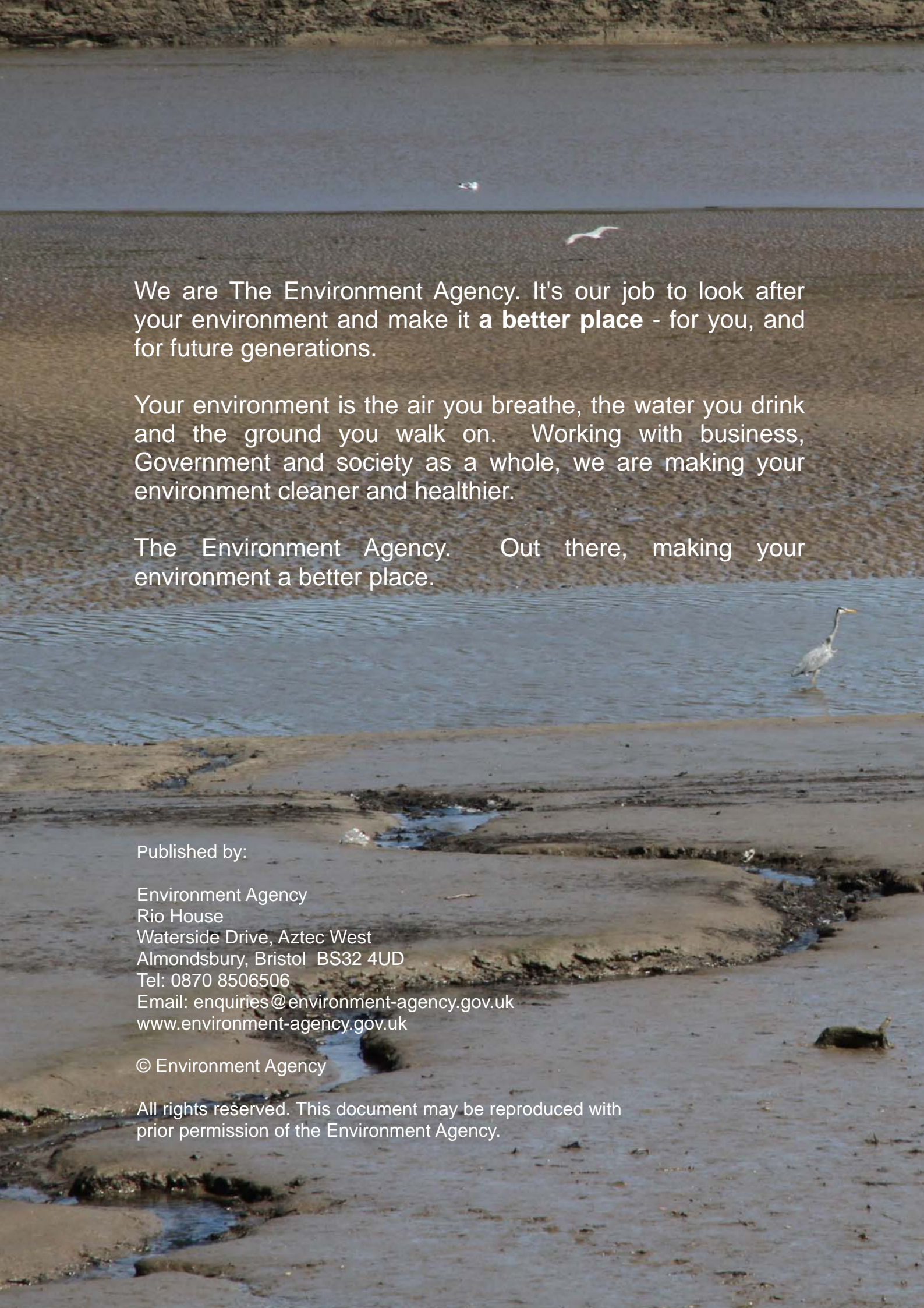




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# Taw Torridge Flood and Coastal Risk Management Study Technical Summary Report



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# Executive summary

This document has been written on behalf of organisations with flood defence management interests in the Taw Torridge Estuary i.e. the Flood Risk Management Authorities under the Flood and Water Management Act 2010. These organisations are the Environment Agency, Torridge District Council, North Devon District Council and Devon County Council. These bodies are referred to as the flood management partners.

The aim of this document is to present the **Taw Torridge Flood and Coastal Risk Management Study**.

## Objectives of the study

- Identify potential flood and coastal risk management options mainly for the short term (to 10 years from today, but also to 100 years);
- Understand the potential impact of our proposals on the estuary;
- Identify habitat creation opportunities; and
- Present a prioritised programme of works.

These establish a basis on which to progress schemes, if funding can be secured either through our grant-in-aid funding, or in partnership with others.

## Environmental assessment of potential options

Projects are likely to arise from this study and our current high level assessment will support subsequent project level Environmental Impact Assessment (EIA) to identify and manage environmental impacts.

## Need for the study

The recent Hartland Point to Anchor Head Shoreline Management Plan Review (SMP2) (North Devon and Somerset Coastal Advisory Group) and the South West River Basin Management Plan (RBMP) recommended this strategic study of this estuary and we recognise that there are areas where standalone schemes could be justified in the next 10 years. These include:

- flood risk management schemes;
- habitat creation schemes; and
- schemes to agree changes to maintenance practices.

The study focuses on identified short term Priority Sites, but also reviews the medium and long term potential works, to ensure that our short term decisions do not compromise future management of flood risk and habitats within the estuary.

All our proposals have been developed following review and consideration of the various plans and policies relating to the study area.

## Why do we need to plan ahead?

We need to plan ahead to ensure that we have plans in place that prepare for future changes and pressures on the estuary and its defences from:

- sea level rise due to climate change;
- change of land use and urban development, and
- natural degradation of the existing defences.

## Next steps

The suggested programme detailed below, indicates options that may be viable schemes, meet our objectives and are worthy of exploring further. We intend to apply the protocol for the maintenance of flood and coastal risk management assets and investigate habitat creation where maintenance is no longer justifiable.

## Location and site description

The location of the study area is indicated on the Key Plan at the end of this Executive Summary.

The Taw Torridge Estuary is on the North Devon Coast. It is fed mainly by the tidal rivers Taw from the east and the Torridge from the south which join at Instow to feed into the Taw Torridge Estuary. The Taw is tidal for 18km to New Bridge, (4km upstream of Barnstaple) and the Torridge is tidal for approximately 13km to Weare Giffard.

The Taw is a broad sandy estuary, whereas the Torridge is a narrower, more meandering estuary constrained within a rocky valley. Torridge sediments are finer than the sandy Taw and there is a small amount of saltmarsh development within each estuary.

The Taw flows north then west. It passes through Barnstaple, then alongside Fremington on its left bank and Chivenor on its right bank before being joined by the Caen Estuary at Blackstone Rock.

The Torridge flows north alongside numerous villages and hamlets before flowing through Bideford, then Appledore on its left bank and Instow on its right bank, where it joins the Taw Estuary at Instow.

The Northam Burrows Pebbleridge, formed of pebbles, cobbles and boulders, extends for 3.5km along the coastal frontage of Northam Burrows. At the northern end the ridge is backed by sand dunes and a now closed landfill site. Immediately to the south of the landfill area is a popular golf club and common grazing land. The ridge is occasionally breached during storm events, yet generally re-forms naturally with time. Appledore village and ship building yard are located on the higher estuary facing margin of Northam Burrows.

The Braunton Burrows dune system is a Special Area of Conservation (SAC). It is high and forms a natural barrier 6 km long to tidal flood water from Saunton southwards to a point where it meets the estuary at Crow Point, which is also within the SAC designation.

## Flood risk, coastal erosion and habitat loss

1,517 properties would be at risk of tidal flooding during a 0.5% AEP (1 in 200 probability) tidal event if there were no flood defences, of which 1271 are residential. The market value of the properties currently protected is approximately £260 million. However, with today's defences only 57 properties would actually be at risk of tidal flooding during a 0.5% AEP (1 in 200 probability) event, of which 52 are residential. The remainder are commercial. However, in 10 years this rises to 421 residential properties (the large majority in Barnstaple) and in 100 years to 1,899 existing residential properties (refer to Appendix C for further detail).

The estuary system is generally starved of sediment and valued intertidal habitat is slow, or difficult to develop. Despite this, habitat loss has not been a key concern to date. However, it will be in the future as there will be insufficient sediment accretion to keep pace with rising water levels due to sea level rise.

Coastal erosion issues are generally focussed on the Pebbleridge fronting Northam Burrows and the north facing coast of the landfill area sited at the northern end of these dunes.

Some of the tidal flood defences in the study area defend areas with little or no built assets to protect and it is not good use of public money to continue to maintain them. In such cases it would be appropriate to apply the procedures for withdrawal or reduction of maintenance set out in the Environment Agency's Asset Maintenance Protocol for these defences. In many cases these areas offer an opportunity for habitat creation. We intend to apply the protocol for the maintenance of flood and coastal risk management assets and investigate habitat creation where maintenance is no longer justifiable.

The partners in the management of the estuary (i.e. Environment Agency, Torridge District Council, North Devon Council, the RSPB, Natural England and Devon County Council) have already identified several areas along the estuary that have potential for habitat creation. We have also undertaken some habitat projects around Landcross. We will look to supplement and possibly support further habitat creation where it is identified as an opportunity in this study.

## Environmental Considerations

We have identified several environmental receptors, which could be positively or negatively affected by the study options. Parts of the study area are designated as shown on Figure 2 in Appendix A of the main document.

We have identified that the options should:

- protect the ecological value of the estuary system;
- not have an adverse impact on Braunton Burrows;
- protect the landscape character of the estuary;
- ensure that works arising from this study will not have an undue impact upon the historic environment, particularly archaeology;
- consider the value of agricultural land as well as developed assets;
- continue to support navigation in the estuary and the tourism value of the area; and
- maintain/enhance the natural form and function of the estuary.

The main opportunities for benefit are:

- The creation of intertidal habitat in various locations which will assist us in delivering our contribution to Biodiversity 2020.
- Improvement in landscape quality through the creation or enhancement of landscape features such as national paths or cultural heritage interpretation, where projects are proposed.
- There are opportunities to reduce pressures on the natural estuary from flood defences which will assist in ensuring that the estuary has a good ecological potential by 2027 under the Water Framework Directive (WFD).
- Building partnerships with Natural England, RSPB, Torridge District Council, North Devon Council, local developers, and the North Devon AONB and Biosphere Reserve.

Our initial findings suggest the options are not likely to adversely affect the estuary. However, we will need to assess this further during detailed environmental assessment if any of the options are progressed.



*Pebbleridge at Westward Ho!*



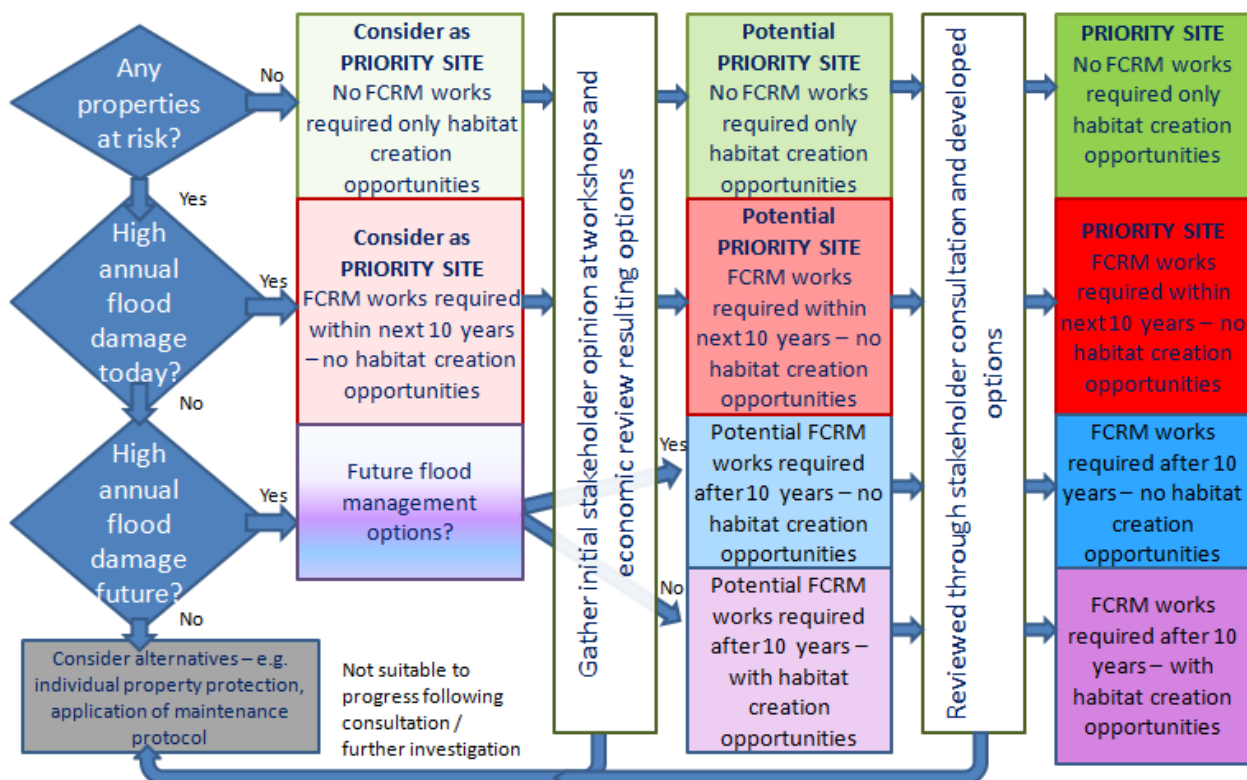
## Approach to the study

We divided the study area into 46 hydraulically independent management units (MUs). (Refer to the Key Plan). These include the areas that would be potentially flooded during a 0.5%AEP (1 in 200 probability) year event if any part of the local flood defences failed today or in the future.

This approach allows us to isolate and assess areas which would suffer losses due to a failure of any part of a defence.

The flow chart below shows how we developed the potential opportunities for each MU once flood risk and environmental potential/importance had been established. These are grouped into:

- Priority sites where management decisions could be made within the next 10 years to either:
  - carry out flood protection works (red);or
  - where there are habitat creation opportunities (green) (often a potential site for application of the maintenance protocol if habitat creation cannot be realised)
- Also identified are sites where flood protection works will be required after 10 years and up to 100 years from today
  - without habitat creation opportunities (blue)
  - with habitat creation opportunities (purple)
- Finally sites where there is no justification to do anything i.e. application of maintenance protocol, within 100 years except a few cases where individual property protection (IPP) may be appropriate in the long term (grey).



**It is important for us to identify the works that offer the best outcome for the investment made. This may mean changing our approach to, or investment in, managing our assets, including flood defences.**

## Overall proposal and potential programme of works - refer to Figure 3 in Appendix A of Main document for mapped results

The following table sets out a potential programme of works. This can be used to target attention to those sites most likely to need either FCRM decisions, or provide a suitable candidate for habitat creation. Both will be dependent on the results of further detailed study and public consultation, especially with statutory bodies and landowners.

MU	Name	Potential action	protocol of maintenance for economic reasons (App B)	Has habitat creation potential for 'x' hectares	Ownership			By 2022		By 2032		By 2042		By 2062		By 2112	
					Environment Agency	Local Authority	Private	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities
1	Northam Burrows	FCRM works required to protect property at Westward Hol-Landfill, golf course and 21 properties - habitat already developing due to regular overtopping	-	-		*	*	Y									
2	Appledore	Low SoP, near shipyard, There are benefits today but unlikely to be viable without partnership funding in the short term. Should be reviewed for potential works in 20 years.	-	-	*	*	*	Y (review with partnership funding)		Y (review with/out partnership funding)							
3	Northam	Low sections of wall - note private defences	-	-			*	Y									
4	Bideford left bank	Should be reviewed by 2042	-	-	*	*	*					Y					
5	Upcott	No managed defence	yes	-			*										
6	River Yeo	Already breached so may be little remaining habitat creation potential with landowner agreement, future few vulnerable properties	-	small			*			Y							
7	Landcross	Potentially withdraw - no remaining habitat potential as already breached to create habitat	yes	-			*										
8	Annerly Park (Kiln)	All properties are located behind a new raised defence	-	-	*		*					Y (review)					
9	Yeo	No managed defence	yes	-			*										
10	Weare Giffard	No managed defence	yes	-			*										
11	Weare Barton	Future project needed as there is some property that may need protecting in the future (but low economic benefit) and habitat creation opportunity with landowner agreement.	-	5.5			*	Y (road)	Y							Y (IPP)	
12	Half Penny Bridge	Does not protect any property, but road would occasionally flood, habitat creation potential - detailed project would confirm relative priorities of management approach.	yes	6	*			Y (road)	Y								
13	Salterns	Private defences - potentially 15ha of habitat creation with landowner agreement	yes	15			*		Y								
14	Hallspill	No managed defence	yes	-			*										
15	Hadlow	No managed defence	yes	-			*										
16	Opposite Pillmouth (Tennacott)	Existing tidal habitat	yes	-			*										
17	Bideford right bank	Low benefits, but potentially low cost viable scheme, low section defence	-	-	*	*	*	Y									
18	Pillhead (Salterns)	Potential for major habitat creation area with landowner agreement, future FCRM works likely to protect road, and property.	-	40		*		Y (road)	Y			Y (IPP)					
19	Westleigh	Already breached to create habitat	yes	-	*												
20	Tapeley Park (Salterns)	Future project needed as there is some property that may need protecting in the future (but low economic benefit) and habitat creation opportunity with landowner agreement.	-	5			*		Y								
21	South Yeo	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.	-	5			*		Y					Y			
22	Instow	Should be reviewed by 2042	-	-	*	*	*					Y (review)					
23	Yelland (Instow Barton)	Low benefits, but potentially low cost viable scheme, private defences where there is 10ha potential habitat creation, properties at risk due to poor condition despite high SoP. High ground behind low defences	-	10	*	*	*	Y (poor defences)	Y								
24	Fremington (Home Farm)	Defences in good condition, economic to maintain, but potentially 40ha of habitat with landowner agreement.	-	40	*	*	*		Y								
25	Fremington Pill	Should be reviewed by 2042	-	-	*	*	*					Y					

MU	Name	Potential action	protocol of maintenance for economic reasons (App B)	Has habitat creation potential for 'x' hectares environment	Ownership			By 2022		By 2032		By 2042		By 2062		By 2112	
					Agency	Local Authority	Private										
								Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities
26	Hollowcombe (Penhill)	LA defences - potentially 25ha of habitat creation with landowner agreement, (8.5ha already identified as immediately feasible by NE) may be able to justify individual property protection by 2112.	yes	25		*			Y								
27	Sticklepath	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.	-	2	*	*				Y	Y						
28	North of A39	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.	-	2	*	*	*									Y	Y
29	South of A39	Potentially 5ha of habitat creation with landowner agreement, if not possible potential to withdraw maintenance.	yes	5	*		*		Y								
30	Shorleigh Bridge	Private defences - potentially 1ha of habitat creation with landowner agreement	yes	1			*		Y								
31	Tawstock Park	Private defences - potentially 5ha of habitat creation with landowner agreement	yes	5			*		Y								
32	Tawstock	Private defences - potentially 5ha of habitat creation with landowner agreement	yes	5			*		Y								
33	Overton	Private defences - potentially 25ha of habitat creation with landowner agreement	yes	25			*		Y								
34	Bishops Tawton	Should be reviewed after by 2042	-	-	*	*	*					Y (review)					
35	Chestwood	Private defences - potentially 5ha of habitat creation with landowner agreement	yes	5			*		Y								
36	North Chestwood	Potentially 5ha of habitat creation with landowner agreement, if not possible potential to withdraw maintenance.	yes	0.5	*		*		Y								
37	Rumsam	No properties are at risk but sewage pumping station is likely to need some additional protection in 2112, some habitat potential with landowner agreement.	-	1.3	*				Y								
38	Newport	Should be reviewed by 2042	-	-	*							Y (review)					
39	Coney Gut	Should be reviewed by 2042	-	-	*	*				Y							
40	Barnstaple	Should be reviewed at 2022	-	-	*	*	*			Y							
41	Pilton	Should be reviewed by 2042	-	-	*	*	*					Y					
42	Pottington	Potentially 20ha of habitat creation with landowner agreement, possibly future retreated line of defence, but it would detrimentally affect the freshwater bird reserve at Bradiford Water.	-	20	*				Y					Y			
43	Chivenor	Private defences, (low economic benefit), 50ha habitat potential with landowner agreement, works review for 2032. Natural England has completed a feasibility study. The study proposes to create 23.7ha of salt marsh; 31.9 ha of freshwater habitat (comprising of existing and new reed beds and grazing marsh)	-	50			*		Y	Y							
44	Wrafton	Should be reviewed after 20 years	-	-	*		*			Y							
45a	Braunton Marshes	Generally low defence, isolated properties	-	-	*	*	*	Y									
45b	Horse Island	Private defences, potentially 82ha of habitat creation with landowner agreement, potential future individual property protection but (low economic benefit).	-	82			*		Y					Y			
46	Crow Point	Potentially withdraw – not a priority site but is of wider interest therefore we have prepared a sheet in Appendix C with further detail	yes	-	*												

Abbreviations FCRM - Flood and coastal risk management: LA – Local Authority: SoP – Standard of protection: NE – Natural England:

This shows us that there is a lot of habitat creation potential in the study area, but all will be dependent on the need, funding and landowner agreement. Relatively little flood defence work is recommended in the short term for only short lengths of defence within the highlighted management units.



In summary, FCRM works are potentially required within the next 10 years (subject to attracting funds) in 5 MUs. These MUs all have significant assets to protect and either a low standard of protection, or defences in a poor condition, at one or more locations. All except Bideford Right Bank are likely to have benefit cost ratios which would attract some public funding. All would be likely to require other funding contributions. Similar numbers of property are at risk in each of these MUs in the short term (Appendix E shows more detail).

9 MUs are fronted by potentially uneconomic defences that are not preferred sites for habitat creation. Application of the Maintenance Protocol (refer to Appendix E) is recommended. These “defences” are mainly high natural banks.

