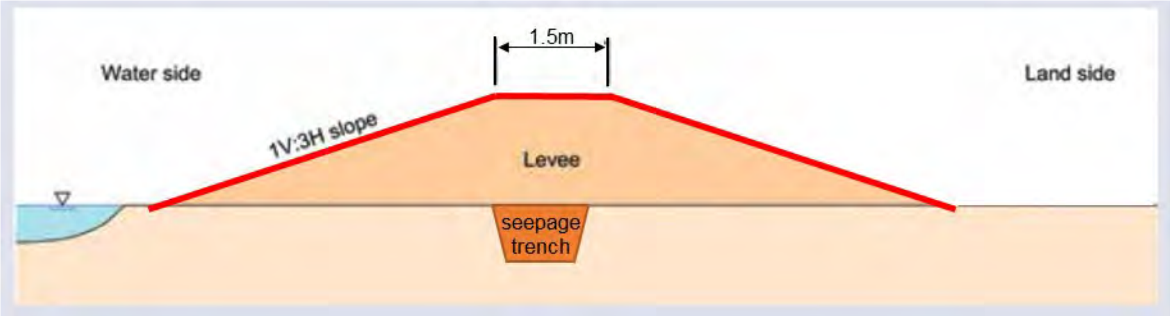
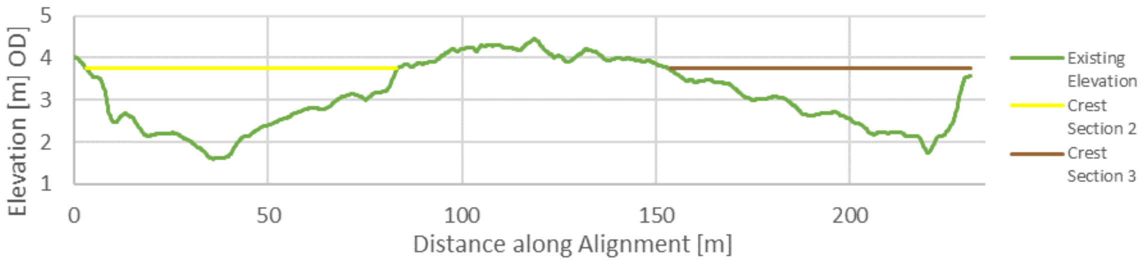


Figure 8-6 Cross section showing elevation and new embankment crest along Section 2 and Section 3 of the new embankment



8.2.3.3 Realignment preparation works

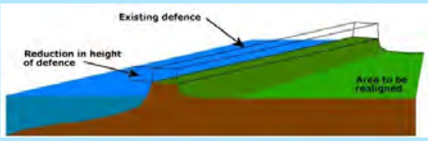
Before opening the existing defences (see section 8.2.3.4), some preparation works should be undertaken within the realigned area. Typical works could include infilling the existing field drain and borrow ditch system to break the linear drainage system and help a 'natural' creek network to become reinstated, whilst artificially constructed creek networks should look to maximise flooding and draining of the site while mimicking the channel and network properties of natural marshes (Hudson et al., 2021). Material from these excavations would be used in the construction of the new defences, depending on soil quality.

8.2.3.4 Existing coastal defence

Once natural features have been enhanced to provide the required level of protection, there are different options for managing the existing coastal defence, which are summarised in Table 8-3. These options focus on the western defence length, particularly on those locations that have already been identified as weak points. The northern defence would stay in place providing a causeway into the Fishbourne Channel with a viewpoint at the end that could be enhanced for recreational use with a bench or bird hide.

However, it is expected that this defence may deteriorate in future as the landward side will become exposed to tidal and wave forcing once the site is breached. It is recommended that the existing defence would be breached; in that case, two 35m breaches are assumed to be created in those sections of the defence that are already in poor conditions. The blockwork would be removed and crushed for use elsewhere (for example to create the footpath) and removed soil would be used for the construction of the embankments.

Table 8-3: Options for the existing defence in case of realignment

Option	Impression	Description
Degrade without intervention	 Image: courtesy of David Brew	Once the new earth embankments are in place, the existing wall could be allowed to degrade until a natural breach occurs. This is very similar to the Do Nothing scenario, although flood risk is managed through the defence. There is limited control of where the breach will occur, and care should be taken around debris from the old defence entering the channel. This can be prevented by removing structural elements from the old defence. However, this would speed up the deterioration and increase the chance of breaching along the whole defence length.
Breach	 Images: Ecoshape.com	A breach would be artificially created at one of the weak points in the defence. Tidal flow will enter the realigned area through this gap, so it is likely that a channel will form through this breach. The old defence will provide a degree of protection from waves to the landward area or allow longer residence time for sediment settling while the new intertidal area develops. It could be chosen to protect the banks of the breach (for example by creating rubble mount roundheads) to keep the defence in place for a longer period after breaching. If the defence is allowed to degrade naturally after breaching, the impact of structural elements should be considered. The footpath could remain in place if the former defence is structurally sound; this should be monitored regularly.
Lower / Remove		The defence would be lowered or removed completely. With this measure, a fully open connection with the harbour is restored. This option provides less sheltered conditions than breaching and would allow the fully natural system to start to develop immediately. This could lead to an initially increased area of intertidal habitats compared to the breaching option. There is a chance, however, that a lack of shelter (compared to the breached scenario)

Option	Impression	Description
	 Image: Ecoshape.com	could cause erosion by waves that would prevent saltmarsh development and could induce a higher wave attack on the new inland embankment.