11 MUs have defences that protect little or no property and have land suitable for habitat creation. We would apply the Maintenance Protocol to establish if a defence is actually needed, or could be supported by the landowner. If this is not the case we would explore with the landowner the potential to create habitat. The small numbers of property should be considered for individual or very local flood protection schemes if the defences were reduced. Thus they have been identified on the table as potential areas with habitat creation potential, but with the secondary option of changing the maintenance regime.

A further 11 MUs also have land with habitat creation potential, but realising this opportunity, even with appropriate funding, is unlikely in the short term as it is likely to be economic to maintain the defences until at least 2032. Future FCRM works may even be considered after this time.

Another 11 MUs are likely to provide adequate service in the short term and do not have land suitable for habitat creation. However FCRM works may be justified in the long term once sea level rise has impacted on the standard of protection, and/or their condition has deteriorated to poor or worse.

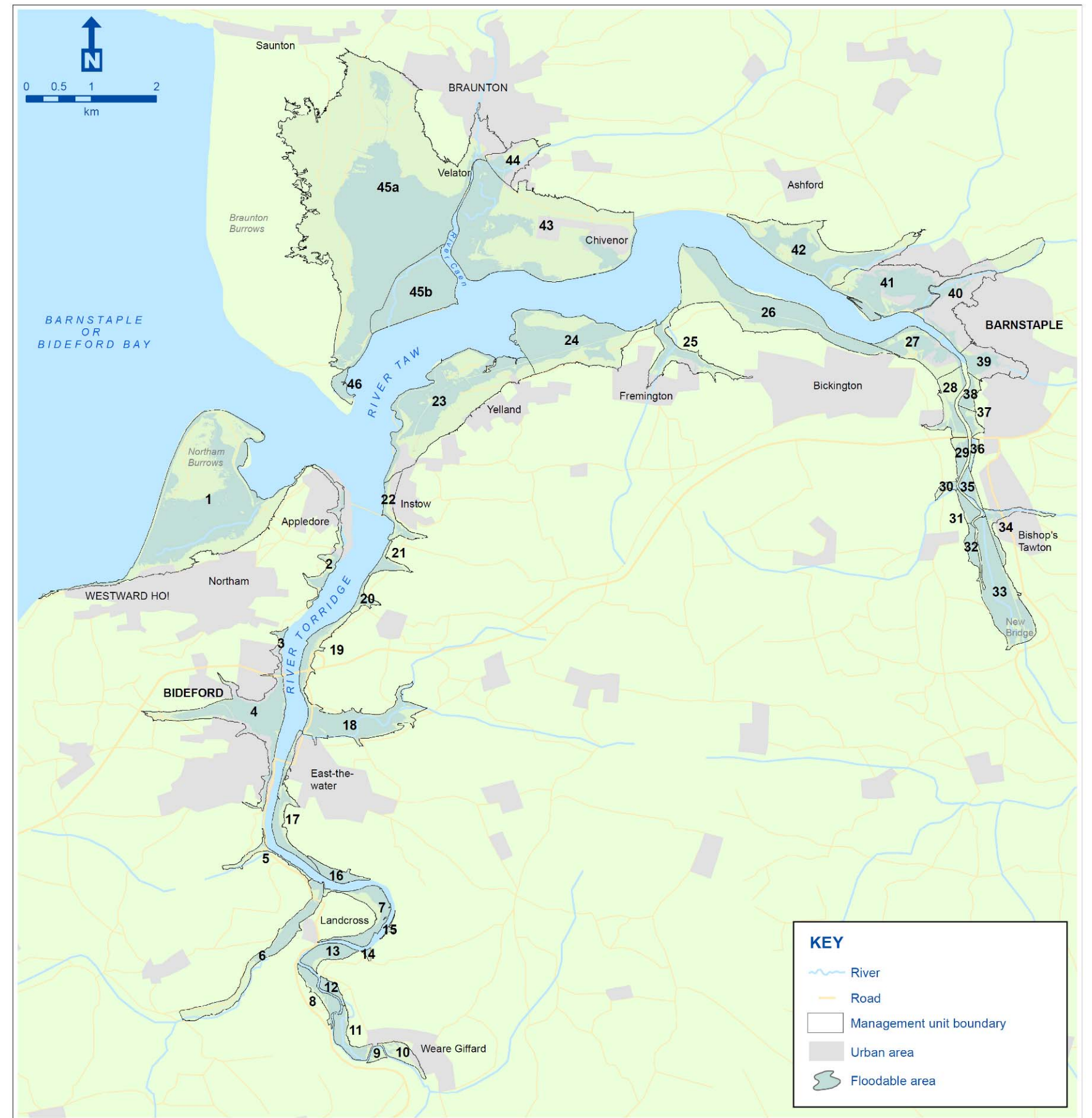
### Interactions between potential options

Potentially changing the shape of the estuary by opening up habitat creation areas to the tidal flow of the estuary, or indeed preventing the estuary from adapting naturally by our actions, has the potential for impacts elsewhere in the estuary. We have considered this and note that if we carry out all the works proposed in the short and long term scenarios:

- Between Instow and the mouth the effects are likely to be immeasurably small and potentially alter the tidal prism (the wedge of the estuary filled with water between high and low tide on an average spring tide is referred to as the tidal prism.) driving natural changes in the estuary by only 1.6%. Due to the hard nature of the geology of this area, this is likely to have no significant impact at all.
- The Torridge would potentially only experience a change of 1.5% if tidal inundation of all potential habitat creation sites is realized. However, only a few sites are likely to be progressed for economic reasons, reducing the potential change in tidal prism to a negligible 0.6%.
- The Taw may experience a 2.2% change in tidal prism as a result of all the potential options. This is a very small change. However, as the Taw is wider than it might be to be in a natural balance, this is very unlikely to translate into erosion forces within the estuary. It is most likely that these changes will only slow the rate of accretion with the estuary.

These impacts relate to proposed managed realignment of defences or positive steps taken to create inter-tidal habitat. There would be greater effects if other defences were not maintained and were allowed to breach.

The estuary will be under pressure from sea level rise, notably at its mouth, which is likely to try to widen to accommodate the increasing tidal volumes. Holding the erosion of the Northam Burrows landfill on the southern side of the mouth of the estuary may put additional pressure on Braunton Burrows on the northern bank to yield instead. The potential managed realignment options would slightly further increase the tidal volume and associated impacts in addition to sea level rise, but to a very small degree. To put this into context - if all the potential managed realignment sites were created, the increase in tidal volume would approximate to only 1 additional year of sea level rise (averaged over 100 years) i.e. the estuary would experience the equivalent of 101 years of sea level rise over 100 years. Accounting for just the most likely sites (identified as potential managed realignment site today – green) this equates to only an additional 0.5yrs equivalent sea level rise (approx). However, scour and sediment distribution will be affected locally by any changes in the local management of the defences and these would be considered in the development of any schemes.



**Figure 1 Key Plan**



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# 1. Introduction

In this section.....

- we explain the purpose of this document;
- explain the objectives for this study and how we determined what these should be;
- discuss the high level plans and strategic framework;
- explain the need for this particular study;
- show why we need to plan ahead.

## Purpose of this report

This document has been written on behalf of organisations with flood defence management interests in the Taw Torridge Estuary i.e. the Flood Risk Management Authorities under the Flood and Water Management Act 2010. These organisations are the Environment Agency, Torridge District Council, North Devon District Council and Devon County Council. These bodies are referred to as the flood management partners.

This document presents the findings of the **Taw Torridge Flood and Coastal Risk Management Study**.

This document will:

- Provide a record of the development of the process by which we have selected potential sites where we may need to make changes to the way we manage flood risk or to provide habitat improvements throughout the Taw Torridge estuary;
- Provide details of the environmental baseline of the estuary and potential environmental impacts and opportunities which could result from potential changes identified in the outcome of this study;
- Demonstrate how we have identified opportunities and constraints.

## Objectives of the study

The objectives of the study were to:

- Identify potential flood and coastal risk management options mainly for the short term (up to 10 years from today), but also those that may be required in the medium and long term (up to 100 years from today);
- Understand how the potential options may impact on the wider estuary;
- Identify habitat creation opportunities; and
- Present a prioritised programme of works.

These establish a basis on which to progress schemes, if funding can be secured through our grant aid or with funding partners. This is to meet our flood and coastal risk management (FCRM) and environmental obligations in the study area without compromising the future management of the estuary.

## Environmental assessment of potential options

We need to ensure that the decisions we make to manage flood and coastal risk do not lead to adverse impacts on the environment. Therefore, as part of our study we have undertaken a high level assessment of the potential environmental issues associated with our developing management options.

Projects are likely to arise from this study and our assessment will support subsequent project level Environmental Impact Assessment (EIA) to identify and manage environmental impacts.

## Background to the Study

### Terms explained

In this document we will refer to some terms and phrases which may not be familiar to all readers. Please refer to the Glossary at the back of this document for our definitions within the context of this study.

### Need for the study

There are areas where projects could be justified in the next 10 years. These could include:

- flood risk management schemes;
- habitat creation schemes; and
- where changes of maintenance practices could be adopted.

Therefore, we embarked on this strategic level study to identify these potential projects, at what we have called 'Priority Site' locations, within the estuary.

The study focuses on the short term, but also reviews the medium and long term from today to ensure that short term decisions do not compromise the long-term sustainable management of flood risk and habitat within the estuary.

### Strategic and legislative framework

There are several strategic and legislative considerations and framework policies relating to the work of this study. Please refer to Table 1.1.



*Torrington towards Rosemoor*



Table 1.1 – Strategic background

Plan / Policy / Programme	Description and relevance to the Taw Torridge Study
<b>The North Devon and Somerset Coastal Advisory Group's Shoreline Management Plan Review (SMP2), Hartland Point to Anchor Head, October 2010</b>	The action plan arising from this document highlighted the need to undertake a study to investigate in greater detail the range of flood risk and habitat issues which had been identified.
<b>The Water Framework Directive (WFD) (2000/60/EC)</b>	We are responsible for overseeing works to meet the objectives of the WFD; including the objective to achieve 'good' status / potential for all waterbodies by 2015 (with some exceptions). The plan for achieving the objectives for individual waterbodies is outlined through our RBMPs. (see below)
<b>The South West River Basin Management Plan (RBMP)</b>	Identified the needs for a 'Taw Torridge Strategy to determine long-term solutions to sustainable flood and coastal risk management and habitat restoration'.
<b>The EC Habitats Directive (92/43/EEC), the Conservation of Habitats and Species Regulations (2010).</b>	Any proposed management option must be assessed under the EC Habitats Directive to show that there are no adverse impacts to European sites (e.g. Braunton Burrows SAC) or European protected species such as otter, Atlantic salmon, and bats.
<b>Wildlife and Countryside Act 1981 (as amended), and the Countryside and Rights of Way Act (CRoW Act) (2000).</b>	We will need to demonstrate that no proposed management options will impact adversely on SSSIs.
<b>The EC Council Regulation (1100/2007) The EC Eel Regulations (2007) and the Eels (England and Wales) Regulations (2009)</b>	Under the European legislation the UK must take actions to halt and reverse the decline in the European eel stock. The EC Eel Regulation requires European member states to prepare Eel Management Plans to describe the current status and highlight management actions to halt the decline of eel populations. The South Western River Basin District Eel Management Plan (2010) has been prepared to action this and we must ensure that any proposed management option is compliant with the plan and legislation.
<b>National and Local Planning Policy and Guidance.</b>	The National Planning Policy Framework (2012) is a new streamlined framework for development control. The policies set out in the framework are material considerations for Local Planning Authorities to take into account when preparing local plans and considering planning applications. The Taw-Torridge Estuary is covered by Torridge District Council and North Devon Council via the Torridge District Local Plan (2007) and the North Devon Local Plan (2006), respectively. We have ensured that the policies given in the local plans have been considered when selecting the potential management options for the Management Units. Torridge District Council and North Devon Council are currently jointly preparing a Core Strategy for the area to feed into the Local Development Framework which will ultimately replace the local plans and other development planning documentation.
<b>Biodiversity 2020/England Biodiversity Strategy, National Biodiversity Action Plan (BAP) and the Local BAP</b>	The overall objective of the UK BAP is ' <i>to conserve and enhance biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms</i> '. The Environment Agency is developing a programme to deliver its contribution to Biodiversity 2020. Local authorities produce local BAPs to identify local priorities. This study needs to, wherever possible, contribute to the BAP targets through opportunities to improve habitats.
<b>Natural Area Profile (English Nature, 1997).</b>	The Taw-Torridge estuary is within the Culm Natural Area and the Exmoor and the Quantocks Natural Area. This study needs to ensure that none of the proposed management options adversely affects these natural areas.
<b>Taw - Torridge Estuary Management Plan 2010 (North Devon AONB and Biosphere Service, 2010)</b>	The Taw-Torridge estuary was one of the first to adopt a Estuary Management Plan (EMP) and it is this which has guided the use of the estuary, not only for commerce but for recreation and nature conservation. This study will be aligned with the actions in the plan.
<b>Flood and Water Management Act (2010)</b>	The Flood and Water Management Act (2010) aims to improve both flood risk management and the way water resources are managed. It assigns specific responsibilities to 'risk management authorities' for different sources of flooding. This includes a new lead role for local authorities such as Torridge District Council in managing local flood risk and a strategic overview/oversight role for all flood risk in England/Wales for the Environment Agency. The Act gives us responsibility for producing a national strategy for Flood and Coastal Erosion Risk Management (FCERM) for England.

Plan / Policy / Programme	Description and relevance to the Taw Torridge Study
<b>Devon County Council Waste and Minerals Planning Policies</b>	Devon Waste Local Plan was adopted in 2006 and provides strategic and local policies related to waste management in the region. The Devon Mineral Local Plan was adopted in 2004 and seeks to balance society's mineral needs with impacts on the environment. The study needs to ensure that the proposed management options do not compromise any of these policies.
<b>Marine and Coastal Access Act (2009)</b>	The Marine and Coastal Access Act (2009) is intended to ensure clean, healthy, safe, productive and biologically-diverse oceans and seas, by putting in place better systems for delivering sustainable development of marine and coastal environment. The Act established the Marine Management Organisation (MMO) consolidating the marine management functions in one organisation. The MMO is responsible for licensing of activities related to any construction in English territorial waters, including dredging and defence breaching below MHWS level in estuaries. The Act commits the UK to establishing Marine Conservation Zones (MCZs) with an aim to designating them in summer 2013. The Taw Torridge Estuary, Bideford and Barnstaple Bay are all recommended MCZs.

### Why do we need to plan ahead?

We need to plan ahead to ensure that we provide a sustainable future in terms of both flood risk management and habitat protection or creation.

To do this we need to accommodate future changes and pressures on the estuary defences from:

- sea level rise due to climate change;
- change of land use and urban development, and
- natural degradation of the defences.

We need to also account for our existing obligations as set out in Table 1.1 including obligations to return rivers to their natural

form, wherever possible under the Water framework Directive (WFD) and the soon to be established MCZs.

Our conclusions from this study will contribute to our plans for the next 10 years and create an appreciation of the issues to inform our medium and long term plans beyond that.

So that we can invest for the best outcome, in a timely manner, we need to understand how estuary changes will impact on our interests in the estuary. We can then target our investment to best effect for the communities of the estuary and the environment.



*Barnstaple and Taw Estuary*

## 2. Context of this study

In this section.....

- we show the flood risk areas covered by this study, with a brief description;
- discuss flood risk, coastal erosion and habitat loss;
- describe the environmental baseline of the Study Area;
- discuss the constraints which have influenced the development of options for the Taw Torridge Estuary;
- discuss the potential opportunities for flood risk management and habitat creation

### Location and site description

The location of the Study Area is indicated on the Key Plan at the end of the Executive Summary. (can be kept folded out for reference). We have divided the study area into 46 hydraulically independent Management Units (MUs), as shown on this plan.

The Taw Torridge Estuary lies on the North Devon Coast with its mouth bordered by Braunton Burrows to the north and Northam Burrows to the south. It is fed by the rivers Taw **from** the east and the Torridge from the south which join at Instow to feed into the Taw Torridge Estuary.

The Taw Torridge Estuary has a tidal range of 7.5m at its outfall into the Bristol Channel. The Taw is tidal to New Bridge, which is 4km upstream of Barnstaple and the Torridge is tidal for approximately 13km to Weare Giffard.

Our Study Area also includes the coastal frontage of both Braunton Burrows and Northam Burrows.

The Northam Burrows Pebbleridge is a SSSI, formed of pebbles, cobbles and boulders, extends 3.5km along the coastal frontage of Northam Burrows. At its northern end the ridge is backed by sand dunes and a now closed landfill site. To

the south of the landfill area is a popular golf club and common grazing land. The ridge is sometimes overtopped and damaged during storm events, yet generally re-forms naturally with time. Appledore village and its ship building yard are located on the higher eastern side of Northam Burrows at the mouth of the Torridge.

Braunton Burrows is 6km of coastal sand dunes extending south from Saunton and inland by 1.5km where they fall to the marshland of Braunton Marsh. Braunton Burrows is one of the largest sand dune systems in the UK. It forms a natural defence behind a broad sandy beach. At its southern end the sandy spit known as Crow Point extends into the estuary mouth. Braunton Burrows is a Special Area of Conservation (SAC) designated under the EU Habitats Directive.

Upstream of Instow the Taw Torridge Estuary splits into the Taw and Torridge.

The Taw is broad and sandy, whereas the Torridge is narrower and more meandering, constrained within a rocky valley. Torridge sediments are finer than the sandy Taw and there is a small amount of saltmarsh, development within the confines of each estuary.

From its upstream extent the Taw passes north then west. It runs through Barnstaple, then alongside Fremington on



its left bank and Chivenor on its right bank before being joined by the Caen Estuary at Blackstone Rock.

The Torridge flows north alongside numerous villages and hamlets before flowing through Bideford, then Appledore on its left bank and Instow on its right bank, where it joins the Taw estuary at Instow.

## Habitat Creation

Our partners in the management of the estuary (including local authorities, Natural England and RSPB) have identified areas along the estuary which have potential for habitat creation at Penhill. Natural England has completed feasibility studies for these sites with the landowners and is currently

leading the process. Section 3 describes how we defined our sub-areas as management units.

Intertidal habitat has already been successfully created in the past by the AONB and Biosphere Reserve Service at Landcross and Annery Kiln at the tidal limit of the River Torridge.

The RSPB reserve at Isley Marsh (Figure 2) is comprised of saltmarsh and mudflats and the Gaia Trust are restoring Home Farm Marsh (MU 24) from an intensive dairy farm into a wetland area.

## Flood risk, coastal erosion and habitat loss



1960



Flooding has historically been reported between 1910, 1945 and 2012 in Velator, Chivenor, Pottington, Barnstaple, Fremington, Instow, East the Water, Weare Giffard, Bideford, Appledore and Westward Ho!. However, defences have been put in place at several of these locations since the late 1970's; notably in Barnstaple in 1984 and more recently in Bideford in 2005. Therefore, the flood risk has greatly reduced and now relatively few properties are at flood risk during a 0.5% AEP (1:200 annual probability) event.

The perimeter of the Taw Torridge Estuary is 84km long (refer to the Key Plan at the front of this document). Raised man-made defences run along 65km of this perimeter (23km hard defence such as walls and 42km of soft embanked defences). The remainder is natural bank or open coast.

The defences manage the flood risk for the urban areas of Westward Ho!, Appledore, Bideford, Instow, Braunton and Barnstaple as well as other rural areas.

1,517 properties would be at risk of tidal flooding during a 0.5% AEP (1:200 annual probability) tidal event if there were no flood defences, of which 1,271 are residential. The market value of the properties protected is approximately £260 million. However, with today's defences only 57 properties would actually be at risk of tidal flooding during a 0.5% AEP (1:200 annual probability) event, of which 52 are residential. The remainder are commercial. However, in 10 years time (2022) this rises to 421 residential properties actually at risk behind the defences (the majority in Barnstaple) and in 100 years time (2112) to 1,899 residential properties (refer to Appendix C for further detail).

The present defences provide a standard of protection (SoP) ranging from more frequent than 100% AEP (probability of flooding annually) to better than 0.5% AEP (1:200 annual probability). 30km of these are recorded as having a SoP which would indicate flooding on an annual basis. 66km are recorded as having a current SoP exceeding 0.5%AEP (1 in 200 year). Although significant lengths of the defences

seem to offer a low SoP, many of them protect few assets. (Refer to Appendix C for further detail) Figures in Appendix C show the SoP of the defences today and the areas at risk during a 0.5% AEP (1:200 annual probability) event

The estuary system is generally starved of sediment. Despite this, habitat loss has not been a key concern to date. However, it is expected to become a concern in the future as it is anticipated there will be insufficient sediment accretion to compensate for sea level rise.

Coastal erosion issues are generally focussed on the pebble ridge fronting Northam Burrows and the north facing coast of the landfill area sited at the northern end of these dunes. Further area specific details for all areas of concern are given in Appendix C.

## Current approach to flood risk and environmental management

Flood risk management is provided by the existing system of defences in tandem with other flood management actions, such as:

- flood warning systems;
- developing this study to prioritise actions;
- influencing planning to move urban development away from the flood plain; and
- engaging with local partners to raise flood awareness.

We inspect our FCRM assets at least annually. The defences are generally reactively repaired and we have a programme of routine maintenance such as grass mowing of banks, removing debris, maintaining safe access, and structural repair. The works implemented since the 1980's have relieved much of the flood risk and this study, together with the SMP2 develops a strategic approach for future management options.

Wherever possible, we work with others to store water or manage run-off in locations that provide overall flood risk reduction or

environmental benefits. This includes removing defences where they do not effectively serve a community, which will

also improve estuary and floodplain connectivity to benefit the environment.

## Environmental Baseline



### *Bideford*

#### Introduction

We need to establish the environmental baseline conditions so that we can predict how the different potential flood risk management options considered in the study might change that environment.

We have identified several environmental receptors, which could be positively or negatively affected by the study's potential options. (We have undertaken a review of existing data, reports and local plans to inform this exercise). Parts of the study area have statutory environmental designations and these are shown on the Environmental Constraints Plan in Appendix A. In Appendix C further information about the environmental baseline of each of the priority sites is included.

#### Human Beings

Flooding events can have significant effects on communities through damage to homes and businesses and in extreme cases may result in significant injury and/or

death. These can also lead to health impacts (both physical and mental), including stress and trauma, sometimes months or years after the flood event or whenever flooding appears likely to occur (Tapsell et al, 2002).

The main settlements in the Taw Torridge Estuary which are at risk from flooding are shown on the Key Plan.

### *Barnstaple*

Barnstaple is a major town within the estuary situated on the Taw. North Devon Council completed a town study of Barnstaple as part of the preparation for their forthcoming Core Strategy and prepared the Barnstaple Town Study Report in October 2011 (North Devon Council, 2011). This states that the population of Barnstaple (and other adjoining built up areas) was 30,916 in 2010. The entire population of North Devon was shown to be 92,894 in 2010. This shows how significant Barnstaple is as a sub-regional centre serving a large area of

north Devon and providing an economic heart to the region.

Areas for growth of Barnstaple are identified in the Town Study Report and are mostly outside of the study area. However, there is a proposal to develop a prominent ridge to the north of Bickington which may overlook the estuary.

#### *Bideford*

Bideford was studied by Torridge District Council in some detail to support stakeholder consultation for the Core Strategy with a report prepared in

September 2011 (Torridge District Council, 2011a). The report noted that Bideford is a medieval market town straddling the River Torridge. It is supported by good highway access from the south via the Atlantic Highway (A39) offering good connections to Bude and Barnstaple. Bideford is a growing town and the study revealed that the population was assessed to be 17,070 in 2010, a rise of 13.8% since 2001.

Areas for the growth of Bideford have been identified to the south of East-the-Water and Handy Cross, south of Bideford.



*Appledore view towards the quay*

the south end of Northam Burrows and faces westwards into Bideford Bay.

#### *Northam, Westward Ho! and Appledore*

Torridge District Council also completed a study of the parish of Northam, incorporating the settlements of Northam, Westward Ho! and Appledore in September 2011 (Torridge District Council, 2011b).

Northam is adjacent to the A386 and is located on the eastern end of a ridge overlooking Northam Burrows and Bideford Bay to the north.

Appledore is situated on the north end of the ridge, at the meeting point of the Taw and Torridge Estuaries. Appledore is an ancient maritime settlement where ships could safely lie and anchor. It was a "strand" village, built directly into the bank above high water mark with ships landing on the beach until the construction of the Quay in 1845.

Westward Ho! developed during the 1860s as a purpose built holiday resort. It lies at

The Northam Parish has grown over the last 20 years, most significantly in Westward Ho! with the redevelopment of tourist accommodation. The parish's population increased by 29% since 2001 to the population for the area in 2010 given as 12,411 in the report.

Northam will be a focus for new growth. However, it will be developed to be a locally distinctive centre, separate from Bideford where the main development will occur in the future. No areas identified for growth in Northam are within any of the Management Units considered by this study.

#### *Human Health and Recreation*

The Tarka Trail and the South West Coast Path are the main national recreational paths in the area. The Tarka Trail follows an old railway line along the two rivers for 30 miles and is used for jogging, walking and cycling. The Rivers Torridge and Taw



are famously associated with Henry Williamson's 1927 novel *Tarka the Otter*.

Anglers fish from the banks and bridges of the estuary and wildlife enthusiasts enjoy wildlife spotting and bird watching from vantage points at the top of the steep sloping estuary.

The waters are popular for water sports such as yachting and jet skiing. There are waterside festivals and regattas held along the estuary and three adventure schools.

Agriculture is the primary industry in the area; predominately dairy and other livestock farming. Fishing trawlers run from Bideford harbour and shell fisheries have been explored as a source of income. There is a major shipyard, aggregate company and fish dock at Appledore Wharf.

The Ministry of Defence (MoD) have Royal Marine bases at Instow and Chivenor.

Tourism is a major industry in the Taw Torridge area, served by the sandy 1.1km wide beach at Instow, Northam Country Park, Royal North Devon Golf Club, Go Kart Centre and other facilities at Westward Ho!. Tourism makes a significant contribution to the economy of Devon, the value of which was estimated in 2007 to be worth £1,299 million from staying visitors and £876 million from day visitors (South West Tourism, 2009).

#### *Material Assets and Critical Infrastructure*

The key material assets and critical infrastructure within the study area are shown on the individual sheets for the Management Units in Appendix C. The main ones are:

- Roads – Atlantic Highway (A39) and A386
- Train line to Barnstaple
- Historic site Yelland Power Station

There is a proposed Atlantic Array Pipeline across the River Torridge to connect an off shore windfarm to a sub-station at Alverdiscott. The crossing is proposed around Hallsannery.

#### *Navigation*

Bideford harbour can accommodate ships of up to 100m in length and has 300m of quay frontage available for vessels. The harbour regularly handles ships which export clay from local quarries to Finland and Spain with other occasional exports such as rock salt. A timber exporting company uses the site to store and export logs. Bideford Harbour Board is the competent harbour authority for Bideford harbour.

Appledore has a rich maritime history and today has one remaining shipyard with one of the largest undercover yards in Europe. The port remains the home of a number of fisherman and the river a favourite for leisure craft.

Fremington Quay was once known as the busiest port between Bristol and Lands End, exporting ceramics, clay and other local produce and importing culm and coal for the railways. The quay now has been redeveloped with the former railway station converted to a café with views over the Taw estuary. It is now a Conservation Area having been designated in 1996.

Barnstaple prospered as a port in the Middle Ages, though the port declined as the River Taw silted up.

#### *Flora and Fauna*

Braunton Burrows is an internationally designated area as a Special Area of Conservation (SAC) for its classic dune geomorphology and specialised dune fauna.

Also, the entire estuary is designated as the Taw-Torridge Site of Special Scientific Interest (SSSI) and is also an Important Bird Area (IBA), although this does not carry any statutory obligation.

The SSSI and IBA are of importance for the estuary's populations of overwintering and migratory wading birds. Other areas which have been designated as SSSI within the study area are:

- Braunton Burrows for its dune systems, rare and vulnerable species and feature of geological interest,



- Northam Burrows for its wide range of coastal habitats, and
- Fremington Quay Cliffs for its unique geological features.

Isley Marsh is an RSPB Reserve on the south bank of the Taw Estuary near to Fremington.

Migratory fish species such as salmon, sea trout and eels use the estuary as a gateway to inland waterways to complete their breeding cycles.

The upper Torridge and Taw estuary forms an important nursery area for commercial fish species such as sea bass and has been designated as a Bass Nursery Area. There are therefore restrictions on boat fishing in the estuary.



Within the estuary other species use the waters and shores such as otter, protected by European legislation and badger, protected under UK legislation.

Seals have also been recorded around Bideford and Barnstaple Bay and dolphins have been noted stranded at Chivenor, Northam Burrows and Westward Ho! The Estuary is nationally important for common greenshank and Eurasian curlew, redshank and dunlin are common.

The Finding Sanctuary report for the South West of England concluded that the inland waters of both the River Taw and River Torridge are recommended Marine Conservation Zones (rMCZ) along with an rMCZ in the Bideford and Barnstaple Bay. The Taw Torridge rMCZ contains habitats which are key to the endangered European Eel which enter the estuary to migrate into the river system to mature for up to 20

years. MCZ's are likely to be designated under the Marine and Coastal Access Act (2009) in 2013.

The southern extent of the River Torridge is within the Northern Devon Nature Improvement Area (NIA) as shown indicatively on the Environmental Constraints Plan (Appendix A). The NIA hosts 35% of the UK remaining Culm grassland, 120 scheduled plants and animals and important populations of 2 of Europe's 10 most threatened species – the marsh fritillary butterfly and the freshwater pearl mussel. A grant has been awarded to the NIA to create/restore habitats including restoring 20km of river for the freshwater pearl mussel. The project is being led by Devon Wildlife Trust on behalf of the Biosphere Partnership. Devon Wildlife Trust is also developing a project for the Biosphere Reserves Partnership to deliver habitat creation projects in the Taw Estuary.

The Taw Rivers Improvement Project (TRIP) is being led by the North Devon Biosphere Reserve and the Westcountry Rivers Trust. The TRIP aims to improve the health of the river ecosystem through targeted habitat management works and by reducing the amount of pollution entering the river. The project will help to meet national targets for sustainable development and environmental protection as well as EU targets which have been set under the Water Framework Directive.

## Air and Climate

### Air Quality

There are no Air Quality Management Areas where the air quality needs to be improved. This is likely to be due to the lack of densely populated towns in the area.

### Climate

Rainfall patterns and the expected increase in peak rainfall as a result of climate change will impact the flood levels, particularly in the upper estuary. However, increasing sea level rise also due to climate change will have a greater impact in the lower estuary.

## Water

### *Surface Water*

Surface water is not a concern of this study as the defences do not manage surface water (other than to allow it to drain to the estuary at lower states of the tide).

### *Water Quality including consideration of the Water Framework Directive*

Under the WFD, we have produced the South West River Basin Management Plan (RBMP). The RBMP describes the current status of the water within the south west and proposed methods to improve the ecological status of the waterbodies within the area prior to 2027.

The Taw Torridge Estuary is defined as a transitional waterbody in the RBMP. It is heavily modified because of the flood protection measures along its length. Its current ecological potential is classed as moderate and by 2027 we aim for this to increase to a good potential. The estuary was classified as moderate in the RBMP because of uncertain levels of inorganic

nitrogen and because the mitigation measures proposed for the site were under development and their effectiveness was unknown. Whether the levels of nitrogen are causing a failure will require further investigation. The proposed mitigation measures are further discussed in Section 8.

Bideford Bay is a coastal waterbody on the RBMP and has a moderate status with an aim to improve it to good by 2027. This waterbody is not classified as good, primarily because of the levels of phytoplankton recorded. However, there is some uncertainty regarding this issue and we will be investigating this further. Barnstaple Bay is classified as a coastal waterbody in the RBMP and is currently classed as having a good status.

Section 8 of this report considers the implications of this study on the waterbodies listed in the RBMP including the rivers which are affected by the tidal influence of the estuary and whether there are any impacts or opportunities arising.



*Torrington towards Taddipport (upstream of the estuary)*

## Landscape

### *Landscape Designations*

Parts of the estuary are located in the North Devon Coast Area of Outstanding

Natural Beauty (AONB) which was designated in 1959 on merit for its outstanding coastal scenery and rich cultural, agricultural and maritime heritage. It is also part of the North Devon United

Nations Educational, Scientific and Cultural Organisation's (UNESCO) Biosphere Reserve, which is one of only two 'New Style' Biosphere Reserves in the UK. This is because it has three complementary functions: Conservation, Learning and Research and Sustainable Development. The North Devon Biosphere Reserve covers all parts of the Study Area. It is split into concentric Core, Buffer and Transition zones, with the Core focussed on Braunton Burrows.

Both sides of the River Torridge and the area predominantly to the south of the River Taw lie within the Culm Natural Area (English Nature, 1997) which is so named because of the Carboniferous slates, shales and sandstones which underlie the area. The rocks give rise to heavily acidic soils which make farming difficult. As a result of this, and the oceanic climate, the predominant land use is grass production for livestock.

Braunton Burrows and the northern area of the River Taw lie within the Exmoor and the Quantocks Natural Area. The Exmoor Natural Area is comprised of moors and bogs. The solid geology of the Natural Area is similar throughout with Braunton Burrows comprised of blown sand deposits (English Nature, 1997b).

The River Taw is recognised in the North Devon Local Plan as an Area of Great Landscape Value.

### *Landscape Character*

A Landscape Character Assessment (LCA) was completed jointly by North Devon Council and Torridge District Council (Land Use Consultants, 2010). The LCA divided

the areas into 22 Landscape Character Types. The Taw Torridge estuary study area comprises:

- **3H Secluded Valleys** – covers the tributaries into the estuary. These have been included in the study area as they are influenced by the tides in the estuary.
- **4A Estuaries** - covers the broad Taw-Torridge Estuary and its surrounding mudflats and marshes. All but the estuary mouth falls within North Devon district.
- **4B Marine levels and coastal plains** - covers the reclaimed estuary fringes of Braunton Marsh and Chivenor airfield on the northern banks of the Taw Torridge Estuary. It also includes the historic landscape of Braunton Great Field backing Braunton Marsh, classified for the purposes of this LCA as a 'coastal plain'. Both Braunton Great Field and Braunton Marsh fall within the North Devon Heritage Coast.
- **4E Extensive intertidal sands** - covers the broad sandy beaches of Westward Ho! – much of the area lying within the North Devon Coast AONB and with a westerly, Atlantic aspect.
- **4F Dunes**- comprise the sand dunes of Braunton Burrows and Northam Burrows. The majority of this LCT falls within the North Devon AONB.
- **7 Main cities and towns**



*View across the River Taw to Braunton Marsh*



The valleys of the Taw, Torridge and their tributaries cut through the landscape. The Taw and Torridge valleys follow broad sweeping courses with woodland on the steep valley sides and fertile, alluvial soils on the flat valley bottoms. The rivers meander across these broad floodplains and are commonly lined with trees.

The deciduous woodland on the steep-sided valleys of the Taw and Torridge are dominated by oak, birch and rowan, often with a covering of lichens and with a lush ground cover in the sheltered, humid valleys. Some of the valley woodlands have been replanted with conifers and with hardwood trees such as sweet chestnut.

### Archaeology and Cultural Heritage

The estuaries have a very high archaeological potential encompassing maritime, foreshore and coastal archaeology. The earliest recorded human activity in the Study Area is Mesolithic (between 10,000 and 3,000 BC) occupation of the coastland at Westward Ho! At that time the land extended much further out to sea than at present.

In the 17<sup>th</sup> and 18<sup>th</sup> centuries Bideford and Barnstaple became prosperous ports. Many of the towns' central buildings date from this period of prosperity and are listed for their importance. Listed buildings are shown on the sheets in Appendix C. Only in the late 19<sup>th</sup> and the 20<sup>th</sup> century did development expand significantly beyond the small towns and quay sides.

The coast was central to Charles Kingsley's *Westward Ho!* and the present settlements were largely developed on the basis of the association with his novel.

Braunton Great Field in MU45a is one of the few remaining open field systems which retains its medieval character through the continuing practice of strip cultivation by different farms. An Archaeological Assessment of a proposed tidal defence scheme in Braunton undertaken in 1993 found that there was no evidence that the Great Field extended as far east as the river (Turton & Weddell, 1993).

The Devon and Dartmoor Historic Environment Record (HER) holds a vast number of records for the study area. Examples of the records are:

- a number of wrecks within the River Torridge.
- a stone axe, bones and hazelnuts were found sealed in the clay of the river during the construction of the road bridge in 1985
- historic wrecks/hulks within estuarine sediments;
- fish weirs within the River Taw;
- Anti-glider poles across Horsey Island.

There is a high possibility of unknown archaeology in the following situations:

- areas of inundated former land surfaces; particularly for the prehistoric through to Roman periods;
- the ancient sediment build-ups where there could be a wealth of palaeo-environmental evidence preserved;
- physical and buried archaeological evidence of human waterside endeavour, such as the remains of quays, jetties and historic shoreline industries.

### Soil, Geology and Hydrogeology

#### *Soil and Geology*

The Taw Torridge Estuary forms a geological boundary between the resistant Devonian slates and sandstones which form the high land of the North Devon Downs<sup>1</sup> and the younger and softer Carboniferous 'Culm Measures', comprising crushed and folded shales and sandstones.

The free draining and more fertile soils sitting above the Devonian slates and sandstones support a combination of arable and pasture, whereas the Culm measures are characterised by brown earth and waterlogged grey soils.

Braunton Marsh and Braunton Burrows are underlain by extensive areas of Quaternary

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<sup>1</sup> These are not 'downs' in the classic sense such as the chalk downs in southern England, but locally, this is what the elevated areas to the north of the Taw Torridge Estuary are referred to.



deposits, including blown sand, alluvium and river terrace deposits.

The following sites are Regionally Important Geological and Geomorphological Sites (RIGS) and geological SSSIs:

- Braunton Burrows – for its dune features.
- Northam Burrows – for its pebble ridge feature.
- Westward Ho! Cliffs - provides evidence for interpreting the Pleistocene of the region. The presence of a submerged forest also provides detailed evidence of Holocene evolution.

### Contaminated Land

There is a historic landfill site at the tip of Northam Burrows (considered to be non-hazardous but risk of littering if eroded) in MU1. There are three historic landfill sites around Sticklepath in MU27:

- Beneath the Severn Brethren Industrial Estate at Bickington. The site at Severn Brethren was established in 1961, tipping was stopped in 1992.
- Taw Wharf historic landfill site cease tipping in 1990.
- The landfill site adjacent to the Railway Sticklepath Hill is closed but the date of closure is unknown.

The site of the former East Yelland Power Station is also known to contain asbestos.

The risk of contamination arising from these sites is unknown. There are no licenced landfills in the Study Area.

### Land Use

The Taw Torridge Estuary Study Area is predominantly rural with large areas of uninhabited land used for grazing. Agriculture is the most common land use in the area.

The Agriculture Land Classification (ALC) provides a method for assessing the quality of farmland to enable informed decisions to be made about its future use within the planning system. Grades 1, 2 and 3 are considered to be the best and most

versatile. The study area is primarily made up of Grade 2, 3 and 4 land.

Environmental Stewardship provides funding to farmers and other landowners who deliver effective environmental management on their land. Horsey Island and Fremington Marsh are currently within a Higher Level Stewardship (HLS) agreement.

### Natural Resources

There are no mines or quarries in the study area.

There is an existing recycling centre and Waste Transfer Station at Seven Brethren in Bickington within MU27.

The only site in the study area which requires an Integrated Pollution Prevention Permit is the Sewage Treatment Works (STW) for Barnstaple at Ashford.

### Key constraints

We have identified many constraints through a process of literature review and consultation with Key Stakeholders, including workshops held in March and November 2012. These are detailed in Appendix B. We have also had separate opportunities to liaise with Natural England, RSPB and the North Devon Biosphere AONB Service throughout the development of this study. We have identified that our potential options should:

- **Protect the ecological value of the estuary;**
- **Not have an adverse impact on the Braunton Burrows;**
- **Protect the landscape character of the estuary;**
- **Consider the value of agricultural land as well as developed assets;**
- **Ensure that works arising from this study will not have an undue impact upon the historic environment, particularly archaeology;**
- **Continue to support navigation in the estuary and the tourism value of the area; and**
- **Maintain/enhance the natural form and function of the estuary.**

## Opportunities

We have also identified opportunities to positively enhance our schemes through our work. The main opportunities are:

- The creation of intertidal habitat in various locations which will assist us in delivering our South West Regional Habitat Creation Programme, as part of Contributing to Biodiversity 2020.
- The options may also provide opportunities to improve landscape quality through the creation or enhancement of landscape features.
- There are opportunities to reduce pressures on the estuary from flood defences where these constrain the natural development of the estuary.

This will assist us in ensuring that the estuary has a good ecological potential by 2027 under the WFD

- Building partnerships with Natural England, RSPB, Torridge District Council, North Devon Council, local developers, and the North Devon AONB Biosphere Reserve.



*Landcross(with thanks to Peter Keene)*

# 3. Methodology

In this section.....

- we explain how we will prioritise and justify our future investments in improvements or maintenance of flood risk management infrastructure and environmental improvements, including habitat creation opportunities;
- we show how we have divided the floodplain into 46 Management Units to assist in our assessment
- we describe the approach and methods we have taken to develop options for:
  - the future management of flood risks in the Estuary;
  - potential habitat creation opportunities;
- we explain how we have concentrated on priority sites where changes may be appropriate within 10 years. These may be justified by increasing flood risk as a result of climate change and sea level rise, cost implications of maintaining the status quo or opportunities for environmental improvements or habitat creation.

## Targeting our investment

Our interests in the estuary are to make best use of the funding available to:

- manage flood risk;
- create and improve habitat; and
- to protect and enhance the existing environment.

Within the estuary there are constant and increasing pressures from:

- development;
- natural degradation; and
- sea level rise as a result of climate change.

**It is therefore important for us to identify the works that offer the best outcome for the investment made. This may mean changing our approach to the management of our assets, including flood defences.**

We have to review our obligations and the actions we need to take to meet them. Each action has to be justified and timely. For example, we would not be acting wisely if we invested today in a flood defence, which may not need attention for 10 years,

even if that asset is very important. Also, we would not be acting responsibly if we continue to spend public money on a flood defence that offers little or no benefit to the community (especially if that defence isolates potential habitat from the estuary tidal system), when we could spend it on a defence that protects a significant number of properties.

Therefore, as a responsible public fund manager we need to identify the best use of our funding. We will prioritise and justify our future investments in improvements or maintenance of flood risk management infrastructure and environmental improvements, including habitat creation opportunities. All potential projects if progressed will be done so in line with FCRM guidance.

We have identified key flood levels throughout the estuary using established hydraulic models and combined this data with a detailed understanding of the current levels and condition of defences. We have taken into account future sea level rise and gradual deterioration in the assets to determine the flood risk today and in the future. Based on the scale of the probability of flooding and the value of the assets

protected we have identified where and when further investment may be appropriate.

We also need to identify and work with funding partners to support our schemes, especially those that may otherwise be difficult for us to justify within our allocated budgets.

## Establishing Management Units

We have divided the study area into 46 hydraulically independent Management Units (MUs). (Refer to the Key Plan). These MUs are sufficiently large to include the areas that would be potentially flooded during a 0.5%AEP (1:200 annual probability) event if any part of the local flood defences failed today. In addition, we have extended the MU boundary further inland to be confident that we have included the area that could be affected by the future effect of sea level rise on flood risk. We have therefore set the inland limit of the flood management unit as the 10mAOD contour around the estuary.

These MUs are generally separated by a watershed created by high ground between them. However, some are linked by a narrow strip of land at the estuary edge (typically the coastal road), which could be easily modified to isolate the units if required.

This approach allows us to identify the areas which would suffer economic losses due to a failure of any length of defence. We can then measure and compare the value of the losses (in both community and environmental terms) with the cost of managing the defences in the area i.e. establish a measure of benefits against costs. A ratio greater than 1 will then demonstrate a net benefit. However, a net benefit may not be sufficient to secure

public funding when prioritised within the applications from the rest of the country. All alternative sources of funding will necessarily be sought for all schemes other than the highest priority schemes.

As with all public expenditure on flood defences, any schemes have to be identified as a priority in comparison with other worthwhile projects. Usually the benefits of the work, compared to doing nothing, have to be a multiple of the scheme cost. Additional funding from development, regeneration or other partners can assist to reduce the cost to the public and improve the chances of a scheme progressing.