8.2.4 Opportunities

For each preferred option, there are several opportunities to maximise the environmental and recreational benefits of the scheme, as summarised in Table 8-4 and discussed below in detail.

Table 8-4 Potential opportunities from different options

Opportunities	Option 1	Option 2	Option 3
Saltmarsh habitat creation	✓	✗	✓
Supports Government environmental, flood alleviation and nature-based coastal management ambitions	✗	✗	✓
Habitat Compensation and Restoration Programme	✗	✗	✓
Maintains total footpath length	✗	✓	✓
Maintains Footpath 3059	✗	✓	✗
Sustainable reuse of existing earthworks and concrete blockwork	✗	✗	✓
Maintains flood defence	✗	✓	✓

The saltmarshes of Chichester Harbour already provide substantial flood and erosion benefits. Protecting, enhancing, and restoring these features are relatively low-cost ways to build resilience against current and future flooding and erosion risks. Natural features also have added benefits, supporting biodiversity and carbon sequestration and through tourism and recreation, supporting local communities and the economy. Historically, saltmarshes have successfully adjusted to past sea-level rise by migrating inland where space has been available. By setting back coastal defences further inland, space can be created to allow saltmarshes to adapt naturally to changing environmental pressures reducing the effect of coastal squeeze.

New saltmarsh habitat creation would support Government strategies and ambitions by:

- Improving the condition of the Chichester Harbour SSSI by slowing the net loss of saltmarsh habitat;
- Improving Biodiversity Action Plan targets supporting Biodiversity Net-Gain;
- Achieving the statutory requirement to reach “net-zero” by 2050 through carbon sequestration;
- Expanding the use of natural flood management solutions, and nature recovery through protection, conservation and enhancing natural beauty as defined in Defra’s 25-year plan; and

- Managing the effects of coastal change by allowing the operation of natural coastal processes and improving the sustainability of current management practices according to the South Coast Plain National Character Area Profile.

New saltmarsh habitat would be created if either Option 1 or Option 3 are implemented. It may be beneficial to create a mix of habitat types in the concept design options including both creation of new intertidal habitats and transitional habitats through natural transitions to the edges of the site as well as micro-topographic variations within the site itself. Hence, both freshwater/brackish and intertidal habitats could be targeted, providing (in theory) an ideal ecological solution. This could create a mosaic of habitats, with the opportunity for freshwater/brackish areas which would also change/evolve over time.

However, there are additional benefits in adopting Option 3 as the scheme could be funded through the Habitat Compensation and Restoration Programme. It would also increase the overall footpath length along this section of the coast and makes provision to maintain use of Footpath 555 and part of Footpath 3059 (along the northern embankment) for as long as it is safe to do so.

If Option 3 is adopted, there is potential to reuse existing material to construct the new embankments which will not only reduce costs, but also the carbon footprint of the scheme by providing a sustainable source of material on-site. If Option 2 is adopted, Footpath 3059 would be maintained but additional material would need to be brought on site for the repairs/maintenance works.

Both Option 3 and Option 2 provide flood protection against the same water levels as it is proposed that any new defence is constructed to the same elevation as the existing defence. However, the proposed flood defence for Option 3 will be fronted by saltmarsh which has the added benefits of dissipating wave energy before it reaches the defence. If Option 2 is adopted, the continued loss of fronting saltmarsh would mean a greater amount of wave energy would impinge on the defence, and it may deteriorate at a faster rate when compared to the new defence.

8.2.5 Constraints

For each preferred option there are a number of constraints that may limit the success of the options, as summarised in Table 8-5 and discussed below in detail.

Table 8-5 Potential constraints from different options

Constraints	Option 1	Option 2	Option 3
Loss of Coastal and Floodplain Grazing Marsh	✓	×	✓
Loss of freshwater habitat (associated with Fishbourne stream)	✓	×	×
High flood risk to infrastructure	✓	×	×
Loss of Footpath 3059	✓	×	×
Abandoned infrastructure in the intertidal zone	✓	×	?*
Restricted access to utilities	✓	×	✓
Requires planning permission/consent	×	✓	✓
No control over timing or impact of inundation	✓	×	×
Funding	×	✓	✓

*Depends on the option for managing the existing defence

If the site in inundated in an uncontrolled manner without construction of a new defence inland (Option 1), it is likely there would be a net loss of freshwater habitat. The chalk stream is an important freshwater feature and whilst it is not designated, if the site was flooded, brackish water would enter the stream having a detrimental effect on its ecology. Furthermore, tidal inundation would change the hydrology of the stream as it would not be able to drain effectively during rising and high tides which may increase the flood risk further upstream, especially if high tide occurs during a high run-off event (e.g. high rainfall). A new defence would be required to protect this freshwater habitat.