## Identifying Priority Sites for investment

In this study we have focussed our interest on works, or management decisions, which may be needed in the next 10 years, with a higher level view over the following 20 years, to allow us to plan our investment programme. To ensure that we do not compromise future management activity in the estuary, we have also considered potential development of the estuary over the next 100 years.

**Priority Sites are areas targeted by our proposed management decisions over the next 10 years.**

Our Priority Sites are areas where:

- **flood defence improvement** is justified; or
- we should **reduce or withdraw our maintenance activities**, applying our established **maintenance protocol**, for defences which are not justified; or
- we should **realign the defences** further inland to reduce costs and support creation of intertidal habitat.



## How we developed our potential options

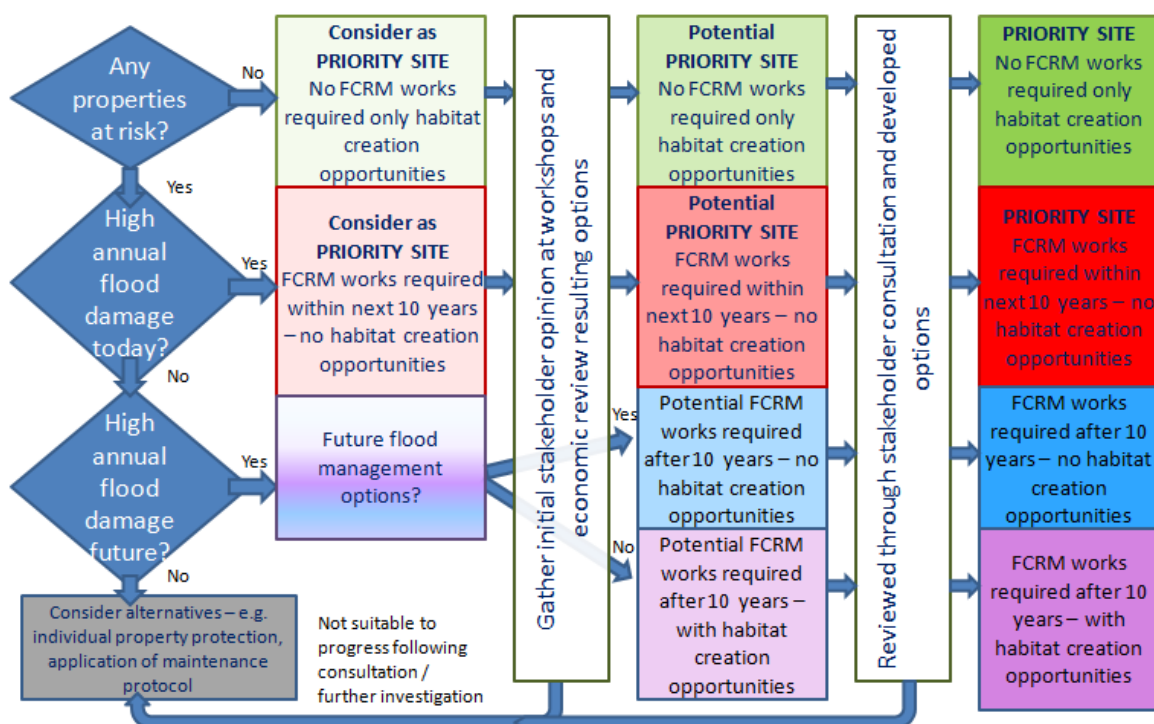
We used existing hydraulic models of the estuary to establish water levels for tidal and river events ranging from those with a probability of occurring in any year of 100% to 0.5% (1:200 annual probability). We then compared this to land levels, including defences, and also took into account the condition of the defences. We were then able to establish flood risk. We have accounted for climate change in our estimates of future water levels in line with Defra current guidance, where sea levels are expected to rise by approximately 750mm over the next 100 years by an accelerating rate from today.

An economic appraisal was undertaken to identify both the benefits and costs. This assessment considered the increasing risk of flooding over time and the corresponding increase in economic flood damage to each MU. The damages were then compared with the approximate cost to determine whether flood management investment is likely to be viable.

We also reviewed the estuary to identify areas where there are few or no constraints to habitat creation through a process of assessment and ranking of influencing factors. In addition we have used the studies and assessments already completed by the partners on the estuary to further establish the potential management options.

The flow chart below shows how we developed the potential options for each Management Unit once flood risk and environmental potential/importance had been established. These are grouped into:

- Priority sites where management decisions could be taken within the next 10 years to either:
  - carry out flood protection works (red); or
  - where there are habitat creation opportunities (green) (often a potential site for the application of maintenance protocol to reduce or withdraw maintenance if habitat creation cannot be realised)
- Also identified are sites where flood protection works will be required after 10 years and up to 100 years from today
  - Without habitat creation opportunities (blue)
  - With habitat creation opportunities (purple)
- Finally sites where there is no justification to do anything i.e. Apply maintenance protocol within 100 years except a few cases where individual property protection (IPP) may be appropriate in the long term (grey).



# Environmental Assessment Methodology

## *Methods of Assessment*

We have undertaken a high level assessment as part of the study to discount any environmentally unacceptable options at an early stage and to inform future EIA work on any projects in the Management Units.

To complete this exercise we gathered data from desk studies, previous studies and assessments and consultation with stakeholders to evaluate whether an option could potentially lead to an environmental change through:

- increasing or reducing flood risk;
- changing the ability of the area of land to be used in a certain way; and
- damage or change caused by the construction of new flood defences or alterations to existing flood defence or river structures.

We assessed each option to see whether it has the potential to significantly affect an environmental receptor. This enabled us to draw up the shortlist of options along with an assessment of whether it was technically and economically feasible.

## *Focussing the Assessment*

We focussed the environmental assessment on the potential impact of the flood risk management options on the environmental receptors detailed in the Environmental Baseline (Section 2).

These influences, their nature and the potential exposure to changes in the environment brought about by those options are summarised in Table 3.1. This provides our view on the scope of the assessment we have undertaken and future EIAs. By considering these influences we have focussed on the receptors which are most likely to be affected by any outcomes from the Taw Torridge Flood and Coastal Risk Management Study.

## *Mitigation*

In our assessment we have considered how we might lessen the negative impacts of each option through mitigation.

Mitigation can take a number of forms and is very dependent on the nature of the adverse potential environmental impact. Mitigation includes the consideration of:

- alternative ways in which we might implement an option which might avoid or reduce its negative effects;
- how the sensitive design of an option might avoid or reduce its negative effects; and
- how we might offset the effect of an option by replacing what may be lost or damaged elsewhere.

## *Recording the Assessment*

Several options may potentially result in negative or positive impacts from their delivery and implementation but still be viable and warrant further investigation. On each of the Management Unit sheets in Appendix C we have highlighted any potential impacts resulting from the high level environmental assessment of the potential management option. We have also included potential mitigation measures for any predicted environmental effects along with any identified opportunities.

In Sections 5 and 6, predicted cumulative impacts are given which may result from the proposed management options on the:

- hydromorphology and sediment movement of the wider estuary.
- landscape character of the estuary
- amenity, navigation and fisheries
- Braunton Burrows SAC, the Taw Torridge Estuary SSSI, IBA and recommended Marine Protection Zones (MPZs).

Opportunities and consideration of WFD issues are recorded in Section 8.

*Table 3.1 Assessment Topics to be included within the Taw Torridge Study Environmental Assessment*

Receptor	Taw Torridge Study Influence	Scoped in
<b>Human beings</b>		
Population and flood risk	The study and the options considered in its development will seek to manage flood risk for the benefit of the population within the Study Area.	Yes
Human health and well being	The options may affect public access to recreational features and public services. The perceived level of flood risk that communities are exposed to may also affect levels of stress and affect people's quality of life.	Yes
Material assets and critical infrastructure	The study will seek to manage flood risk to critical infrastructure and material assets within the Study Area. The implementation of options has the potential to disrupt critical transport infrastructure, utilities or access to community care facilities.	Yes
Navigation	The proposed options could lead to minor impacts on the navigable waters within the estuary from alterations in sediment transport.	Yes
<b>Flora and Fauna</b>		
Biodiversity, Designated Conservation Sites, BAP Habitats and Species, Fisheries	The options may include construction, land use changes, changes in flood risk, frequency or changes in water levels that have the potential to adversely affect nature conservation and biodiversity features. Alternatively, such changes may present opportunities to improve the condition of existing habitats or create new biodiversity features.	Yes
<b>Air and Climate</b>		
Air quality	The options resulting from the study are unlikely to change air quality in the Study Area.	No
Climate	The options may provide the opportunity to address any potential increase in flood risk due to climate change, but will not affect the climate.	Yes
<b>Water</b>		
Water quality including WFD obligations	Options could result in changes to flood risk of potentially contaminated land. Any of the options could have a negative or beneficial effect on the ecological status/potential of a waterbody and some of the options may have the potential to provide an opportunity for some of the mitigation measures within the estuary to be undertaken improving its ecological status/potential.	Yes
<b>Soils, Geology and Land Use</b>		
Soils, Geology and Land Quality	The options could degrade or compromise soil quality and/or function.	Yes
Land Use	The options could change the frequency and extent of flooding leading to consequent changes in the use of the land.	Yes
<b>Water resources</b>	The options could affect ground water or abstractions.	Yes
<b>Landscape and Visual Amenity</b>	The options have the potential to lead to construction activities and land use change which may alter the character of the existing landscape and visual amenity. The options may also provide opportunities to improve landscape quality through the creation or enhancement of landscape features.	Yes
<b>Archaeology and Cultural Heritage</b>	The options may involve construction activities, land use changes or alterations to flood regimes which can adversely affect historic environment sites and their settings.	Yes
<b>Natural Resources</b>	The options could have the potential to lead to changes in flood risk, which may adversely affect the management or ability to exploit natural resources within the Study Area. Any FRMS may require the use of natural resources.	Yes

*Left intentionally blank for double sided printing*



## 4. Our priorities for the estuary

In this section.....

- we summarise the results of our studies and analyses for each of the 46 management units;
- explain how we have identified our 'Priority Sites' where future changes may be appropriate.

### Overall proposal

Our overall proposal for management of the Management Units considered in this study in terms of flood defence and habitat creation opportunities over the next 100 years is shown on Figure 3.

We are focussed on Priority Site locations where management decisions are required in the next 10 years. However we have also presented the likely outcome over the next 100 years to provide a context for our decision making. The table below provides outline justification for our selection of Priority Sites followed by detailed pages for each of those identified.

In Appendix C we include pages of detail for each of the Management Units containing Priority Sites and in Appendix B we include details of economic methodology and outline assessment. Detail pages are not included for Management Units which do not have potential schemes within the next 10 years. A summary of the resulting programme of management decisions following our detailed review is given in Section 9. : We will apply the protocol for the maintenance of FCRM assets. Where it is no longer economic to continue to maintain assets we will investigate the possibility for habitat creation.

In summary, FCRM works are potentially required within the next 10 years (subject to attracting funds) in 5 MUs. These MUs all have significant assets to protect and either a low standard of protection, or defences in a poor condition, at one or more locations. All except Bideford Right Bank are likely to have benefit cost ratios which would



attract some public funding. All would be likely to require other funding contributions. Similar numbers of property are at risk in each of these MUs in the short term (Appendix E shows more detail).

9 MUs are fronted by potentially uneconomic defences that are not preferred sites for habitat creation. Application of the Maintenance Protocol (refer to Appendix E) is recommended. These “defences” are mainly high natural banks.

11 MUs have defences that protect little or no property and have land suitable for habitat creation. We would apply the maintenance protocol to establish if a defence is actually needed, or could be supported by the landowner. If this is not the case we would explore with the landowner the potential to create habitat. The small numbers of property should be considered for individual or very local flood protection schemes if the defences were reduced. Thus they have been identified on the table as potential areas with habitat creation potential, but with the secondary option of changing the maintenance regime..

A further 11 MUs also have land with habitat creation potential, but realising this opportunity, even with appropriate funding, is unlikely in the short term as it is likely to be economic to maintain the defences until at least 2032. Future FCRM works may even be considered after this time.

Another 11 MUs are likely to provide adequate service in the short term and do not have land suitable for habitat creation. However FCRM works may be justified in the long term once sea level rise has impacted on the standard of protection, and/or their condition has deteriorated to poor or worse.

Table 4.1 – Summary of option development – row colours relate to flow chart in Section 3 and Figure 3

Management Unit Reference	Management Unit	Number properties currently at flood risk during 0.5% AEP event <u>without defences</u> - undefended flood plain		Minimum Standard of Protection – return period (years)	Number properties at flood risk during 0.5% AEP event <u>with defences</u> maintained at present levels and sea level rise.						Acceptable condition (i.e.Y=very good/good/ fair )	Is it potentially economically beneficial to invest in these defences with public money						Possible site for application of maintenance protocol for economic reasons	Has habitat creation potential for "X" hectares	Ownership			Priority site – see detail in Appendix C	Comments (where costs are shown, values refer to initial construction costs only and exclude maintenance and future investment)
		Present			Present		By 2022		By 2112			Year								Environment Agency	Local Authority	Private		
		Residential	Commercial		Residential	Commercial	Residential	Commercial	Residential	Commercial		2012	2017	2022	2032	2062	2112							
FCRM works required within the next 10 years (subject to attracting funds)																								
1	Northam Burrows	21	-	<1 in 1	21	-	25	-	50	4	yes	yes	yes	yes	yes	yes	yes	-	-		*	*	yes	FCRM works required to protect property at Westward Ho!- Landfill, golf course and a 21 properties - habitat already developing due to regular overtopping. Cost of works to protect existing landfill likely to be in the range of £120,000 to £375,000. See report in Appendix L.
3	Northam	7	1	1 in 1	7	1	7	1	12	1	yes	yes	yes	yes	yes	yes	yes	-	-			*	yes	Low sections of wall - note private defences. Scheme cost approximately £230,000
17	Bideford right bank	10	2	<1 in 1	10	2	11	2	16	7	yes	yes	yes	yes	yes	yes	yes	-	-	*	*	*	yes	Low benefits, but potentially low cost viable scheme, low section of defence. Works potentially in conjunction with redevelopment of quay. Costs approximately £925,000
23	Yelland (Instow Barton)	-	12	> 1 in 200	-	12	-	12	-	13	-	yes	yes	yes	yes	yes	yes	-	10	*	*	*	yes	Low benefits, but potentially low cost viable scheme, private defences where there is 10ha potential habitat creation, properties at risk due to poor structural condition... High ground behind low defences. Approximate cost of works £380,000
45a	Braunton Marshes	13	-	<1 in 1	13	-	14	1	19	4	yes	yes	yes	yes	yes	yes	yes	-	-	*	*	*	yes	Generally low defence, isolated properties. Economic appraisal uncertain due to complex site with dispersed properties. Indicative scheme cost of £1,000,000.
Potentially uneconomic defences that are not preferred sites for habitat creation - recommend application of Maintenance Protocol (refer to Appendix E)																								
5	Upcott	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	-			*	-	No managed defence
7	Landcross	-	-	<1 in 1	-	-	-	-	-	-	-	-	-	-	-	-	-	yes	-			*	-	Potentially apply maintenance protocol- no remaining habitat potential as already breached to create habitat
9	Yeo	-	-	<1 in 1	-	-	-	-		-	yes	-	-	-	-	-	-	yes	-			*	-	No managed defence
10	Weare Giffard	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	-			*	-	No managed defence
14	Hallspill	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	-			*	-	No managed defence
15	Hadlow	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	-			*	-	No managed defence
16	Opposite Pillmouth (Tennacott)	-	-	1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	-			*	-	Existing habitat
19	Westleigh	-	-	<1 in 1	-	-	-	-	-	-	N/A	-	-	-	-	-	-	yes	-	*			-	Already breached to create habitat
46	Crow Point	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	-	*			-	Potentially apply maintenance protocol – not a priority site but is of wider interest therefore we have prepared a sheet in Appendix C with further detail
Habitat creation potential (with secondary option of Maintenance Protocol)																								
12	Half Penny Bridge	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	6	*			yes	Does not protect any property, but road would occasionally flood, habitat creation potential - detailed project would confirm relative priorities of management approach.
13	Salterns	-	-	1 in 10	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	15			*	yes	Private defences - potentially 15ha of habitat creation with landowner agreement

Management Unit Reference	Management Unit	Number properties currently at flood risk during 0.5% AEP event <u>without defences</u> - undefended flood plain		Minimum Standard of Protection – return period (years)	Number properties at flood risk during 0.5% AEP event <u>with defences</u> maintained at present levels and sea level rise.						Acceptable condition (i.e.Y=very good/good/ fair )	Is it potentially economically beneficial to invest in these defences with public money						Possible site for application of maintenance protocol for economic reasons	Has habitat creation potential for 'x' hectares	Ownership			Priority site – see detail in Appendix C	Comments (where costs are shown, values refer to initial construction costs only and exclude maintenance and future investment)
		Present			Present		By 2022		By 2112			Year								Environment Agency	Local Authority	Private		
		Residential	Commercial		Residential	Commercial	Residential	Commercial	2012	2017		2022	2032	2062	2112									
24	Fremington (Home Farm)	3	-	> 1 in 200	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	40	*	*	*	yes	Defences in good condition, economic to maintain, but potentially 40ha of habitat with landowner agreement.
26	Hollowcombe (Penhill)	-	-	> 1 in 200	-	-	-	-	1	-	yes	-	-	-	-	-	-	yes	25		*		yes	LA defences - potentially 25ha of habitat creation with landowner agreement, (8.5ha already identified by NE as immediately feasible) may be able to justify individual property protection by 2112.
29	South of A39	-	-	> 1 in 200	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	5	*		*	yes	Potentially 5ha of habitat creation with landowner agreement, if not possible potential to apply maintenance protocol.
30	Shorleigh Bridge	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	1			*	yes	Private defences - potentially 1ha of habitat creation with landowner agreement
31	Tawstock Park	-	-	> 1 in 200	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	5			*	yes	Private defences - potentially 5ha of habitat creation with landowner agreement
32	Tawstock	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	5			*	yes	Private defences - potentially 5ha of habitat creation with landowner agreement
33	Overton	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	25			*	yes	Private defences - potentially 25ha of habitat creation with landowner agreement
35	Chestwood	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	5			*	yes	Private defences - potentially 5ha of habitat creation with landowner agreement
36	North Chestwood	-	-	<1 in 1	-	-	-	-	-	-	yes	-	-	-	-	-	-	yes	0.5	*		*	yes	Potentially 0.5ha of habitat creation with landowner agreement, if not possible potential to apply maintenance protocol.
Habitat creation potential (but unlikely in the short term as economic to maintain defences until at least 2032 and future FCRM works likely)																								
6	River Yeo	3	-	> 1 in 200	-	-	5	-	5	-	yes	-	-	-	-	yes	yes	-	small			*	yes	Already breached so may be little remaining habitat creation potential with landowner agreement, future few vulnerable properties
11	Weare Barton	-	-	<1 in 1	-	-	-	-	3	-	yes	-	-	-	-	-	(yes) v low benefit	-	5.5			*	yes	Future project needed as there is some property that may need protecting in the future (but low economic benefit) and habitat creation opportunity with landowner agreement.
18	Pillhead (Salterns)	-	-	1 in 20	-	-	-	-	1	1	yes	-	-	-	-	yes	yes	-	40		*		yes	Potential for major habitat creation area with landowner agreement, future FCRM works likely to protect road, and property.
20	Tapeley Park (Salterns)	-	-	> 1 in 200	-	-	-	-	-	1	yes	-	-	-	-	-	(yes) v low benefit	-	5			*	yes	Future project needed as there is some property that may need protecting in the future (but low economic benefit) and habitat creation opportunity with landowner agreement.
21	South Yeo	2	-	> 1 in 200	-	-	-	-	-	2	yes	-	-	-	-	yes	yes	-	5			*	yes	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.
27	Sticklepath	72	18	> 1 in 200	-	-	-	-	73	24	yes	-	-	-	-	yes	yes	-	2	*	*		yes	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.
28	North of A39	2	-	> 1 in 200	-	-	-	-	3	-	yes	-	-	-	-	-	yes	-	2	*	*	*	yes	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.



Management Unit Reference	Management Unit	Number properties currently at flood risk during 0.5% AEP event <u>without defences</u> - undefended flood plain		Minimum Standard of Protection – return period (years)	Number properties at flood risk during 0.5% AEP event <u>with defences</u> maintained at present levels and sea level rise.						Acceptable condition (i.e. Y=very good/good/ fair )	Is it potentially economically beneficial to invest in these defences with public money						Possible site for application of maintenance protocol for economic reasons	Has habitat creation potential for "X" hectares	Ownership			Priority site – see detail in Appendix C	Comments (where costs are shown, values refer to initial construction costs only and exclude maintenance and future investment)
		Present			Present		By 2022		By 2112			Year								Environment Agency	Local Authority	Private		
		Residential	Commercial		Residential	Commercial	Residential	Commercial	Residential	Commercial		2012	2017	2022	2032	2062	2112							
37	Rumsam	1	-	> 1 in 200	-	-	-	-	-	-	yes	-	-	-	-	-	yes	-	1.3	*			yes	No properties are at risk but sewage pumping station is likely to need some additional protection in 2112, some habitat potential with landowner agreement.
42	Pottington	6	13	> 1 in 200	-	-	-	-	21	16	yes	-	-	-	-	yes	yes	-	20	*			yes	Potentially 20ha of habitat creation with landowner agreement, possibly future retreated line of defence, but it could detrimentally affect the freshwater bird reserve at Bradiford Water There are major utilities running along the Tarka Trail also.
43	Chivenor	-	1	> 1 in 200	-	-	-	-	22	2	yes	-	-	-	-	(yes)	(yes)	-	50			*	yes	Private defences, (low economic benefit), 50ha habitat potential with landowner agreement, works review for 2032. Natural England has completed a feasibility study. The study proposes to create 23.7ha of salt marsh; 31.9 ha of freshwater habitat (comprising of existing and new reed beds and grazing marsh)
45b	Horsey Island	1	-	<1 in 1	-	-	1	-	1	-	-	-	-	-	-	(yes)	(yes)	-	82			*	yes	Private defences, potentially 82ha of habitat creation with landowner agreement, potential future individual property protection but (low economic benefit).
No habitat creation potential (economic to maintain defences until at least 2032 and later FCRM works likely)																								
2	Appledore	-	2	<1 in 1	-	2	3	4	48	10	-	-	-	-	-	-	yes	-	-	*	*	*	-	Low SoP, near shipyard, There are benefits today but unlikely to be viable without partnership funding in the short term. Should be reviewed for potential works in 20 years.
4	Bideford left bank	488	86	1 in 200	-	-	-	-	548	109	yes	-	-	-	yes	yes	yes	-	-	*	*	*	-	Should be reviewed after 20 years
8	Annerly Park (Kiln)	6	-	> 1 in 200	-	-	-	-	10	-	yes	-	-	-	-	yes	yes	-	-	*		*	-	All properties are located behind a new raised defence
22	Instow	14	3	1 in 200	-	-	-	-	44	7	yes	-	-	-	-	yes	yes	-	-	*	*	*	-	Should be reviewed after 20 years
25	Fremington Pill	3	1	> 1 in 200	-	-	-	-	11	1	yes	-	-	-	-	yes	yes	-	-	*	*	*	-	Should be reviewed after 20 years
34	Bishops Tawton	13	-	> 1 in 200	-	-	-	-	17	1	yes	-	-	-	-	yes	yes	-	-	*	*	*	-	Should be reviewed after 20 years
38	Newport	-	1	> 1 in 200	-	-	-	-	1	2	yes	-	-	-	-	-	yes	-	-	*			-	Should be reviewed after 20 years
39	Coney Gut	188	10	> 1 in 200	-	-	-	-	292	14	yes	-	-	-	-	-	yes	-	-	*	*		-	Should be reviewed after 20 years
40	Barnstaple	162	29	> 1 in 200	-	-	352	73	352	73	yes	-	yes	yes	yes	yes	yes	-	-	*	*	*	-	Should be reviewed at 10 years
41	Pilton	256	67	> 1 in 200	-	-	-	-	299	90	yes	-	-	-	-	yes	yes	-	-	*	*	*	-	Should be reviewed after 20 years
44	Wrafton	-	-	<1 in 1	-	-	-	-	50	-	yes	-	-	-	-	yes	yes	-	-	*		*	-	Should be reviewed after 20 years

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## 5. Interactions between potential management options

In this section.....

- we describe our assessment of any interactions between our management options. We need to know whether actions in one part of the Taw Torridge Estuary might have effects elsewhere in the estuary system.

### Current understanding

One of the objectives set for this study was to make full use of previous investigations rather than using scarce resources to 'reinvent the wheel' or to undertake expensive estuary modelling. We have made full use of an extensive study by Professor John Pethick into the Geomorphology and Management of the Taw-Torridge Estuaries (Pethick, 2007). This study was also used to support the recent SMP2 recommendations. The report established the likely evolution of the estuary, with and without extending the floodplain into new habitat creation sites. Many of these sites coincide with the habitat creation opportunities identified in this study. This evolution is largely dependent on the volume of water passing in and out of the estuary on each tide. The wedge of the estuary filled with water between high and low tide on an average spring tide is referred to as the tidal prism. A large tidal prism demands a wider estuary than a smaller tidal prism.

Habitat creation areas will add to the tidal prism and so possibly demand a wider estuary. Sea level rise is also likely to increase the tidal prism. Table 5.1 below shows the percentages by which the potential habitat creation sites could increase the tidal prism.

If all the potential sites identified by this study became tidal habitat, the increase in estuary tidal prism would only be

approximately 1.6%. This would increase erosive pressure on the mouth of the estuary to a small degree. Coastal squeeze (refer to Glossary) arising from sea level rise is also likely to increase erosion pressure at the mouth of the estuary by a similar amount to the proposed managed realignments within the next 20 years. Erosion pressure arises from an increased volume of water due to sea level rise passing through a relatively fixed channel width. To achieve this, the water must flow with more force and energy.

However, Pethick considered that the mouth is pinned on the northern side by the rock incised northern channel and on the southern side by a continuous (albeit diminishing) supply of sediment being pushed across the mouth from Northam Burrows to the south. He considered, and the SMP2 concurs, that the mouth is very unlikely to take a different route from today's alignment even with an increased tidal prism. The main issue identified by Pethick affecting the future evolution of the Taw and Torridge estuaries is that they are currently starved of sediment.

As the estuaries are generally over-wide they tend not to be very energetic and do not carry a lot of sediment. In an estuary system that is thought to be starved of fine sediment, accretion rates are likely to be low. What sediment there is accretes in low flow/low energy areas. Pethick makes an important point that introduction of realignment sites will increase the demand

for fine sediments within the estuaries. There may be a tendency to strip fine sediment from areas where it currently settles and move it into the realigned sites, especially if they are more sheltered.

More specific comments are given on the following table. (Note where sea level rise is referred to we have assumed an average of 7mm/yr over 100 years – a levelled approach to current guidance for approximate analysis).

*Table 5.1 – Indicative estuary volume changes due to habitat creation*

Management unit (MU)	Name	Location within estuary system	% of tidal prism of that part of the estuary	Equivalent to "x"yrs of anticipated sea level rise (approx) – av. over 100yrs	Comments
Instow to Mouth – volume of tidal prism of this part = 21million m <sup>3</sup>					
1	Northam Burrows	Coastal	0.50	0.1	Total is approximately half that reviewed by Pethick. Only 0.5% likely to be realised until the defences degrade in the future. The effects of these proposals on estuary regime are likely to be small. MU 45b will have the greatest impact.
45b	Horsey Island	Coastal	1.00	0.2	
46	Crow Point	Coastal	0.09	0.0	
Total			1.6%	0.3yrs	
Torridge - volume of tidal prism of this part = 15 million m <sup>3</sup>					
6	River Yeo	Upper	0.18	neg.	This is similar to the tidal prism change assessed by Pethick. He considered that in this oversized estuary, additional intertidal habitat creation is likely to lead to reduced estuary accretion rates rather than erosion, maintaining the current estuary shape. MU 18 is likely to have the most extensive effects, but is not economic for at least 10 years. The immediately potentially economically feasible sites account for only a 0.3% increase in estuary volume.
11	Weare Barton	Upper	0.09	neg.	
12	Half Penny Bridge	Mid	0.05	neg.	
13	Salterns	Mid	0.23	neg.	
16	Opposite Pillmouth (Tennacott)	Mid	0.16	neg.	
18	Pillhead (Salterns)	Mid	0.69	0.1	
20	Tapeley Park (Salterns)	Mid	0.02	neg.	
21	South Yeo	Mid	0.04	neg.	
Total			1.5%	0.2yrs	The suggested habitat creation may have a small influence on the estuary meanders. Sites 6 and 11 would also offer fluvial flood risk attenuation.
Taw - volume of tidal prism of this part = 31 million m <sup>3</sup>					
23	Yelland (Instow Barton)	Lower	0.16%	neg.	Pethick's analysis assessed a 3% increase. This estimate would have a similar but slightly reduced impact. The upper estuary sites would likely be fed by fluvial sediments, which would capture sediment supplies to the middle estuary. Mid and lower sites may act as sediment sinks for coastal sediment and remove more fine sediments from the system. Again as this estuary is over wide, the most likely outcome is that rates of accretion would be slowed rather than increasing erosion. There would be some increase in erosive pressure at the mouth which is currently pinned in position, and at Crow Pont where the estuary is relatively narrow. This would be in addition to that associated with sea level rise. The suggested habitat creation may have a small influence on the estuary meanders. Sites 28 to 37 would also offer fluvial flood risk attenuation. Sites 43, 24 and 26 are relatively close and could together have more extensive effects. However, recent feasibility studies by Natural England indicate that only 30% of the potential habitat is suitable at Chivernor. Therefore the impact is reduced. The immediately potentially economically feasible sites account for only a 1.4% increase in estuary volume.
24	Fremington (Home Farm)	Lower	0.35%	0.1	
26	Hollowcombe Penhill)	Lower	0.66%	0.2	
27	Sticklepath	Mid	0.01%	neg.	
28	North of A39	Upper	0.02%	neg.	
29	South of A39	Upper	0.03%	neg.	
30	Shorleigh Bridge	Upper	0.01%	neg.	
31	Tawstock Park	Upper	0.04%	neg.	
32	Tawstock	Upper	0.04%	neg.	
33	Overton	Upper	0.20%	0.1	
35	Chestwood	Upper	0.04%	neg.	
36	North Chestwood	Upper	Neg.	neg.	
37	Rumsam	Upper	0.01%	neg.	
42	Pottington	Mid	0.20%	0.1	
43	Chivenor	Lower	0.41%	0.1	
46	Crow Point	Lower	0.05%	neg.	
Total			2.2%	0.6yrs	



## Summary of changes to estuary tidal prism

Changing the shape of the estuary by opening up habitat creation areas to the tidal flow of the estuary, or indeed by preventing it from adapting naturally by our actions, may potentially have a knock on impact elsewhere in the estuary. We have considered this and note that if we carry out all the works proposed in the short and long term scenarios:

- Between Instow and the mouth the effects are likely to be immeasurably small and potentially change the tidal prism driving natural changes in the estuary by only 1.6%. Due to the fixed nature of the sub-tidal geology of the area this is likely to have no significant impact.
- The Torridge would potentially experience a change of 1.5% if all schemes were developed. However, only a few sites are likely to be progressed for economic reasons, reducing the potential change in tidal prism to a negligible 0.6%.
- The Taw may experience a 2.2% change in tidal prism as a result of all the potential options (however all are unlikely to be realised). Again this is a relatively small change. However, this is very unlikely to translate into erosion forces within the estuary as the Taw is wider than it might be if it were in natural balance. It is most likely that these changes will only slow the rate of accretion with the estuary.

These impacts relate to proposed managed realignment of defences or positive steps taken to create inter-tidal habitat. There would be greater effects if other defences were not maintained and were allowed to breach.

Pethick notes that the estuary will be under pressure from sea level rise, notably at its mouth, which is likely to try to widen to accommodate the increasing tidal volumes. Holding the erosion of the Northam Burrows landfill on the southern side of the mouth of the estuary may put additional pressure on Braunton Burrows on the northern bank to yield instead. The potential managed realignment options would slightly further increase the tidal volume and associated impacts in addition to sea level rise, but to a very small degree. To put this into context - if all the potential managed realignment sites were created, the increase in tidal volume would approximate to only 1 additional year of sea level rise (averaged over 100 years) i.e. the estuary would experience the equivalent of 101 years of sea level rise over 100 years. Accounting for just the most likely sites (identified as potential managed realignment site today – green) this equates to only an additional 0.5yrs equivalent sea level rise (approx). However, scour and sediment distribution will be affected locally by any changes in the local management of the defences and these would be considered in the development of any schemes.

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## 6. Wide Ranging Environmental Effects – requirements and assessment of opportunities

In this section.....

- we detail where we predict there may be cumulative impacts from the proposed management options
- we discuss whether losses of inter-tidal habitats, particularly relating to sea level rise, give rise to obligations under the Habitat Regulations
- we discuss any implications from the study which could lead to adverse effects on the recommended MCZs in the Estuary and around its mouth, the SSSI's in the study area and the Taw Torridge IBA
- we show the suitability of sites short-listed for habitat creation opportunities and how this could be achieved.

### Land Use, Amenity, Navigation and Fisheries

Several of the potential options include the proposal to either remove maintenance from defences or to realign them. This could lead to a change from an agricultural use to a nature conservation one if the area forms a salt marsh. Cumulatively this could have a significant impact on the users of the land if the proposals occur.

Several of the potential options proposed could involve the relocation of the Tarka Trail and the South West Coast Path. Careful consideration will be required to ensure that the amenity value of these national paths is retained and where possible enhanced, particularly if several of the potential management options occur.

Access to fishing spots close to the estuary waters may be affected if defences are realigned or not maintained. These will need to be assessed during Environmental Impact Assessments of any of the potential management options.

There will be no significant increases in sediment load in the estuary or changes to the bed of the estuary so there is unlikely to be an effect on fish species present.

### Landscape Character

The LCA completed by North Devon and Torridge District Councils detailed a number of guidelines for future plans and programmes. Table 6.1 details the relevant guidelines provided in the LCA and gives the relationship between them and the Taw Torridge Study. The cumulative effect from the potential management options to the character of the estuary is unlikely to be significant. It will remain a broad, sweeping estuary with expansive mudflats inundated at high tide, fringed with saltmarsh.

*Table 6.1 Landscape Character of the Taw Torridge Estuary as described in the Joint North Devon and Torridge District Councils LCA and the relationship to the Taw Torridge Study*

Landscape Character Type	Relevant LCA Landscape Strategy Guidelines (Refer to LCA for further detail)	Relationship to the Taw Torridge Study
Estuaries: <i>Taw Torridge Estuary</i>	Protect the open character of the estuary and its important views to and from the surrounding landscapes	No significant change
	Protect, and where appropriate, restore historic features along the estuary edges, including quays and bridges. Provide sensitively sited interpretation to help tell the story of the ever-changing nature of the landscape and its cultural significance.	Historic features were used within the GIS exercise to identify the potential options and are noted in the individual Management Unit sheets in Appendix C. There is an opportunity for interpretation as part of any future projects resulting from this study.
	Manage the landscape's popularity for recreation, encouraging use of existing facilities such as the Tarka Trail and South West Coast Path whilst providing sustainable transport options and green infrastructure links to the surrounding towns.	Through sensitive design potential options will not affect the recreation uses of the estuary
	Manage the estuary's internationally important habitats, including saltmarshes and mudflats, ensuring marshes are grazed at appropriate levels and the location of engineered sea defences respect the natural environment wherever possible.	The proposal could lead to an increase in important intertidal habitat.
	Plan for the future impacts of climate change, particularly as a result of sea level rise and coastal erosion, allowing natural processes to take place wherever possible whilst ensuring that local communities are involved in making decisions about their future landscape. Plan for opportunities to expand estuarine habitats to build resilience to future climate change.	The study has considered climate change impacts from sea level rise.
Marine Levels and Coastal Plains: <i>Braunton Marsh and Chivenor</i>	Manage the landscape's valued coastal grasslands, reedbeds, grazing marsh and network of drainage ditches, including through a continuation of livestock grazing at appropriate levels and the careful management of water levels on Braunton Marsh.	Details of potential impacts to Braunton Marsh are provided in Appendix C.
	Plan for the future effects of climate change, particularly as a result of sea level rise, allowing natural processes to take place wherever possible whilst adapting farming practises to respond to future changes. Plan for opportunities to expand wetland habitats to strengthen species and habitat resilience.	The study has considered future climate change impacts and has identified areas where intertidal habitat could be created.
Extensive inter-tidal sands: <i>Sandy beaches at Saunton and westward ho!</i>	Manage the beaches' important habitats as part of the wider coastal ecosystem of the North Devon Biosphere Reserve	There will be no significant change to the beaches important habitats
	Plan for the future effects of climate change, particularly as a result of sea level rise and coastal erosion, allowing natural processes to take place wherever possible whilst ensuring that local communities are involved in making decisions about their future landscape.	This study has proposed that the Pebbleridge at Westward Ho! is allowed to naturally evolve. Further details are provided in Appendix C (MU1). Consultation is ongoing with the local community.
Dunes: <i>Braunton Burrows and Northam burrows</i>	Plan for the future effects of climate change, particularly as a result of sea level rise and coastal erosion, allowing natural processes to take place wherever possible whilst ensuring that local communities are involved in making decisions about their future landscape.	The study has considered future climate change impacts.



Landscape Character Type	Relevant LCA Landscape Strategy Guidelines (Refer to LCA for further detail)	Relationship to the Taw Torridge Study
	Explore opportunities for managed realignment and habitat creation to make spaces for coastal squeeze and species migration in light of future sea level rise.	
Marine Levels and Coastal Plains: <i>Braunton Marsh and Chivenor Airfield</i>	Manage the landscape's valued coastal grasslands, reedbeds, grazing marsh and network of drainage ditches, including through a continuation of livestock grazing at appropriate levels and the careful management of water levels on Braunton Marsh.	The hydrological regime at Braunton Marshes requires further investigation as it is unclear the impact of changes the defences could have. There could be an impact on the character of the marshes if a scheme is progressed which will required further assessment via a Landscape and Visual Impact Assessment as part of a wider EIA.
	Plan for the future effects of climate change, particularly as a result of sea level rise, allowing natural processes to take place wherever possible whilst adapting farming practises to respond to future changes. Plan for opportunities to expand wetland habitats to strengthen species and habitat resilience.	The study has considered future climate change impacts. Habitat creation at Chivenor is proposed and is currently being progressed by Natural England.
Secluded Valleys: <i>Includes the valleys which feed into the estuary, some of which are affected by the tides e.g. MU 6</i>	Create, extend and link woodland and wetland habitats to enhance the water storage capacity of the landscape (reducing incidences of downstream flooding) and improve water quality through reducing soil erosion and agricultural run-off. The natural regeneration of woodland should be encouraged and new planting (using climate hardy species) undertaken to link fragmented sites.	The study has identified areas of saltmarsh which can be created or extended within the valleys of the tributaries to the estuary. There is an opportunity as part of a project for woodland planting to be undertaken.

## Archaeology and Cultural Heritage

The Taw Torridge estuary contains a wealth of archaeological potential. In all cases where changes to the management of a site are proposed, a detailed appropriate archaeological assessment will be required to ensure there are no negative impacts. Within all the ancient sediment build up there is the potential for preserved remains.

## Habitat Requirements

We have undertaken a high level assessment of whether any of the proposed management options could lead to an effect on the neighbouring Braunton Burrows SAC which would require compensation under the EC Habitats and Species Regulations 2010 (the 'Habitat Regulations').

Coastal squeeze of internationally designated sites is unlikely to be an issue as they are either high and therefore, not subject to coastal squeeze, or have been identified as a potential area for habitat creation. The detail of this would need to be investigated and confirmed at project level.

Braunton Burrows is primarily designated for the following habitats and species which are listed on Annexes I and II of the Conservation of Habitats and Species Regulations 2010 (**as amended**):

- Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')
- Fixed dunes with herbaceous vegetation ('grey dunes')
- Dunes with *Salix repens* spp. *argentea* (*Salicion arenariae*)
- Humid dune slacks
- Petalwort *Petalophyllum ralfsii*

Crow Point (MU 46) and Braunton Marshes (MU 45a) are the only study Management Units which are within the SAC.

#### Crow Point

Crow Point is formed of shifting dunes protected by rock armour. The system is not pinned by landward defences therefore will retreat with rising sea levels due to climate change. Further investigation of any effects to the Habitats at Crow Point will be required if works are proposed. .

*Petalwort (Petalophyllum ralfsii)* has been recorded in the grid square to the north of Crow Point however; *P. ralfsii* is a species which grows in open, damp, calcareous dune slacks. Dune slacks are not present at Crow Point and therefore any changes to this MU will not affect *P. ralfsii*.

#### Braunton Marshes

The potential management option here is to investigate proposals to ensure the properties in Braunton are protected against flooding, while operating the maintenance protocol. This will potentially result in a small area of tidal inundation some of which is shown to be within the Braunton Burrows SAC. Investigations will be required to assess whether this could significantly affect the dune system in a negative way. At present it is unknown how much tidal flood waters are stored in the marshes. Further detailed modelling will be required of this area.

### Potential Impacts and Opportunities on SSSI's in the Study area

Table 6.2 details the SSSI in the Study Area and the potential effects that the

possible management options could have on the sites. The Environmental Constraints Plan in Appendix A shows the locations of the SSSIs.

### Recommended MCZs

The proposal for habitat creation may lead to an increase in the tidal prism around the mouth of the estuary (Refer to Section 5). However; this is likely to be very slow allowing the Bideford and Barnstaple Bay MCZ to adapt. The Taw Torridge MCZ is proposed to protect the sensitive habitats in the MCZ which are subtidal mud and sand, saltmarsh and reedbeds. The proposals to create additional intertidal habitat may alter the amount of this habitat which may lead to positive or negative impacts on the eels and other fish using the MCZ (refer to Table 6.3 for details of potential habitat creation sites). If any projects are developed in the MUs then both the effects on the tidal prism and the addition of habitat to the estuary will have to be evaluated.

### Taw and Torridge Estuary Important Bird Area

The IBA supports a diverse assemblage of wintering wildfowl and waders.

The proposals outlined in this study will not affect any existing intertidal habitats within the estuary and the study has identified additional areas where habitat could be created, which would give additional habitat for the birds in the IBA. The study outcomes will not lead to changes in the bird use of the estuary. However, further investigation of impacts will be required for any projects completed in the estuary.

*Table 6.2- SSSIs within the Taw Torridge Study Area*

SSSI Site	Brief Description of SSSI	Condition of SSSI Units	Relationship to the Taw Torridge Study
Taw Torridge Estuary	Overwintering and migratory populations of wading birds e.g. curlew, golden plover. Rare plants along shores. Saltmarsh. Estuarine fish species e.g. mullet, bass, migratory salmon, trout and eels	Units 102 and 103 are Favourable. Unit 101 east of Northam Burrows is Unfavourable no change due to inappropriate coastal management resulting from the road preventing a transition to fixed-dune grassland and overgrazing.	Covers all of the tidal range of the estuary. Management options to remove maintenance of defence and habitat creation will complement SSSI however; there will be no change to the pressure from the road on Northam Burrows.
Braunton Burrows	One of the largest dune systems in England. A system of variably flood dune slacks, grasslands, scrub all inland of a sandy foreshore supporting several species of rare or vulnerable invertebrates, birds and plants.	There are 8 units of which 6 are unfavourable recovering units and 1 is Favourable. Unit 107 is Unfavourable declining because of inappropriate coastal management.	Many of the unfavourable are within Higher Level Stewardship schemes. The proposed management option for MU 45a is for a detailed study to evaluate the influence of tidal flooding in the marshes to see whether the maintenance of the embankment can be altered. A further investigation around Crow Point (MU45b) is proposed to evaluate what options are available for the rock armour.
Northam Burrows	Designated for its wide range of coastal habitats, rare and local plants and overwintering and migratory birds. The pebble ridge is an important land form feature which protects yellow dunes on the landward side which support many species of plant.	Units 1 and 3 within the central section of Northam Burrows are Unfavourable no change because of overgrazing, vehicles and inappropriate scrub management. Unit 2 is Unfavourable declining due to undergrazing. Unit 4 to the east Unfavourable no change because of the road stopping the estuary accessing the unit. Unit 5 covers the pebble ridge and is Unfavourable recovering. Unit 6 is around the old landfill site and is Unfavourable no change due to inappropriate coastal management.	The proposed management options outlined in Taw Torridge Study are likely to affect Units 1-4 through tidal inundation in the future as the risk of breach of the pebble ridge increases with sea level rise. Allowing the pebble ridge to evolve naturally will ensure that Unit 5 will continue to recover to favourable condition. The rock armour at the northern end may be extended which will prevent the pebble ridge from moving northwards however, this end is fairly immobile. Any project to alter the management of the pebble ridge in MU 1 will need to consider impacts to the SSSI.
Fremington Quay Cliffs	Provide stratigraphical evidence for interrupted marine sedimentation in North Devon around the Devonian-Carboniferous boundary.	All 4 units are Favourable.	The proposed management options given in the study will not affect Fremington Quay Cliffs.