The creation of saltmarsh though managed realignment will change the habitats in Apuldram Meadow leading to a net loss of Coastal and Floodplain Grazing Marsh which is a priority habitat. However, the net loss would be offset by the creation of saltmarsh habitat which is also a priority habitat. Consultation with nature conservation bodies would be required to determine if the complete transformation from a freshwater to a more brackish or intertidal assemblage would be accepted without the requirement to recreate freshwater habitat elsewhere.

If Option 1 is adopted and the defence is allowed to deteriorate, this will increase the flood risk to adjacent land and infrastructure. Therefore, the development of any scheme without a new defence inland is not recommended.

At present, access to Footpath 3059 is restricted due to safety concerns with the degrading embankment resulting in a net loss of footpath of approximately 450 m. If the embankment is repaired, the footpath could reopen reinstating access and there would be no net change in footpath length. Similarly, if a new footpath is installed along the proposed new defence, there would be no net change in footpath length as the new embankment will provide up to 450 m of new footpath.

Another constraint with Option 1 is that as the existing embankment continues to deteriorate, blockwork and other masonry and fill material will become abandoned in the intertidal zone creating an unnatural view of the Fishbourne Channel with a possible perceived lack of management or consideration for the environment.

Once the embankment is breached (Option 1 or Option 3), inundation would eventually flood Footpath 555 and the treeline running alongside it. The footpath is a temporary structure that can be removed. However, if unmanaged, the trees would gradually die leaving branches and stumps stranded in the intertidal zone. This could be manged by removing the trees before inundation.

A significant constraint Option 1 and Option 3is access to buried utilities, particularly the gas pipe running through the site. Any inundation of the site will limit access to the pipe which would require additional measures should access be required (e.g. cofferdams and restricted working times in line with the tidal regime). A change from freshwater to brackish water may also have negative impact on the utilities with brackish water potentially leading to corrosion of the pipe (likely through ground water percolation as the pipe is buried).

The pipe also poses a major constraint on the construction of a new defence (Option 3). The proposed location of the new embankment currently crosses the pipe to the south-west of the site (Figure 8-3). Depending on local land levels in the vicinity of the pipe, there is potential to avoid the infrastructure by tying the embankment into areas of higher ground. This could be confirmed with detailed topographic surveys. However, construction activities would still occur in close proximity to the pipe which would require additional mitigation measures to ensure the pipe is not compromised (e.g. supervision by a representative of Southern Network Gas). If the pipe cannot be avoided, relocation of the pipe could be an option with relevant permissions, but this would add an additional cost that is acknowledged here but has not been incorporated in the cost estimate below.

Implementation of Option 3 will require planning permission and consent, potentially requiring a full Environmental Impact Assessment (the cost of which has not been included because it would be dependent on its need and scope as defined by an EIA screening and scoping, respectively). The planning requirements for Option 2 will depend on the preferred method of repair but considering that complete sections will need to be removed and reinstated, this may not be considered routine maintenance and will therefore require consent. As works are likely to include areas of the embankment below MHWS, a marine licence will be required from the Marine Management Organisation.

A cost estimate for implementing Option 2 or Option 3 is presented below and both options will require funding. The AIMS database indicated the Environment Agency are listed as the asset maintainer for these defences (at the time of writing). However, this assumption would need to be confirmed with the Environment Agency. An alternative source of funding may be the private sector, potentially through a Habitat Compensation and Restoration Scheme.

8.2.6 Cost estimate

For Options 2 and 3, this section presents a cost estimate for the execution of the works. A sheet with a more detailed breakdown has been included in Appendix A for each of these options. Cost estimates are mainly based on RHDHV's previous experience on similar projects, and assume the appointment of a local earthworks contractor under a competitive tendering exercise rather than use of a major national or regional civil engineering contractor (the likes of which are on the Environment Agency's Collaboratively Delivery Framework). The cost estimates include the following items:

- Material, Plant and Labour
- General Preliminaries
- Contractor Overheads & Profits
- Earthworks Design Costs; excluding any costs for the design of fencing, local ecological enhancement, etc.
- Topography Survey and Ground Investigations
- Permissions, licenses, and consents (PLCs); it is assumed that an EIA will not be necessary for these works.
- Contract Admin & Site Supervision
- Client Staff Costs

Option 2 is based on repairing the existing defence using in-situ concrete over sections 2 and 4. It assumes that any backfill material is sourced locally and does not need imported. For costing purposes, a 0.2 m thick slab of concrete is assumed to be cast in-situ over the length of sections 2 and 4, similar to previous repairs. No changes will be made to the existing profile. A temporary access road will be needed to facilitate heavy construction traffic to reach the defence from the main road. As these works only concern repairs to the existing structures, it is assumed that permits, licenses and consents are not applicable; this has therefore not been considered for this option. As mentioned in Section 8.2.2, as this option only concerns repairing the current defects to existing standards, it might fail again in future, which might require additional repairs to be made. Additionally, the current defences are not robust when looking at future climate change. Therefore, a similar order cost will be needed over time to repair future defects on a repeated basis.