SSSI Site	Brief Description of SSSI	Condition of SSSI Units	Relationship to the Taw Torridge Study
Greenaways and, Freshmarsh	Herb-rich marshy grasslands and also the rich water-plant communities occurring in the drainage ditches. These habitats are of particular importance as they now have a very restricted distribution in Devon.	Unit 1 is Favourable and Unity 2 is Unfavourable declining because it is failing on the number of positive indicators present in the neutral grassland.	This SSSI is within MU45a and is currently shown to be affected if the defences are removed. Further investigation is required to understand the flood risk across Braunton Marshes and the impacts on the SSSI will require further assessment as tidal inundation could negatively affect the habitats and species present. Refer to MU 45a (Appendix C)
Braunton Swanpool	Braunton Swanpool is important for its reedbed and herb-rich marshy grasslands, habitats which are rare in North Devon.	Units 2 and 5 are Favourable. Unit 1 (neutral grassland) is Unfavourable, recovering.	This SSSI is within MU45a and is currently shown to be at flood risk if the defences were not present which could lead to a negative impact on the SSSI. Further investigation is required in this location to understand the hydrology of the marshes.

## Habitat Creation

The study has identified 14 sites where there is potential for habitat creation. To identify these sites we reviewed over 50 data sets targeting the physical, chemical and ecological factors which control the potential suitability of a site for selection for habitat creation (detail is included as Appendix D). We applied this analysis to the whole of the Study Area to ensure that all potential sites were discovered. These could be delivered by either managed realignment or regulated tidal exchange in consultation with the landowners of the site as is shown in Table 6.3

*Table 6.3 - Approach to habitat creation*

Potential Intertidal Habitat Creation Site	Area of potential habitat *
<b>MU 12 Halfpenny Bridge</b>	3ha
<b>MU 13 Salterns</b>	15ha
<b>MU 20 Tapeley Park</b>	5ha
<b>MU 24 Fremington (Home Farm Marsh)</b>	40ha
<b>MU 26 Hollowcombe (Penhill)</b>	25ha **
<b>MU 29 South of A39</b>	5ha
<b>MU 30 Shorleigh Bridge</b>	1ha
<b>MU 31 Tawstock Park</b>	5ha
<b>MU 32 Tawstock</b>	5ha
<b>MU 33 Overton (Tawstock)</b>	25ha
<b>MU 35 Chestwood</b>	5.3ha
<b>MU 36 North Chestwood</b>	0.5ha
<b>MU 43 Chivenor</b>	50ha***
<b>MU 46 Crow Point</b>	7.1ha

Areas of habitat have been obtained through a Geographic Information Modelling assessment and reflect the areas within each MU which are suitable for habitat creation. In some cases intertidal habitat may already exist. Further investigation will be required to ascertain areas of habitat creation within each MU.

\*\* 8.5ha already identified as immediately feasible by Natural England.

\*\*\* Natural England have completed a feasibility study. The study proposes to create 23.7ha of salt marsh; 31.9 ha of freshwater habitat (comprising of existing and new reed beds and grazing marsh)



## 7. Consultation

In this section.....

- we discuss the way we have engaged with stakeholders to understand the constraints and opportunities;
- we set out our proposals for future consultation to finalise our proposals.

### Review of existing studies and plans

At the start of this project we reviewed existing documents including the plans and policies outlined in Section 1. Notably this study leads on from the recent SMP2 which was consulted on from 2008-2010. We noted the feedback from the SMP2 consultation exercise as we built the baseline for this study.

We have also had close liaison with the North Devon AONB and Biosphere Reserve team who led the development of the Taw Torridge Estuary Management Plan (North Devon AONB and Biosphere Service, 2010). We have also attended a meeting hosted by Natural England attended by RSPB, North Devon Council and DCC where we presented outline proposals for the estuary and received positive feedback with indications of other proposed works in the area. This feedback is amalgamated with the feedback from the subsequent Stakeholder Workshop 1 and shown in Figure 3 in Appendix A.



### Stakeholder Engagement Workshops

We held an initial Stakeholder Engagement Workshop in March 2012. It was well attended and we are very grateful to those who attended for their enthusiastic and constructive input. A record of the issues raised is shown on Figure 3 in Appendix A.

These issues have been considered in the development of the options set out in this document.

A 2<sup>nd</sup> Stakeholder Engagement Workshop occurred in November 2012 where we gathered feedback from the consultation document which was circulated to Key Stakeholders in

October 2012. The comments received have been summarised in Table 7.1 along with details of how they have been incorporated into the study.

*Table 7.1 -External Stakeholder Responses to the Consultation Document (October 2012)*

Consultee	Summarised Response	How the outcome of the study incorporated comments made
<i>Dave Edgecombe AONB Project Officer North Devon Area of Outstanding Natural Beauty Team Received 21/11/12</i>	<ul style="list-style-type: none"> <li>The AONB Team are separate from the Biosphere Reserve</li> <li>The proposals for MU1 Northam Burrows are in line with the WMP assessment and the views of the AONB team. It is vital that the existing tip is maintained at Northam Burrows and properties at Westward Ho! will require coastal protection as the ridge begins to rotate. The AONB agrees that the high costs of maintaining the pebble ridge is unsustainable and allowing natural coastal processes is in line with current thinking.</li> <li>The AONB team view is that the Great Bank between Horsey Island (MU 45b) and Braunton Marshes (MU 45a) should be maintained. Flooding of Horsey Island could reduce water surge up the Caen River as the water could spread out into a much larger area, rather than being confined within a narrow channel. The AONB team would expect a comprehensive archaeological study of the island before the area is allowed to tidally flood. The stone cladding from the Inner or Great Bank was taken to clad the Horsey Bank in the 1850's so if the Horsey Bank is breached making the Great Bank the sea defence it will need to be stone clad again.</li> <li>The AONB agrees that a proper coastal modelling study is required at Crow Point within the next 10 years.</li> </ul>	<ul style="list-style-type: none"> <li>A separate detailed study for Crow Point has been commissioned.</li> <li>The issues concerning Horsey Island would need to be considered as part of any subsequent EIA.</li> </ul>
<i>Peter Burgess Conservation Advocacy Manager Devon Wildlife Trust Received 22 November 2012</i>	<ul style="list-style-type: none"> <li>Devon Wildlife Trust is currently developing, on behalf of the Biosphere Reserve Partnership with core partners (RSPB), a project to deliver habitat creation projects within the Taw estuary. The project is in the early stages however, it is a key habitat creation delivery mechanism which should be identified within the document. Currently Devon Wildlife Trust is securing support to develop a high environmental and visitor carrying capacity site at Sticklepath Marsh (MU 27) as a flagship site.</li> <li>Devon Wildlife Trust are keen to see the potential funding framework scoped within the Taw Torridge Study Documentation</li> </ul>	<ul style="list-style-type: none"> <li>Page 12 includes details of the Biosphere projects being led by Devon Wildlife Trust.</li> <li>The potential funding framework is not part of the <b>scope of this study</b>. The potential sources of funding referred to by Devon Wildlife Trust will be considered for future projects.</li> </ul>
<i>English Heritage Received 21 November 2012</i>	<ul style="list-style-type: none"> <li>Pleased that archaeology and cultural heritage has been scoped in as an issued requiring assessment when, or if, proposals go forwards however, the summary of historic environment within the Consultation Document was too short and patchy considering the high archaeological potential of the Taw Torridge Estuary.</li> <li>The name 'Salterns' indicates the presence of Roman, Saxon or Medieval shoreline salt manufacturing sites.</li> <li>The Devon County Council Historic Environment Service (HES) input will be important in scoping out the potential archaeological impact of any works eventually proposed.</li> <li>It is important to recognise the potential presence of archaeology at this stage as a core aspect in environmental assessments. The NPPF contains clear guidance on the need to make an appropriate assessment of any heritage assets affected by a development, to identify their significance and the impact of that development on significance. This is also relevant for any works which may require a licence from the Marine Management Organisation (MMO) as English Heritage has a memorandum of agreement with the MMO to provide advice on applications.</li> </ul>	<p>The document has been edited to note these comments.</p> <p>The DCC HES would be consulted on any future works arising.</p> <p>Any future EIA should note the high probability of the presence of as yet undiscovered archaeological remains</p>
<i>Adrian Middlewick Senior Waste Management Officer Devon County Council Received 27 November 2012</i>	<ul style="list-style-type: none"> <li>Statements which imply that the golf course is to be protected should be re-phrased throughout the document.</li> <li>The landfill should be referred to as "non-hazardous" not "inert".</li> <li>It is more appropriate to say "Licenced" L landfill not "Authorised".</li> <li>Remove the words toxins from Figure 3 as the council has completed extensive research to prove non-existence of toxins in the landfill site. As the site is unlined if any toxins were</li> </ul>	<ul style="list-style-type: none"> <li>The document was amended to incorporate the comments provided.</li> </ul>

	<p>present they would migrate into the environment regardless of erosion.</p> <ul style="list-style-type: none"> <li>Page 63 of the consultation document refers to maintaining the ridge in the short term to protect the golf tee. Unless this is being proposed by Torridge DC this should not appear in the report.</li> </ul>	
<p><i>Justin Gillet</i> Lead Advisor – Land Management, North Devon Team Natural England Received 26 November 2012</p>	<ul style="list-style-type: none"> <li>Page 50 Table 6.2 suggests that the unfavourable but recovering units are in Braunton Marshes but they are in Braunton Burrows.</li> <li>Page 126 Greenaways SSSI and Freshmarsh SSSI is one SSSI called Greenaways and Freshmarsh SSSI.</li> <li>Northam Burrows is predominantly grazed by sheep and only a few horses. The report suggests it is just horse grazed.</li> <li>The language around the SSSI condition could be more consistent. To avoid ambiguity use the full description of the condition category e.g. Unfavourable no change,</li> </ul>	<ul style="list-style-type: none"> <li>The document was amended to incorporate the comments provided.</li> </ul>
<p><i>Catherine Burgess</i> Lead Advisor – North Devon Team Natural England Received 20 November 2012</p>	<ul style="list-style-type: none"> <li>Ms Burgess is the lead for Natural England on inter-tidal habitat creation on the Taw Torridge and oversees the feasibility studies at Penhill and Chivenor Marsh and the management of Home Farm HLS agreement.</li> <li>MU26 – Hollowcombe (Penhill). The feasibility study has only focussed on 8.5ha with full support of the two landowners. This study shows that there is the potential for 25ha of habitat creation but this would not be fully supported by the landowners. The Study mentions that the feasibility study is in progress but it is complete. The study concludes that saltmarsh could be created by opening up two culverts to allow unregulated tidal exchange. The study has addressed and mitigated potential risks to the Tarka Trail. There are power lines which will need to be protected or diverted if the project was to progress. The next stage for the project is to commission Detailed Design and then carry out the capital works as part of the proposed HLS that the two landowners are currently looking to apply for. However, currently there is no budget available for this so alternative funding is being sought.</li> <li>MU43 Chivenor. The feasibility study has been completed and part of the study was attached to the consultation response for reference. The study proposes to create 23.7ha of saltmarsh and 31.9 ha of freshwater habitat (comprising existing and new reed beds and grazing marsh). The next stage is to progress to Detailed Design and currently funding sources are being explored.</li> <li>Clarity about why the MU was placed in the purple category not the green one is required as the feasibility study has shown that it is feasible.</li> <li>MU24 Fremington (Home Farm Marsh). The study is incorrect in saying that there are proposals to create saltmarsh through an HLS agreement as there is currently no budget for this. Through the HLS agreement, the site is being managed as wet grassland for the estuarine bird interest. Natural England would support salt marsh creation through appropriate HLS land management if the Gaia Trust could secure funding for an inter-tidal project to be developed.</li> </ul>	<ul style="list-style-type: none"> <li>Contact details for Ms Burgess have been noted for any future consultation.</li> <li>The details of MU26, MU43 and MU24 have been changed to reflect the comments provided.</li> <li>MU43 is classified as purple because there are significant numbers of property at risk in the long term and future FCRM works are likely to be required once the currently good defences have deteriorated. In the mean time there is some land suitable for habitat creation if supported by the landowners and sponsored by a private body.</li> </ul>
<p><i>Paul Robertshaw</i> North Devon Council Received 16 November 2012</p>	<ul style="list-style-type: none"> <li>MU 37 the sewage treatment works is a sewage pumping station and there is a main electricity sub-station for Barnstaple is adjacent to it.</li> <li>MU 42 there are major utilities running along the Tarka Trail so the railway embankment will need to be maintained.</li> <li>The contaminated land section should include East Yelland Power Station as it contains asbestos.</li> <li>Bradford Water runs through MU 42.</li> <li>The boundary between Torridge DC and North Devon Council runs along Pill Head watercourse in MU18 which should be shown on the plan.</li> <li>MU23 Yelland Power Station was further west than shown on plan.</li> </ul>	<ul style="list-style-type: none"> <li>The document was amended to incorporate the comments made.</li> <li>MU 42 has been updated to refer to the major services and the need for them to be maintained if anything occurs to the railway embankment.</li> </ul>

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## 8. Water Framework Directive

In this section.....

- we discuss how the study impacts on the Water Framework Directive and how this can be mitigated
- we show where the environmental opportunities resulting from this study can help to achieve the objectives of the WFD.

### Introduction

The Taw Torridge Estuary is a transitional waterbody within the South West RBMP. It is classed as being heavily modified because of the flood protection measures throughout the estuary.

The current Ecological Potential of the estuary is defined as Moderate within the RBMP and the aim is that by 2027 this will be raised to Good. Normally we would aim to achieve this by 2015. However, it is not feasible for this estuary.. The Taw Torridge Estuary is defined as Moderate in the RBMP for the following reasons:

- The levels of dissolved inorganic nitrogen could be leading to a failure / impact. However, this is uncertain without further investigation.
- There are confirmed physical modification in the estuary for flood and coastal erosion protection. Morphological improvement measures to mitigate and reduce impacts from physical modification have been proposed (refer to Table 8.1). However, there was low confidence in the outcome and effectiveness of the measures in relation to the quality elements and further investigation was proposed.

This Study has not addressed nitrogen levels in the estuary but we are also supporting other projects to address the levels of inorganic nitrogen from agricultural and waste water treatment sources with our partners in the estuary. The Study has been able to consider the mitigation measures proposed for the Taw Torridge Estuary and the feasibility of their implementation within the MUs. This is documented in Table 8.1.

To achieve Good Ecological Potential, we and our estuary management partners, need to address the requirements of the WFD. We plan to do this by integrating WFD improvements into our potential management options.

### How have we ensured that the WFD is integrated?

Our internal specialists held a WFD workshop in March 2012. The aim of the workshop was to review the pressures on the estuary and potential mitigation measures proposed. It was agreed that the following pressures hindered the WFD aspirations for the estuary:

- **Shoreline reinforcement / bank reinforcement** against erosion, which lock up sediment otherwise available to the estuary system i.e. sediment retention; and
- **Manipulation of sediment transport** - structures that interrupt and stall sediment transport (e.g. rock armour around Crow Point) i.e. sediment traps

We have ensured that our potential options contribute to addressing these issues and avoid adding to the problem as is shown in Table 8.1. This will assist in achieving Good Ecological Potential for the estuary by 2027.

We have also considered previously proposed mitigation measures identified by previous estuary studies, policies and workshops not associated with our current study. These are detailed below along with how the potential management options given in Chapter 4 will help to achieve them.

We have also ensured that we have had regard to other waterbodies in the Study Area when selecting the potential management options for each of the management units and also in relation to the wide estuary. Table 8.2 details the results of this.

*Table 8.1 – Review of currently proposed WFD mitigation measures for the Taw Torridge Transitional Waterbody*

WFD Pressure	Potential Impact	Relevant SW RBMP Mitigation measure	Potential Contributing MU
Shoreline Reinforcement / bank reinforcement	Shoreline, or flood defences, can encroach on the intertidal zone thus reducing the amount of intertidal area.	<b>Management realignment of flood defence</b> – this measure is already partially in place as some sites have already been allowed to breach e.g. at Annery Kiln, Chivenor Base, Landcross and Pillmouth Marsh. This study has identified that managed realignment could also be feasible in the habitat Priority Sites identified in Appendix C	MU11 Weare Barton, MU12 Halfpenny Bridge, MU13 Salterns, MU20 Tapeley Park (Salterns), MU21 South Yeo, MU23 Yelland (Instow Barton), MU24 Fremington (Home Farm Marsh), MU26 Hollowcombe (Penhill), MU28 North of A39, MU29 South of A39, MU30 Shorleigh Bridge, MU31 Tawstock Park, MU32 Tawstock, MU33 Overton (Tawstock), MU35 Chestwood, MU36 North Chestwood, MU37 Rumsam, MU42 Pottingham, MU43 Chivenor, MU45b Horsey Island
	Structures can also prevent the intertidal zone moving landward in response to wider coastal changes, causing coastal squeeze and a further reduction in intertidal area.		
	In addition, these structures could lead other negative impacts on the estuary such as: <ul style="list-style-type: none"> <li>the disruption of tidal flow and channel interactions;</li> <li>disruption or alteration of estuarine process dynamics;</li> <li>modification of sediment dynamics;</li> <li>disruption of natural habitats and</li> <li>the loss of faunal nursery, refuge and feeding areas.</li> </ul>	<b>Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution</b> – the study has considered this measure for all of the Management Units. However; we have concluded that there is no situation where it would be justified or necessary to replace hard reinforcements with soft engineering solutions.  <b>Restore / create / enhance aquatic and marginal habitats</b> – (Now listed as two separate mitigation measures: Preserve and where possible enhance ecological value of marginal aquatic habitat, banks and riparian zone; Retain marginal aquatic and riparian habitats [channel alteration]) – we have identified the MUs where regulated tidal exchange could occur which would allow intertidal habitat to be created without removing important infrastructure.	MU 18 Pillhead (Salterns) MU 27 Sticklepath
Manipulation of sediment transport	The potential impacts from the manipulation of sediment transport in the estuary are: <ul style="list-style-type: none"> <li>changes in flow,</li> <li>changes in the wave energy or direction,</li> <li>changes in the water quality resulting from changes in flows,</li> <li>direct or indirect habitat loss and;</li> <li>disruption of habitat continuity or connectivity.</li> </ul>	<b>Removal of Structure</b> —Crow Point has been identified as a location where the rock armour could be removed to create an area of intertidal habitat and also remove material in the estuary which may be affecting the sediment transport routes in the estuary. However by doing this we could increase flood risk and therefore we need to undertake a detailed assessment of this proposal to ensure that it is feasible.  <b>Modify structure design</b> – Changes have been made at Instow in the last couple of years to reduce the loss of sand from the waterbody onto the road.  <b>Restore / create / enhance aquatic and marginal habitats</b> - this measure is discussed above.	MU46  none

*Table 8.2 – Waterbodies within the Taw Torridge Study Area and influence of WFD considerations. Source of data is the South West RBMP (Environment Agency, 2009)*

Waterbody name and ID <sup>1</sup>	Waterbody category	Hydro-morphological designation	Current Status / Potential	Predicted Status / Potential	Relationship to the study
<b>Bideford Bay</b> GB610807240000	Coastal	Not designated	Moderate Status	Good Status by 2027	There may be an increase in tidal prism around the mouth of the estuary resulting from the proposed management options. This is likely to be gradual allowing the bay to adapt. Bideford Bay is classed as moderate at present because of the levels of phytoplankton.
<b>Barnstaple Bay</b> GB610807680003	Coastal	Not designated	Good Status	Good Status by 2015	
<b>Taw Torridge</b> GB540805015500	Transitional	Heavily modified water body	Moderate	Good Potential by 2027	Covers the entire study area as it is defined by the tidal limit of the estuary. Refer to Table 8.1.
<b>River Caen</b> GB108050020010	River	Not designated	Moderate	Good Status by 2027 <sup>2</sup>	The River Caen runs adjacent to MU 45a. The study outcomes will not affect the classification of the waterbody nor affect any mitigation measures proposed to improve its status by 2027.
<b>River Yeo (Bideford)</b> GB108050014400	River	Not designated	Moderate	Good Status by 2015	MU 6 is the tidal limit of the estuary into the River Yeo. The proposed management approach is to continue to allow tidal inundation into the river. Abstraction is the pressure in this water body which is being investigated. The study will not affect this.
<b>Torridge Tidal</b> GB108050014500	River	Not designated	Moderate	Good Status by 2027	MU 4 contains this waterbody which is failing on phosphate levels.
<b>Horwood Stream</b> GB108050014510	River	Not designated	Good	Good by 2015	MU18 incorporates this waterbody Management option for this MU is RTE. If this occurs it will need to be assessed to ensure that it does not reduce the status of this waterbody
<b>Taw Estuary</b> GB108050014600	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 25' are.
<b>Torridge Tidal</b> GB108050014550	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 21' are.
<b>Torridge Tidal</b> GB108050014570	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 22' are.
<b>Taw Estuary</b> GB108050020000	River	Heavily modified waterbody	Moderate	Good 2027	by This waterbody runs through MU45a. There is a known morphological pressure on this waterbody causing an observed biological impact. Currently uncertainty surrounds the effectiveness of any mitigation measure to reduce impact.
<b>Knowl Water</b> GB108050020020	River	Not designated	Moderate	Good 2027	by This waterbody runs through FC44 and is moderate because of fish. Further investigation is required.
<b>Taw Estuary</b> GB108050014610	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 25' are.
<b>Bradiford Water</b> GB108050020040	River	Not designated	Good	Good 2015	by This waterbody runs through MU42 where it is proposed to maintain the existing defences until 2062. This is unlikely to be an effect on the waterbody. There is a potential for habitat creation in this MU which could impact on the waterbody so an assessment will be required to ensure that there is no negative impact.
<b>Yeo (Barnstaple)</b> GB108050019990	River	Not designated	Moderate	Good 2015	by Runs through MU40. Further investigation needed to confirm whether abstraction is leading to moderate status.
<b>Taw Estuary</b> GB108050019980	River	Heavily modified waterbody	Good	Good 2015	by Potential upgrading works which are to be reviewed in 2032 MU39 will have to be assessed to ensure that the waterbody status is not reduced
<b>Taw Estuary</b> GB108050014590	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 28' are.
<b>Venn</b> GB108050014620	River	Not designated	Moderate	Good 2027	by Runs through MU34. Source of zinc which is causing the moderate status is unknown.
<b>Taw Estuary</b> GB108050014580	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 30' are.
<b>Taw Estuary</b> GB108050014540	River	Not designated	Moderate	Good 2027	by It is unknown what the pressures on this waterbody which runs through MU 33' are.
<b>Taw River</b> GB108050014530	River	Not designated	Moderate	Good 2027	by Downstream of the tidal limit of the Taw Estuary. Levels of macrophytes, phyto-benthos and phosphate are affecting the status of this waterbody.
<b>Torridge River</b> GB108050014660	River	Not designated	Moderate	Good 2027	by Downstream of the tidal limit of the Torridge Estuary Levels of tributyltin compounds and phyto-benthos are affecting the current status

<sup>1</sup> Details of the locations of the waterbodies are available on the Environment Agency website at: <http://www.environment-agency.gov.uk/homeandleisure/37793.aspx>



## 9. Programme of works/Conclusion

In this section.....