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Option 3 is based on constructing the natural land level enhancements as set out in Section 8.2.3. It is assumed that the fill material (approximately 2,600 m^3) can be won from the realigned area (from the creating of tidal creeks and / or local lagoons and the breaches in the existing defence, and that any excess from these activities can be used locally. No remediation works for the gas pipeline have been included in these estimates.

Table 8-6 presents the costs for these different options, however, a more detailed overview for both options is presented in Appendix A. In both cases, a 60% optimism bias has been included, which is a reasonable contingency at concept design stage. This accounts for uncertainty in predicting costs and as a project develops and more information becomes available, the optimism bias will likely reduce.

Table 8-6: Cost Estimates for Options 2 and 3. It should be noted that Option 2 is based on current defects only; over time, this order of cost will be needed on a repeated basis to repair future defects.

Option	Construction Costs	Optimism Bias (60%)	Total Costs
Option 2: Repair Defences	£ 258,053	£ 154,832	**£ 457,135**
Option 3: Managed Realignment	£ 377,636	£ 266,582	**£ 604,218**

9 Communication and Engagement Plan

9.1 Introduction

This communication and engagement plan sets out different ways the Conservancy can engage with the public and stakeholders in relation to the maintenance and future management of Apuldram Meadow and associated coastal defences and public footpaths.

Working closely with and listening to the various partners and communities of Fishbourne Parish and wider Chichester Harbour environment is an important step in developing the proposed scheme and requires local input to draw upon the diverse strengths of others. The plan should make sure that interested parties have a way to access relevant information to them. Communities and other stakeholders will have valuable information to contribute as to how the coast of Chichester Harbour behaves, what the key drivers are, and how the coast can be adapted to accommodate change in a managed and sustainable way. Therefore, it is key that the right approach is adopted, with the right stakeholders, at the right stage of the project, if the plan is to be truly effective in engaging views and opinions to inform the processes.

Community engagement should begin early and be undertaken often. The most sustainable solutions come from involving many perspectives and insights at an early stage. Inclusive processes give greater ownership of the solutions and empowerment to people and communities. This communication and engagement plan sets out the stages, objectives, stakeholders, and recommended approaches to be followed at different stages of the project. The plan is a live document that can be updated during the project.

9.2 Stages of project

Coastal management projects are delivered in phases and this study has been undertaken at the very early stages of the project to identify opportunities and constraints to future management. At such an early stage, it is difficult to define project phases, but it is anticipated the following phases will form key elements of the project:

- Feasibility Study;
- Options Appraisal;
- Funding;
- Planning; and
- Construction.

During each of these phases, the communication and engagement plan should be reviewed and updated to reflect any changes in the project.

9.3 Engagement objective

It is important at each stage of the project to consider what the project is trying to achieve and that the engagement objectives are clearly defined as this will help determine who the key stakeholders are and how best to engage with them. This Feasibility Study has the following engagement objective: Communicate the outcomes of the Feasibility Study with a wide range of stakeholders so they have all relevant and available information to inform their views which can be fed back to the Conservancy.

9.4 Stakeholders

Stakeholders for this Feasibility Study are organisations, groups or individuals that could be affected by or be interested in the future management of Apuldram Meadow. It is important to identify all stakeholders to ensure the engagement objective can be achieved. Therefore, as the project develops and engagement objectives change, stakeholders must be reviewed to ensure they are comprehensive and appropriate.

An initial assessment of stakeholders has been undertaken as outlined in Table 9-1. This list is not exhaustive and if any stakeholders are absent, they can be included when this communication and engagement plan is reviewed during the next project phase.

Depending on the engagement objective, stakeholder analysis may be required which will consider each stakeholder individually against their influence over the project (e.g. funders, regulatory bodies), their interest (e.g. local groups and public users) and the impact the project may have on them (local residents or businesses).

Table 9-1 Apuldram Meadow Stakeholders

Local Government	Statutory Consultees

• Apuldram Parish
• MP
• Local Councillors
• Cabinet Members
• Chichester District Council Departments
   o Town Team / Town Deal Board
   o Tourism & Culture
   o Conservation Officer
   o Regeneration
   o Highways
   o Flood Risk Management
• West Sussex County Council (Highways Authority)
• Residents Panels
	• Environment Agency
	• Natural England
	• Marine Management Organisation
	• Historic England
	• Chichester District Council Planning Department
	• The Crown Estate

Safety Organisations	Transport Interests
• Emergency Services • RNLI • Coastguard	• Highways Agency
Local Business Groups	**Local Interest Groups**
• Chichester Harbour Trust (landowner) • Harbour Users Group	• Coastal Partners • Fishbourne Parish Council • Bird Aware Solent. • Chichester and District Archaeology Society • The RSPB

Table 9 1 Apuldram Meadow Stakeholders (continued)

Local Leisure/Recreation Groups	General Public
• Ramblers and walking groups • Dell Quay Sailing Club • Dell Quay Fishing Club • Chichetser Wildfowlers	• Residents of Apuldram Lane • The Tenant Farmer / Neighbouring Farmer • Visitors/tourists • Education – local schools, colleges, university
Media	**Utility Providers**
• Local • Regional • National • Radio • Newspapers	• Southern Gas Network • Southern Water (Wastewater Treatment Works)
Potential Funding Partners	**Regeneration/Placemaker Links**
• Private	• CHaPRoN

9.5 Approach

Once the engagement objective and stakeholders have been defined, it is important to adopt an appropriate way of engaging which will depend on what needs to be achieved and who the stakeholder is. There are different types of engagement which are defined below in Table 9-2 alongside examples of methods that can be adopted to facilitate the engagement.

Table 9-2 Types and methods of engagement

<table>
<tr><th>1. Inform</th><th>2. Gather information</th></tr>
<tr><td>• CHaPRoN newsletter
• Digital information resource
• Public drop-in sessions
• Advertise public drop-in sessions and online public consultation to encourage participation
• Share technical reports
• Share meeting minutes and recordings
• Technical briefings (and share recordings)</td><td>• Meetings with individual or groups of stakeholders (gather information)
• Presentations to specific groups
• Online public consultation
• Public drop-in sessions</td></tr>
<tr><th colspan="2">3. Collaborate</th></tr>
<tr><td colspan="2">• Technical working group meetings
• Steering groups
• Meetings with individual or groups of stakeholders (feedback information)
• Social media forum
• Collaborative relationships</td></tr>
</table>

9.6 Initial plan

Considering the engagement objective of this Feasibility Study, an initial communication and engagement plan has been developed, as outlined in Table 9-3. This plan is a live document and should be updated as the project progresses to include a review and update of the engagement objectives, stakeholders and approach/methods of engaging.

Table 9-3 Initial communication and engagement plan

Project stage	Engagement objective	Stakeholder(s)	Method
Feasibility Study	Communicate the outcomes of the Feasibility Study with a wide range of stakeholders.	All	Share Feasibility Study report CHaPRoN newsletter
		Chichester Harbour Trust Local councillors Environment Agency Natural England	Present results of Feasibility Study at Chichester Harbour Trust Advisory Group Meeting (17/04/2023)
		Local councillors Chichester Harbour Trust	Present results of Feasibility Study at Chichester Harbour Trust Board Meeting (24/04/2023)
		Local residents General public Local businesses Apuldram parish	Present results of Feasibility Study at Apuldram Parish meeting (Date to be confirmed)
		Utility providers	Arrange meeting with Southern Gas Arrange meeting with Southern Water

10 Preferred option and next steps

Considering the opportunities and constraints of each of the short-list options, managed realignment (Option 3) is the preferred approach as this provides an opportunity to control the inundation of Apuldram Meadow whilst maintaining a level of flood defence that can be adapted in line with future sea-level rise and land-use changes. The solution supports Government ambitions to increase biodiversity net gain and will contribute to wider efforts that are addressing the declining state of Chichester Harbours saltmarshes.

Whilst management realignment presents a range of opportunities, it is key to understand the potential constraints of the gas pipe as this may limit any scope to implement the scheme. Therefore, engagement with the relevant utilities companies is advised as a next step. The design of the new earth embankment is based on predicted land levels determined from LiDAR data. Given uncertainty in the data, potentially related to the presence of vegetation biasing the data giving the impression land levels are higher, a topographic survey of the site is recommended to ensure levels are suitable to implement the proposed scheme. Finally, it is also important to consider future funding sources, and given the financial scale of the scheme and the number of stakeholders that have an interest or influence, acquiring a diverse funding portfolio from public and private sources may be required.

Upon completion of this Feasibility Study, it is recommended that the communication and engagement plan is implemented and adapted to gain as many perspectives and insights as possible from stakeholders before progressing the project to the next stages which would require design, funding, consent and construction.

Appendix A

11 References

Allen, M. & Gardiner, J. (2000) *Our Changing Coast: A survey of the intertidal archaeology of Langstone Harbour, Hampshire*, CBA Research Report 124, Council for British Archaeology, York. Available at: https://archaeologydataservice.ac.uk/archiveDS/archiveDownload?t=arch-281-1/dissemination/pdf/RR124.pdf [Accessed 28 February 2023]

Bardsley, L., Brooksbank, J., Giacomelli G., Marlow, A., and Webster E. 2020. Review of Chichester Harbour sites: intertidal, subtidal and bird features. Natural England Research Report, Number 090.

Cartwright, C. (1984) 'Field Survey of Chichester Harbour' in *Sussex Archaeological Collections Relating to the Counties of East and West Sussex,* Archaeology Data Service.

CIRIA. (2013). *The International Levee Handbook* (C731). CIRIA, London.

CITiZAN (2016) 'Salt Working in Chichester Harbour: Counties of Hampshire and West Sussex', MOLA, London.