- we show the programme for the potential future works or changes to the management of the Taw Torridge Estuary flood risk management infrastructure and floodplain.

The potential programme of works, depending on the funding available, is indicated in Table 9.1 on the following page. Only minor works and changes to the maintenance regime though application of the maintenance protocol for flood defences, where no properties are at flood risk, are proposed by 2022. Most of the later works will need to be reviewed to confirm the need before progressing to a project level assessment.



*Bideford – Outside Torridge District Council Offices*

In summary, FCRM works are potentially required within the next 10 years (subject to attracting funds) in 5 MUs. These FMUs all have significant assets to protect and either a low standard of protection, or defences in a poor condition, at one or more locations. All except Bideford Right Bank are likely to have benefit cost ratios which would attract some public funding. All would be likely to require other funding contributions. Similar numbers of property are at risk in each of these MUs in the short term (Appendix E shows more detail).

9MUs are fronted by potentially uneconomic defences that are not preferred sites for habitat creation. Application of the Maintenance Protocol (refer to Appendix E) is recommended. These “defences” are mainly high natural bank.

11 MUs have defences that protect little or no property and have land suitable for habitat creation. We would apply the maintenance protocol to establish if a defence is actually needed, or could be supported by the landowner. If this is not the case we would explore with the landowner the potential to create habitat. The small numbers of property should be considered for individual or very local flood protection schemes if the defences were reduced. Thus they have been identified on the table as potential areas with habitat creation potential, but with the secondary option of changes to the maintenance regime.

A further 11 MUs also have land with habitat creation potential, but realising this opportunity, even with appropriate funding, is unlikely in the short term as it is likely to be economic to maintain the defences until at least 2032. Future FCRM works may even be considered after this time.

Another 11 MUs are likely to provide adequate service in the short term and do not have land suitable for habitat creation. However FCRM works may be justified in the long term once sea level rise has impacted on the standard of protection, and/or their condition has deteriorated to poor or worse.

Table 9.1 – Summary Programme of works (further detail is included in Appendix C)

The following table sets out a potential programme of works. This can be used to target attention to those sites most likely to need either FCRM decisions, or provide a suitable candidate for habitat creation. Both will be dependent on the results of further detailed study and public consultation, especially with statutory bodies and landowners.

MU	Name	Potential action	Possible site for application of maintenance protocol of economic reasons (App B)	Has habitat creation potential for "X" hectares environment	Ownership			By 2022		By 2032		By 2042		By 2062		By 2112	
					Agency	Local Authority	Private	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities
1	Northam Burrows	FCRM works required to protect property at Westward Ho!- Landfill, golf course and a 21 properties - habitat already developing due to regular overtopping	-	-		*	*	Y									
2	Appledore	Low SoP, near shipyard, There are benefits today but unlikely to be viable without partnership funding in the short term. Should be reviewed for potential works in 20 years.	-	-	*	*	*	Y (review with partnership funding)		Y (review with/out partnership funding)							
3	Northam	Low sections of wall - note private defences	-	-			*	Y									
4	Bideford left bank	Should be reviewed by 2042	-	-	*	*	*					Y					
5	Upcott	No managed defence	yes	-			*										
6	River Yeo	Already breached so may be little remaining habitat creation potential with landowner agreement, future few vulnerable properties	-	small			*			Y							
7	Landcross	Potentially withdraw - no remaining habitat potential as already breached to create habitat	yes	-			*										
8	Annerly Park (Kiln)	All properties are located behind a new raised defence	-	-	*		*					Y (review)					
9	Yeo	No managed defence	yes	-			*										
10	Weare Giffard	No managed defence	yes	-			*										
11	Weare Barton	Future project needed as there is some property that may need protecting in the future (but low economic benefit) and habitat creation opportunity with landowner agreement.	-	5.5			*	Y (road)	Y							Y (IPP)	
12	Half Penny Bridge	Does not protect any property, but road would occasionally flood, habitat creation potential - detailed project would confirm relative priorities of management approach.	yes	6	*			Y (road)	Y								
13	Salterns	Private defences - potentially 15ha of habitat creation with landowner agreement	yes	15			*		Y								
14	Hallspill	No managed defence	yes	-			*										
15	Hadlow	No managed defence	yes	-			*										
16	Opposite Pillmouth (Tennacott)	Existing tidal habitat	yes	-			*										
17	Bideford right bank	Low benefits, but potentially low cost viable scheme, low section defence	-	-	*	*	*	Y									
18	Pillhead (Salterns)	Potential for major habitat creation area with landowner agreement, future FCRM works likely to protect road, and property.	-	40		*		Y (road)	Y			Y (IPP)					
19	Westleigh	Already breached to create habitat	yes	-	*												
20	Tapeley Park (Salterns)	Future project needed as there is some property that may need protecting in the future (but low economic benefit) and habitat creation opportunity with landowner agreement.	-	5			*		Y								
21	South Yeo	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.	-	5			*		Y				Y				
22	Instow	Should be reviewed by 2042	-	-	*	*	*					Y (review)					
23	Yelland (Instow Barton)	Low benefits, but potentially low cost viable scheme, private defences where there is 10ha potential habitat creation, properties at risk due to poor condition despite high SoP. High ground behind low	-	10	*	*	*	Y (poor defences)	Y								

MU	Name	Potential action	Possible site for application of maintenance protocol of maintenance for economic reasons (App B)	Has habitat creation potential for "x" hectares	Ownership			By 2022		By 2032		By 2042		By 2062		By 2112	
					Environment Agency	Local Authority	Private	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities	Potential FCRM works	Potential habitat creation opportunities
		defences															
24	Fremington (Home Farm)	Defences in good condition, economic to maintain, but potentially 40ha of habitat with landowner agreement.	—	40	*	*	*		Y								
25	Fremington Pill	Should be reviewed by 2042	-	-	*	*	*					Y					
26	Hollowcombe (Penhill)	LA defences - potentially 25ha of habitat creation with landowner agreement, (8.5ha already identified as immediately feasible by NE) may be able to justify individual property protection by 2112.	yes	25		*			Y								
27	Sticklepath	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.	-	2	*	*				Y	Y						
28	North of A39	Future project needed as there is some property that may need protecting in the future and habitat creation opportunity with landowner agreement.	-	2	*	*	*									Y	Y
29	South of A39	Potentially 5ha of habitat creation with landowner agreement, if not possible potential to withdraw maintenance.	yes	5	*		*		Y								
30	Shorleigh Bridge	Private defences - potentially 1ha of habitat creation with landowner agreement	yes	1			*		Y								
31	Tawstock Park	Private defences - potentially 5ha of habitat creation with landowner agreement	yes	5			*		Y								
32	Tawstock	Private defences - potentially 5ha of habitat creation with landowner agreement	yes	5			*		Y								
33	Overton	Private defences - potentially 25ha of habitat creation with landowner agreement	yes	25			*		Y								
34	Bishops Tawton	Should be reviewed after by 2042	-	-	*	*	*					Y (review)					
35	Chestwood	Private defences - potentially 5ha of habitat creation with landowner agreement	yes	5			*		Y								
36	North Chestwood	Potentially 5ha of habitat creation with landowner agreement, if not possible potential to withdraw maintenance.	yes	0.5	*		*		Y								
37	Rumsam	No properties are at risk but sewage pumping station is likely to need some additional protection in 2112, some habitat potential with landowner agreement.	-	1.3	*				Y								
38	Newport	Should be reviewed by 2042	-	-	*							Y (review)					
39	Coney Gut	Should be reviewed by 2042	-	-	*	*				Y							
40	Barnstaple	Should be reviewed at 2022	-	-	*	*	*			Y							
41	Pilton	Should be reviewed by 2042	-	-	*	*	*					Y					
42	Pottington	Potentially 20ha of habitat creation with landowner agreement, possibly future retreated line of defence, but it would detrimentally affect the freshwater bird reserve at Bradiford Water.	-	20	*				Y					Y			
43	Chivenor	Private defences, (low economic benefit), 50ha habitat potential with landowner agreement, works review for 2032. Natural England has completed a feasibility study. The study proposes to create 23.7ha of salt marsh; 31.9 ha of freshwater habitat (comprising of existing and new reed beds and grazing marsh)	-	50			*		Y	Y							
44	Wrafton	Should be reviewed after 20 years	-	-	*		*			Y							
45a	Braunton Marshes	Generally low defence, isolated properties	-	-	*	*	*	Y									
45b	Horsey Island	Private defences, potentially 82ha of habitat creation with landowner agreement, potential future individual property protection but (low economic benefit).	-	82			*		Y					Y			
46	Crow Point	Potentially withdraw – not a priority site but is of wider interest therefore we have prepared a sheet in Appendix C with further detail	yes	-	*												

This shows us that there is a lot of habitat creation potential in the study area, but all will be dependent on the need, funding and landowner agreement. Relatively little flood defence work is recommended in the short term for only short lengths of defence within the highlighted management units.



# Glossary of terms

Accretes	The accumulating sediments, deposited by natural fluid flow processes, usually related to the coastal accumulation of sands, muds or gravels that extend the line of the coast seawards.
Annual exceedence probability	Annual exceedence probability – i.e. the probability of the event being exceeded in any one year. For example, a flood event with a 0.5% AEP can be equally expressed as a flood which in any given year has a 1 in 200 chance of occurrence.
Air Quality Management Area	Since December 1997 each local authority in the UK has been carrying out a review and assessment of air quality in their area. This involves measuring air pollution and trying to predict how it will change in the next few years. The aim of the review is to make sure that the national air quality objectives will be achieved throughout the UK by the relevant deadlines. These objectives have been put in place to protect people's health and the environment. If a local authority finds any places where the objectives are not likely to be achieved, it must declare an Air Quality Management Area there. This area could be just one or two streets, or it could be much bigger
Biosphere Reserve	Biosphere reserves are areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use. They are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located. Biosphere reserves serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity. Collectively, biosphere reserves form a world network: the World Network of Biosphere Reserves (WNBR). Within this network, exchanges of information, experience and personnel are facilitated. There are over 500 biosphere reserves in over 100 countries.
Calcareous	Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone;
Carboniferous	Period of geological history dating from 345-350M years before present, when the Coal Measures, sandstone, siltstones, limestones and shales were laid down
Coastal squeeze	Occurs where fixed sea defences prevent the natural migration of saltmarsh inland as estuaries become subject to sea level rise
Core strategy	Key compulsory Local Development Document specified in United Kingdom planning law. Every other Local Development Document is built on the principles it sets out, regarding the development and use of land in a Local Planning Authority's area.
Defended floodplain	The floodable area with the defences in place
Dune slacks	The valley or trough between dunes is called a slack
Environmental baseline	A measurement, calculation, or location used as a basis for comparison of environmental features, especially to be able to assess how they change.
Environmental receptor	An environmental element which can be impacted by change.
Environmental Stewardship	Environmental Stewardship is an agri-environment scheme that provides funding to farmers and other land managers in England to deliver effective environmental management on your land.
Geomorphology	The study of the changing landscape
High Level Stewardship	High Level Stewardship agreements are provided by Natural England to landowners and managers to seek the most environmental benefits for wildlife, landscape, the historic environment and resource protection.

Holocene	The more recent of the two epochs of the Quaternary Period, beginning at the end of the last major Ice Age, about 10,000 years ago. It is characterized by the development of human civilizations.
Hydraulic model	Computer simulation programme of a water system
Hydromorphology	The physical characteristics of the shape, boundaries and content of a water body.
Key Stakeholders	Especially influential group that has an investment, share, or management interest in the estuary. Generally a public funded body.
Management units (MU)	We have divided the study area into 46 hydraulically independent management units. (Refer to the Key Plan). These management units are sufficiently large to include the areas that would be potentially flooded during a 0.5%AEP (1;200) year event if any part of the local flood defences failed today. In addition, we have extended the management unit boundary further inland to be confident that we have included the area that could be affected by the future effect of sea level rise on flood risk. Therefore, we set the boundary of the flood management unit as the 10mAOD contour around the estuary.
Marine Conservation Zone	A marine protected area under a number of international and European agreements To protect marine biodiversity from human activities.
Mesolithic	Of or relating to the cultural period of the Stone Age between the Palaeolithic and Neolithic periods, marked by the appearance of microlithic tools and weapons and by changes in the nature of settlements.
Biodiversity Action Plan (BAP)	An internationally recognized program addressing threatened species and habitats and is designed to protect and restore biological systems.
Pleistocene	Of or belonging to the geologic time, rock series, or sedimentary deposits of the earlier of the two epochs of the Quaternary Period, characterized by the alternate appearance and recession of northern glaciation, the appearance and worldwide spread of hominids, and the extinction of numerous land mammals, such as the mammoths, mastodons, and saber-toothed tigers
Priority Site	Priority sites are areas targeted by our proposed management decisions over the next 10 years.
Ramsar	Ramsar site, a wetland protected under the Ramsar Convention.
Riparian	Of or relating to or located on the banks of a river or stream “riparian land”
Rock armour	A loose assemblage of broken stones erected in water or on soft ground as a protection to the land behind.
Sediments	Materials such as shingle, sand, silt and clay, which may be moved about by the waters of the estuary, or be deposited on the bed and shoreline of the estuary
Sinuuous	Characterized by many curves or turns; winding: <i>a sinuous stream.</i>
Strand	Upper limits of the beach or other tidally washed area
Tidal prism	The difference in the volume of an estuary between the mean high and low water spring tide levels
Undefended floodplain	The floodable area if there were no defences in place
Water Framework Directive	The Water Framework Directive (more formally the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) is a European Union directive which commits European Union member states to achieve good qualitative and quantitative status of all water bodies (including marine waters up to kilometre from shore) by 2015. It is a framework in the sense that it prescribes steps to reach the common goal rather than adopting the more traditional limit value approach.

# List of abbreviations

AEP	Annual Exceedence Probability
AOD	Above Ordinance Datum
Defra	Department of Food and Rural Affairs
DC	District Council
CWS	County wildlife site
EIA	Environmental Impact Assessment
FCRM	Flood and Coastal Risk Management
FDGiA	Flood Defence Grant in Aid (UK government funding)
HLS	Higher Level Stewardship
IBA	Important Bird Area
IPP	Individual property protection
LNR	Local Nature Reserve
NPPF	National Planning Policy Framework
RBMP	River Basin Management Plans
RIGS	Regionally Important Geological Site
RSPB	Royal Society for the Protection of Birds
RTE	Regulated Tidal Exchange
MCZ	Marine Conservation Zone
MU	Management unit
NIA	Nature Improvement Area
SAC	Special Area of Conservation
SMP	Shoreline Management Plan
SSSI	Site of Special Scientific Interest
WFD	Water Framework Directive

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# Appendices

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# Appendix A – Figures

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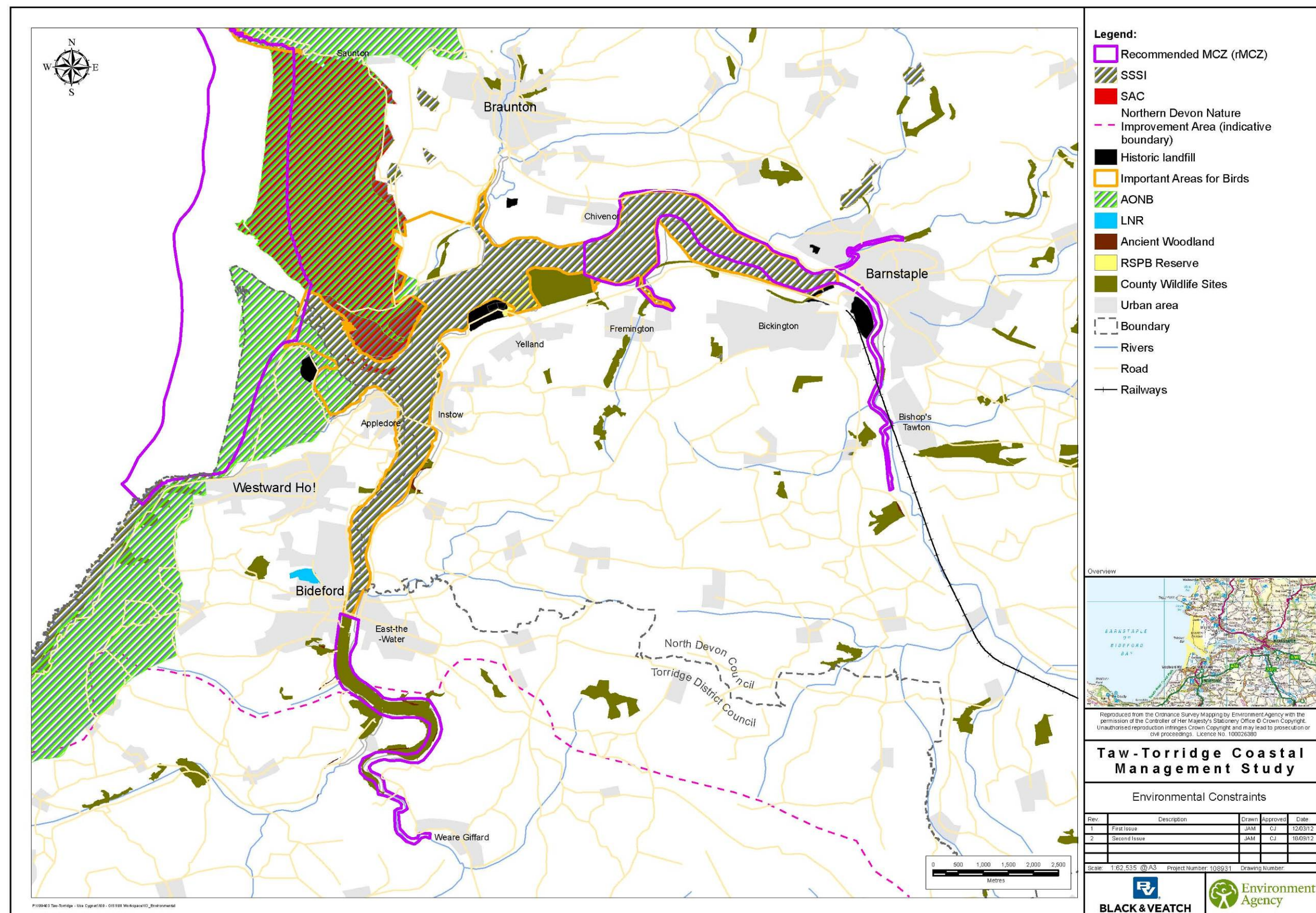


Figure 2 Environmental Constraints Plan (For further detail on individual sites refer to Appendix C)





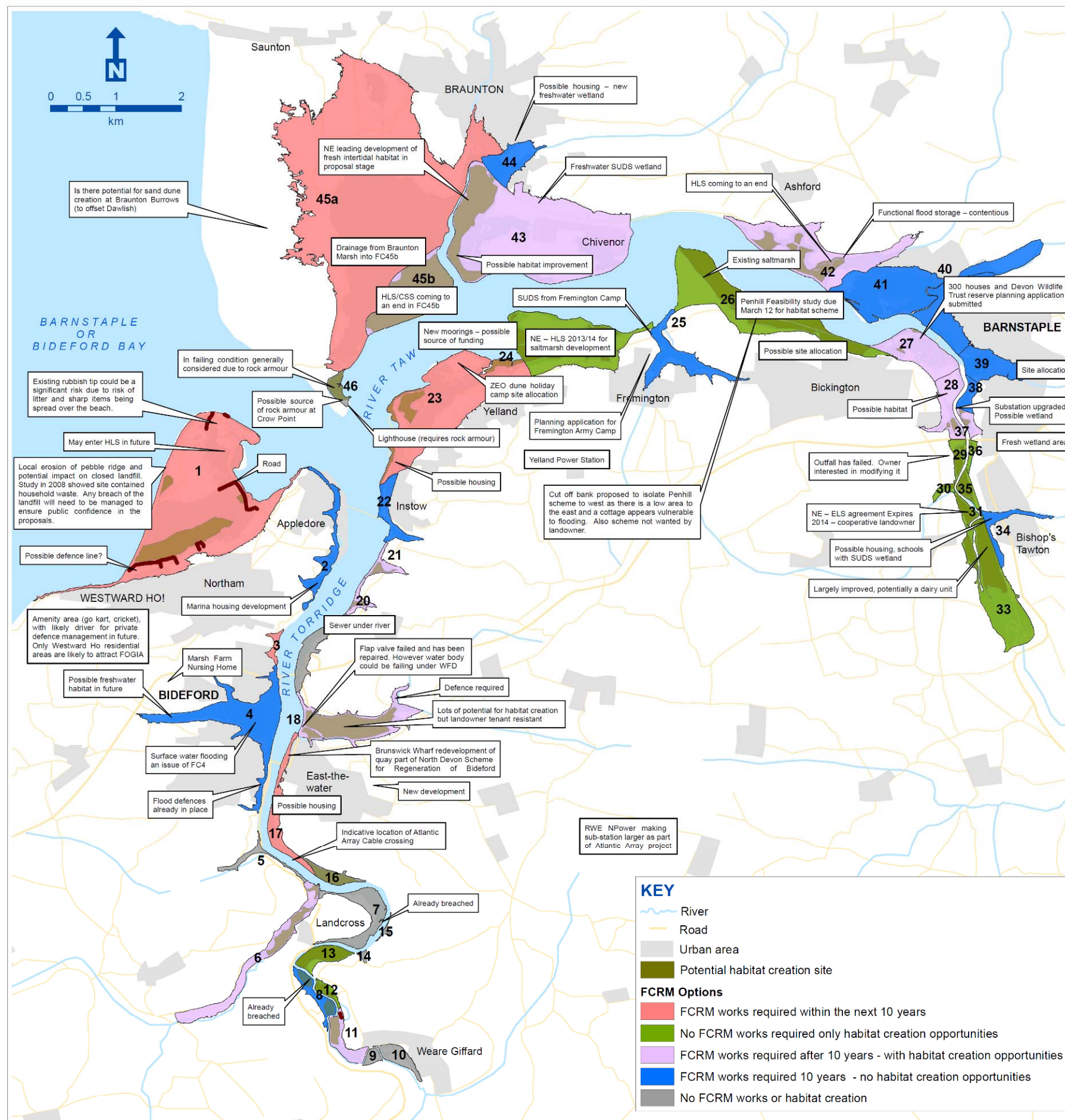


Figure 3 Consultation Plan and proposals - larger version available on request



# Appendix B – List of Consultees



### **External Consultees**

Torrige District Council including the Bideford Harbour Master  
North Devon Council  
Devon County Council (North Devon AONB, Biosphere Service, and Highways)  
Devon County Council Historic Environment Service (HES)  
Natural England English Heritage  
RSPB  
Local Businesses and Residents  
Devon Historic Environmental Record  
Devon Wildlife Trust  
Ministry of Defence for Chivenor and Braunton  
Braunton Internal Drainage Board  
Marine Management Organisation  
Braunton Burrows owners  
Royal North Devon Golf Club  
South West Water (Ashford Treatment Works, Chivenor Pumping Station)  
Holme Farm Marsh  
North Devon Angling  
Various consultees listed in the SMP Appendix B.