Environment Agency (2023) AIMS Spatial Flood Defences (inc. standardised attributes). Available at AIMS Spatial Flood Defences (inc. standardised attributes) - data.gov.uk [Accessed 24 April 2023]

Environment Agency (2013) Saltmarsh Extent and Zonation. Available at https://www.data.gov.uk/dataset/0e9982d3-1fef-47de-9af0-4b1398330d88/saltmarsh-extent-zonation [Accessed 01 March 2023)

Environment Agency. (2018) *Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels.* [GIS dataset]. Retrieved from https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018.

Historic England (2023). Available at Search the List - Find listed buildings, monuments, battlefields and more | Historic England. [Accessed 28 February 2023]

Hudson, R., Kenworthy, J. and Best, M. (eds) (2021). Saltmarsh Restoration Handbook: UK and Ireland. Environment Agency, Bristol, UK.

Kenny, J. (1992) 'An Archaeological Evaluation at Fishbourne West Sussex', Southern Archaeology Report, Archaeology Data Service.

Kenny, J. (1996), 'An Archaeological Investigation of Land at Fishbourne Harbour, West Sussex', Archaeology Data Service.

Le Patourel, H. E. J. (1986) 'Documentary Evidence and the Medieval Pottery Industry', *Medieval Archaeology* 12(12), pp. 101-126.

Museum of London Archaeology Service, (2007) 'Uncovering the Past: Archaeological Discoveries in Chichester Harbour AONB 2004-2007'. Available at https://www.yumpu.com/en/document/read/24568655/uncovering-the-past-chichester-harbour-conservancy [Accessed 2 March 2023]

Ordnance Survey (1880) *Sussex Sheet LXI*

Ordnance Survey (1899) *Sussex Sheet LXI.SW*

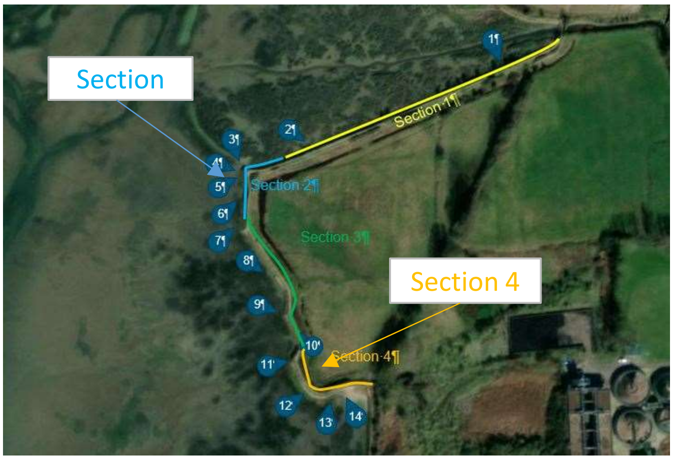
Rudkin, D. J. (1986) 'The Excavation of a Romano-British Site by Chichester Harbour, Fishbourne' in Hudson, T. P. (ed.) *Sussex Archaeological Collections Relating to the Counties of East and West Sussex*, vol. 124, pp. 51-78.

Salzman, L. F. (ed.) (1953) 'New Fishbourne', *A History of the County of Sussex: Volume 4, the Rape of Chichester*, pp. 154-156. British History Online. Available at: http://www.british-history.ac.uk/vch/sussex/vol4/pp154-156 [Accessed 2 March 2023].

Sussex Biodiversity Partnership (2008) The Sussex Biodiversity Opportunity Areas. Available at: Sussex BOA Statement (brighton-hove.gov.uk) [Accessed 26 April 2023]

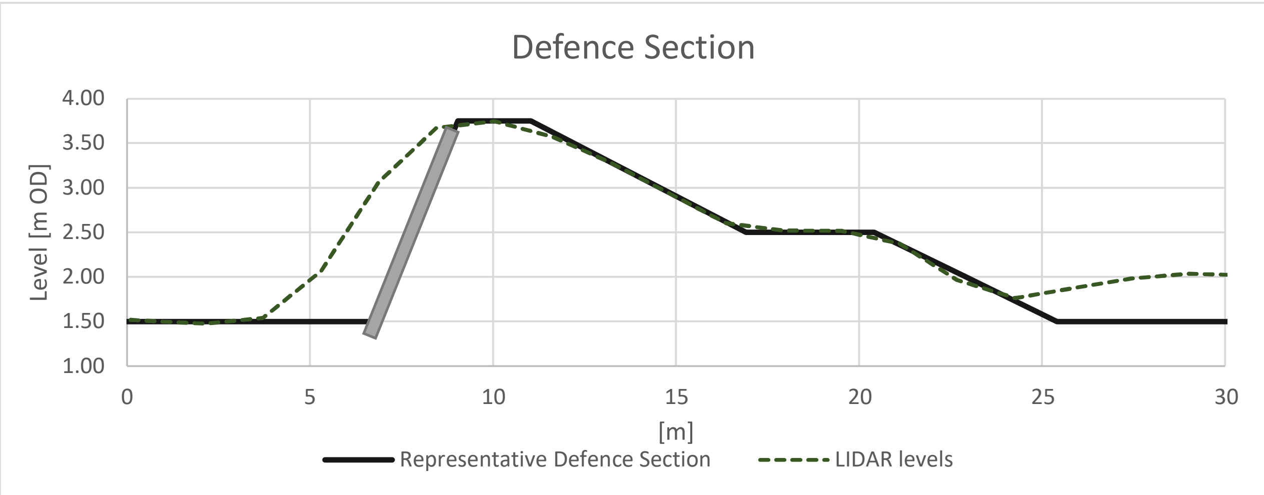
WWF 2014 The State of England's Chalk Streams. WWWF UK Report.

Option 2: Repair



Assumtions

* Defence cross-section representative of full length of defences.
* Partial excavation / backfill of existing defences necessary as part of repair works.
* Any backfill will be sourced locally.
* A 0.2m concrete slab will be cast in-situ, similar to previous repairs.
* No changes will be made to the existing profile.
* A temporary work road (aluminium matting) will be needed to access the site from the main road.
* As this option only considers a repair of the existing structure, PLC is not expected to be needed.



* Note that the outer slope is assumed to be steeper than the LIDAR would suggest;
This slope (1V:1H) is based on observations during the site visit and is a conservative estimate.

Concrete Layer

Slab thickness	0.2	m
Slope length	3.2	m
Required concrete volume	0.64	m3/m

Embankment Repair

Embankment Volume	17.6	m3/m
% to be replaced	33%	

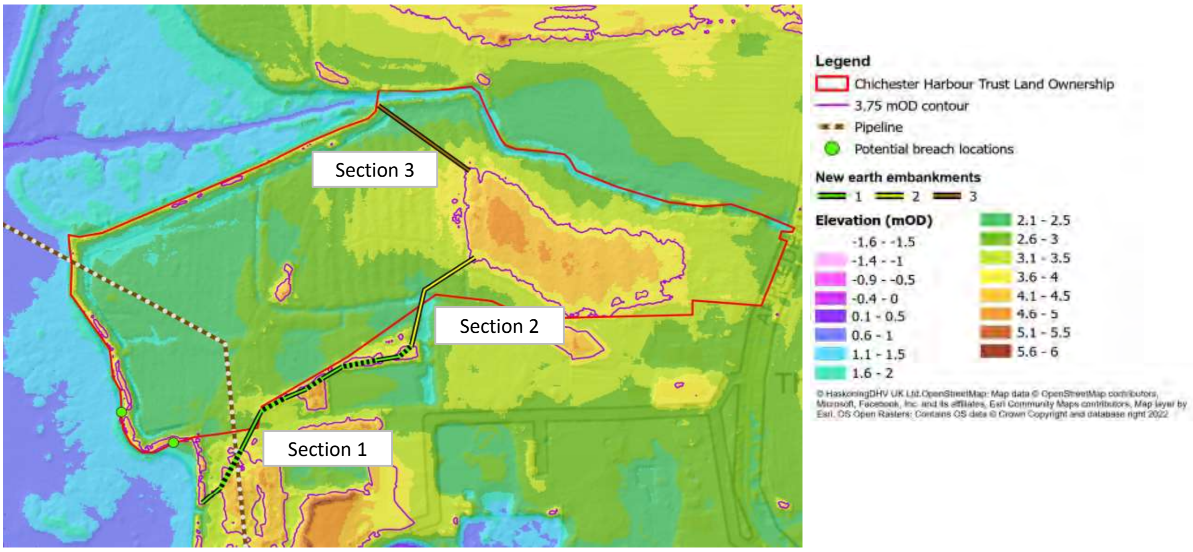
Repaired Lengths

Section 2	100	m
Section 4	110	m

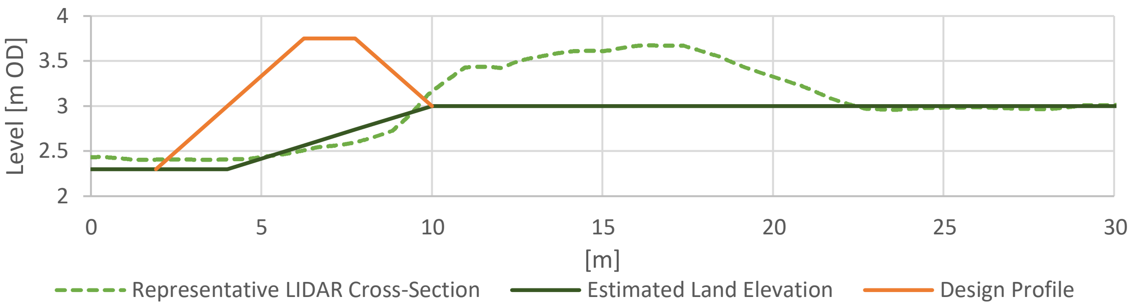
Option 2: Repair

	Qty	Unit	Unit Rate	Cost
Embankment Repair (excavation/fill)	1219.2	m3	£ 40.00	£ 48,770
Concrete casting (in-situ)	133.6	m3	£ 500.00	£ 66,822
Temporay Work Road	550.0	m	£ 67.50	£ 37,125
				£ 152,716
General Preliminaries	25%			£ 38,179
Contractors Overheads and Profit	15%			£ 22,907
				£ 213,803.05
Design Costs	lump sum			£ 30,000
Topography Survey	lump sum			£ 7,500
PLC's	0%			£ -
Contract Admin & Site Supervision	20%			£ 6,000
Council Staff Costs	10%			£ 750
Compensation (Land)	0%			£ -
				£ 258,053
			60% Optimism Bias	£ 154,832
			Total	**£ 457,135**

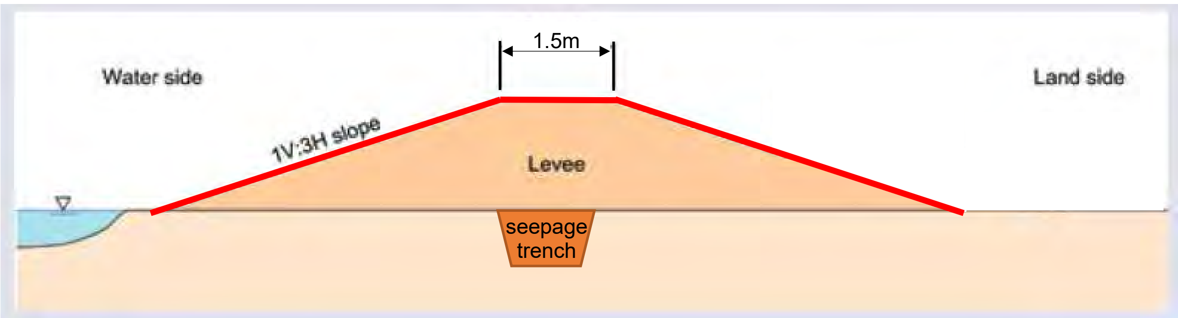
Option 3: Managed Realignment

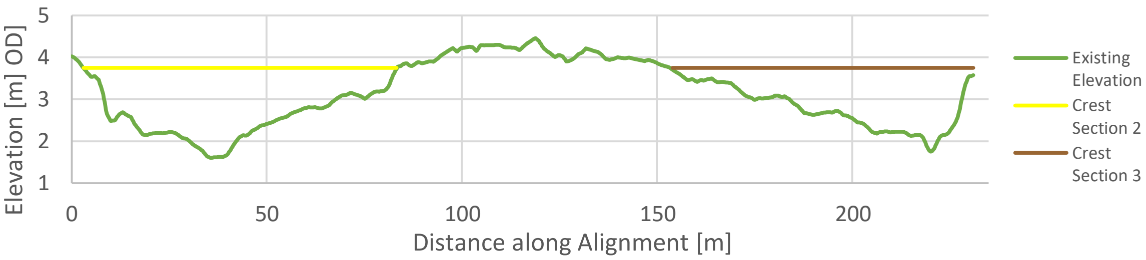


Section 1



Sections 2 & 3





Embankment Design

Crest Level	3.75	m OD
Crest Width	1.50	m
Slope 1:	3.00	-

Seepage Control

Trench Volume:	1.00	m3/m

* typically approximately 1m x 1m

Option 3: Managed Realignment

Assumptions

* Embankment with clay core; clay can be sourced locally through:
  * breach excavation
  * creation of tidal creeks and/or local lagoons
* There is a net balance of material (cut / fill);- any excess can be used locally.
* Seepage control is implemented through a cut and backfill toe trench.
* Breaching in two locations; breach width 35m.
* No remediation to the gas pipeline included
* Land does not need to be bought / compensated
* Fencing / local ecological enhancements / etc are excluded from the Design Costs
* EIA is not necessary and excluded from PLC costs.
* 60% optimism bias included, which is reasonable at concept design stage

	length [m]	volume [m3]
Section 1	235.0	1327.8
Section 2	80.0	557.4
Section 3	77.0	307.7

Breach Volume	12.3	m3
Breach Length	70.0	m

Item	Qty	Unit	Unit Rate	Cost
Embankment Fill	2192.9	m3	£ 20.00	£ 43,858
Seepage Trench	392.0	m3	£ 30.00	£ 11,760
Breaching Existing Defence	864.1	m3	£ 20.00	£ 17,281
Excavation Creeks (or Local Lagoons)	1720.8	m3	£ 20.00	£ 34,417
Processing of blocks for use in footpath	111.4	m3	£ 60.00	£ 6,682.16
				£ 107,316
Footpath / Access Structures / etc	20%			£ 21,463
				£ 128,779
General Preliminaries	15%			£ 19,317
Contractors Overheads and Profit	15%			£ 19,317
				£ 167,412
Earthworks Design Costs	lump sum			£ 60,000
Topography Survey / Ground Investigations	lump sum			£ 50,000
PLC's	lump sum			£ 50,000
Contract Admin & Site Supervision	20%			£ 33,482
Client Staff Costs	10%			£ 16,741
Compensation (Land)	0%			£ -
				£ 377,636
			60% Optimism Bias	£ 226,582
			Total	**£ 604,218**

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