### **Internal (Environment Agency) Consultees**

Monitoring and Data (Hydrometry)  
Monitoring and Data (Chemical Appraisal)  
Environmental Management  
Ecological Appraisal (Analysis and reporting)  
Groundwater and Contaminated Land  
Fisheries and Biodiversity (F&B)  
Environmental Planning  
Asset System Management  
Operations Delivery  
Archaeology (NEAS)  
Landscape (NEAS)  
Development & Flood Risk  
Coastal Technical Specialist  
Water Framework Directive contact  
Geomorphology

A stakeholder database is kept by the project team, and managed under data protection legislation.

# Appendix C – Detail of potential Priority Sites

(Only sheets for priority sites included)

The following sheets provide further detail on sites where management decisions are needed within the next 10 years. These decisions have been split into the following on the sheets:

- carry out flood protection works (red); or
- where there are only habitat creation opportunities (green) (these include application of maintenance protocol and revising the defences)
- Sites where flood protection works will be required after 10 years and up to 100 years from today with current habitat creation opportunities (purple).



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# Management Unit 1 – Northam Burrows

FCRM Priority

Key Information				
Size (ha)				
(a) management unit	331			
(b) floodable area (0.5% AEP)	160			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	21	21	0	
(b) defended floodplain (2012)	21	21	0	
Area of agricultural land within the floodable area (ha)	107			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	8,077	2,567	28	5,482
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4 & 5			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Local Authority and private			
Essential infrastructure within floodable area	Electricity sub-station and pumping station			

**There are 21 properties at risk in Westward Ho! at the southern end of the Northam Burrows Management Unit.**

## Existing flood defences

The defences consist of both natural and man-made flood and coastal erosion protection. The natural defences consist of cliffs and a 2.3km long pebbleridge. A seawall provides protection to low lying areas of Westward Ho!. Rock armour has been used to provide coastal erosion protection to the northern end of Northam Burrows, but falls short of protecting the currently eroding section immediately to the east. The ridge frequently breaches. The breach areas migrate and fill in over quite short timescales. Partners have not felt it is a good use of public funds to fill these areas in.

## Potential management approach

The preferred approach recommended by this study is to allow the pebble ridge to evolve and rotate naturally whilst continuing to repair any breaches as far as practical. A new defence is recommended to maintain protection to property in Westward Ho! as the pebbleridge evolves, although there is currently no programme of funding to do this. The landfill and its access track will continue to be protected. Property in Westward Ho! is vulnerable to tidal flooding and coastal erosion as a result of wave overtopping, foreshore erosion, movement and breach of the pebble ridge. The ridge is slowly moving east and the supply of new pebbles from the west is thought to be diminishing due to coastal processes. In future, with sea level rise, the risk of breach is expected to increase.

## Proposed works in the next 10 years

Carry out the protection works on the northern extent of the landfill to contain the already eroding material. Maintain the pebble ridge where breaches occur as far as practical. Extend the rock armour erosion protection at the northern end of Northam Burrows to protect the landfill from erosion (similar alternative to rock may be appropriate). If funding can be raised, promote a scheme to protect properties at Westward Ho! at risk of erosion and tidal flooding if the pebble ridge moves or breaches.

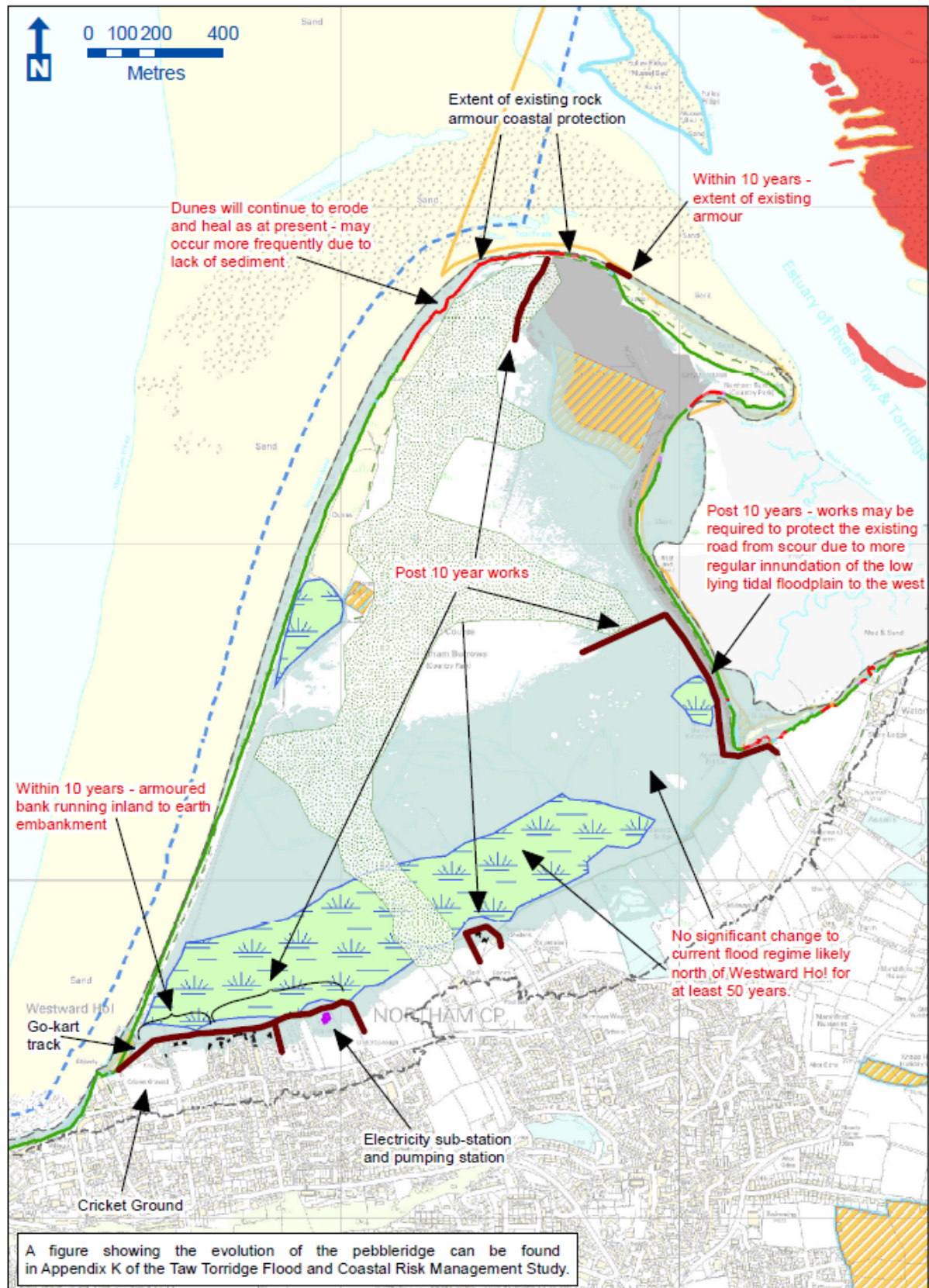
## Natural and Historic Baseline Environment

Northam Burrows is a Country Park and a SSSI and is grazed by horses as common land. The Royal North Devon Golf Club is the oldest links course in England. To the west of the management unit there is a Go-Kart track and cricket ground. There is a historic landfill site at the northern end of Northam Burrows.

## Potential Environmental Constraints, Opportunities and Mitigation

A golf course tee off would be affected as a result of allowing the ridge to naturally evolve as sea level rise. However, there is space to relocate the tee. The new defence to protect Westward Ho! could involve works within the Go-Kart Track and cricket ground. These businesses/clubs will need to be consulted about the proposals. Impacts to the SSSI will need to be reviewed to evaluate whether any important habitats and geological features will be significantly affected.





Key Information				
Size (ha)				
(a) management unit	4.9			
(b) floodable area (0.5% AEP)	1.1			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	8	7	1	
(d) defended floodplain (2012)	8	7	1	
Area of agricultural land within the floodable area (ha)	1.1			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	627	627	0	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3			
Current standard of protection	Varies, Minimum 100% AEP (1 in 1 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	Sewage Treatment Works			

*Approximately 8 properties are at risk around Cleave Quay. The land rises steeply behind, limiting the overall extent of the floodplain behind the defences. The majority of the defences are masonry walls, though there is a short length of natural bank at the northern edge of the flood cell. All the defences are maintained privately.*

## Existing flood defences

627m of raised man made defences which are privately maintained. These consist of a gabion wall, complex wall and masonry wall.

## Potential management approach

The management unit has been identified as a FCRM Priority Site with works potentially required within the next 10 years. There are two sections of defence which appear to be low according to the level data which is mainly influencing its categorisation. However; further investigation may show that the defences have a longer life span than 10 years.

## Potential Works in the next 10 years

New detailed level survey data obtained and if required the masonry wall, which is low, may be raised.

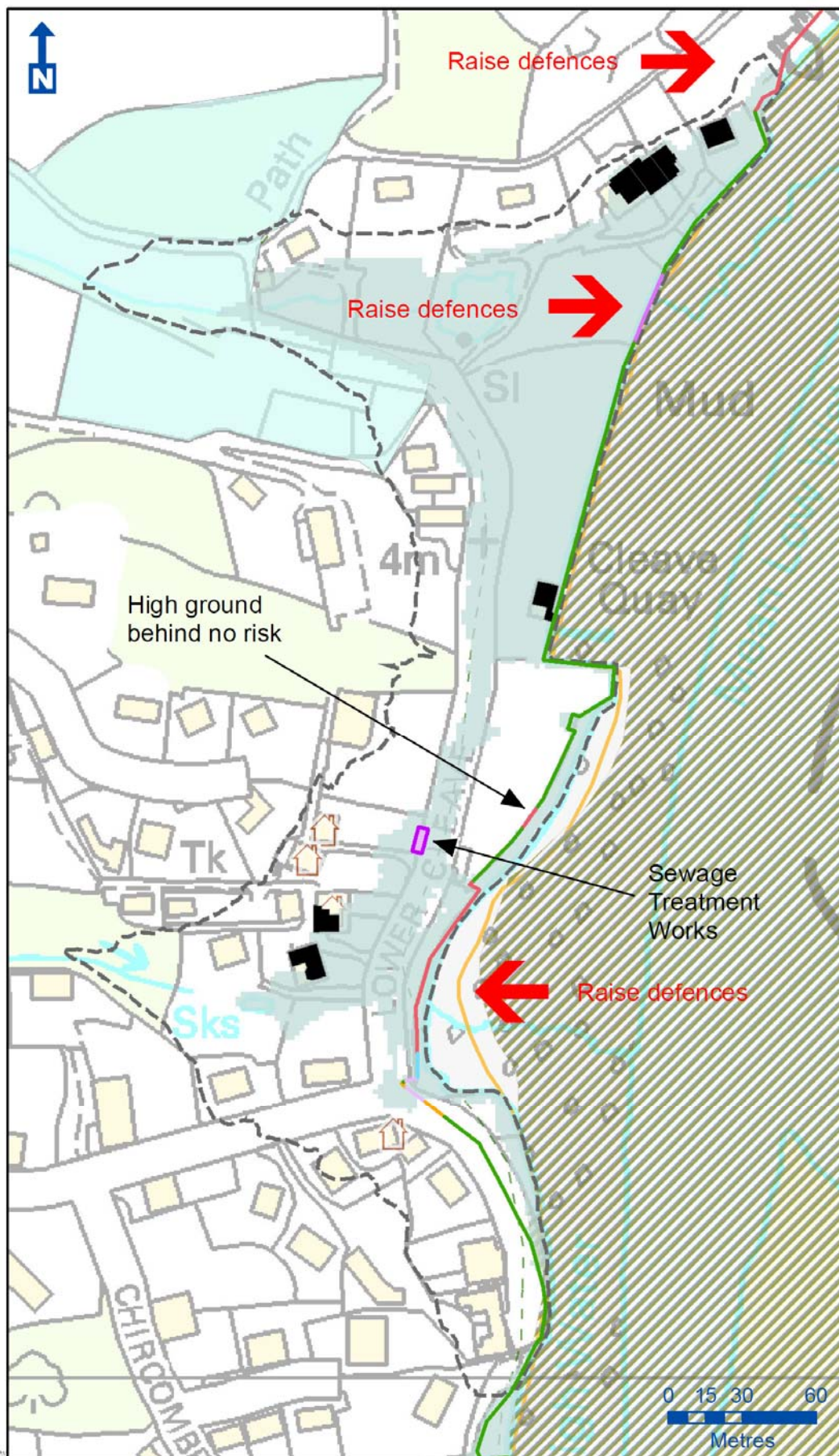
## Natural and Historic Baseline Environment

Northam is a small town lying north of Bideford. Cleave Quay is a small quay for recreational moorings. Northam is thought to have been the site of an Anglo-Saxon castle.

## Potential Environmental Constraints, Opportunities and Mitigation

The proposals to repair or upgrade the low defences are unlikely to result in any environmental impacts which cannot be mitigated by appropriate design and construction management. These details would be identified during an EIA process. Holding the defence line in this location will mean that the properties and any unknown archaeology will be protected.





# Management Unit 6 – River Yeo (Bideford)

Not FCRM Priority  
Habitat Creation

Rk Key Information				
Size (ha)				
(a) management unit	49			
(b) floodable area (0.5% AEP)	21			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	3	3	0	
(b) defended floodplain (2012)	0 (5 residential in the future)	0	0	
Area of agricultural land within the floodable area (ha)	10			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	15	15	0	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3 & 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

*There are no properties at risk from tidal flooding at the present time, they are successfully protected. However, as a result of sea level rise, 5 properties (all residential) are at risk in the medium term. The management of the defences in this Management Unit have already changed to allow some habitat creation. There are potentially further habitat creation opportunities further inland along the tidally influenced River Yeo.*

## Existing flood defences

The majority of the defences adjacent to the River Torridge within this management unit are no longer classified as flood defence structures as they have been breached, creating new habitat. This applies to a 205m length of embankment which was reclassified in February 2011 to a non-flood defence structure. There is only 15m of actual hard raised defence within this management unit, which is associated with a bridge abutment for the disused railway line (now the Tarka Trail).

## Potential management approach

The preferred approach is to continue to allow tidal inundation to increase the potential for a small amount of intertidal habitat creation with the landowner's agreement. The five properties vulnerable in 2062 under current climate change predictions may require individual property protection to manage flood risk in the medium term.

## Proposed works in the next 10 years

None

## Natural and Historic Baseline Environment

The Management Unit is situated on a meandering section of the River Yeo where it joins the Torridge Estuary. Much of the north eastern section of the unit is already saltmarsh habitat. The Tarka Trail runs underneath the A386 and through woodland in this section and this restricts views to the River Yeo.

A small area of the Torridge Estuary CWS is within the Management Unit and is designated for its estuary and saltmarsh habitat. The Hallsannery CWS is to the north of the unit is an area of parkland. A small area of Heale Wood Ancient Woodland is within the unit however it is unaffected. Salmon have been recorded at Edge Mill on the River Yeo upstream from the potential habitat creation areas.

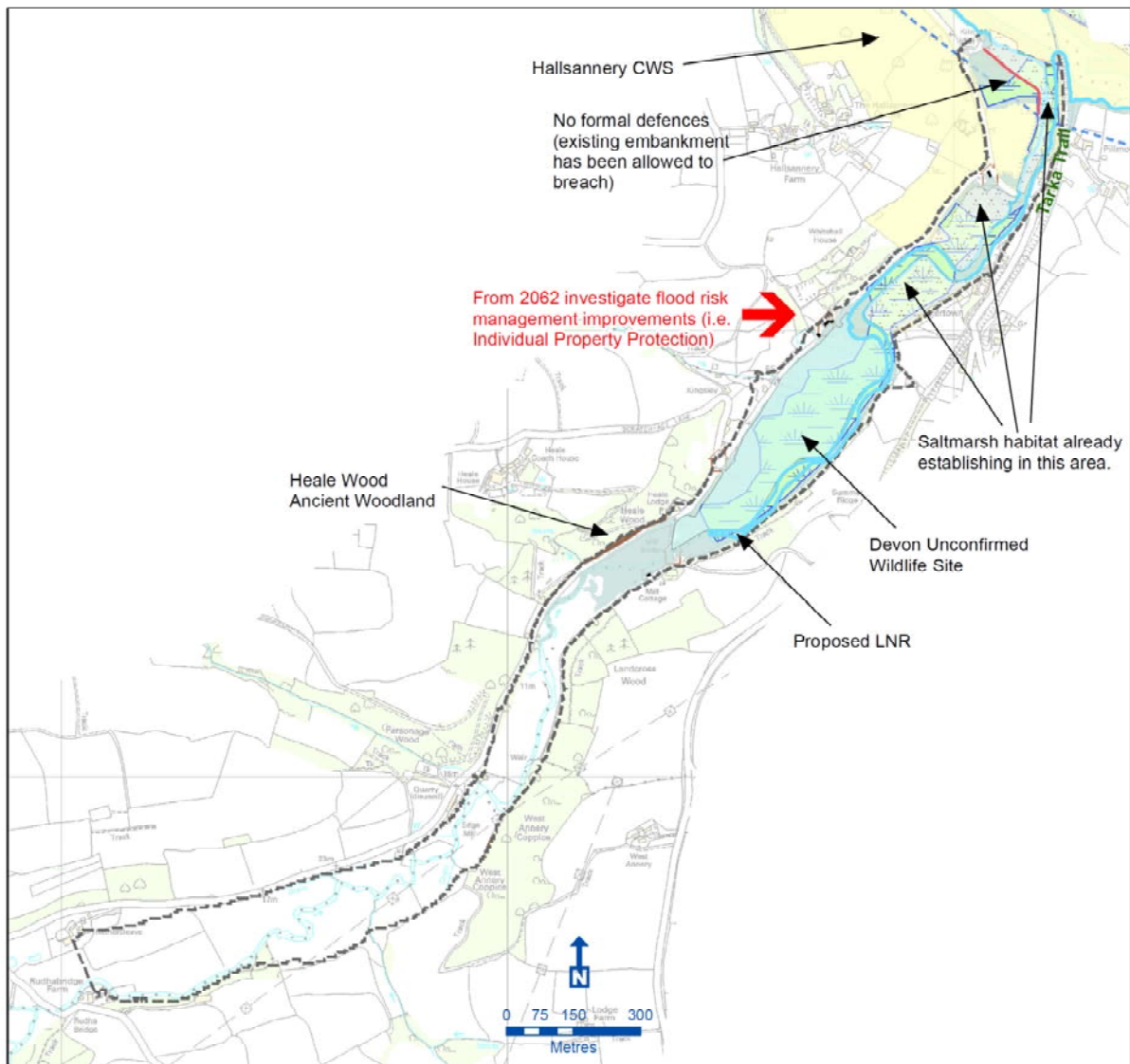
There are 4 Grade II Listed Buildings within the Management Unit which are not affected now or in the future.

## Potential Environmental Impacts, Mitigation and Opportunities

The management option to allow intertidal habitat creation in the unit will benefit the Torridge Estuary CWS by extending the already developing as saltmarsh.

## Management Unit 6 – River Yeo (Bideford)

Not FCRM Priority  
Habitat Creation





# Management Unit 11 – Weare Barton

Not FCRM Priority  
Habitat Creation

## Key Information

Size (ha)				
(a) management unit	18.5			
(b) floodable area (0.5% AEP)	13.8			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0 (3 residential in future)	0	0	
Area of agricultural land within the floodable area (ha)				
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	761	0	761	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Private defences			
Essential infrastructure within floodable area	None			

*This Management Unit is predominantly rural, there are no properties at risk today from a tidal flood event however; with climate change, in the future 3 properties are at risk. This Management Unit is also vulnerable from fluvial flood events.*

### Existing flood defences

The majority of the defences are embankments and are privately maintained.

### Potential management approach

The study has shown that completing flood defence upgrading works to improve the standard of protection is not economically viable as only 3 properties are at risk in the future. The preferred approach is therefore to discuss with landowners stopping/modifying the maintenance of the embankments to allow them to breach to create intertidal habitat and we will assist with the consideration of property level protection by 2112 to protect the properties at flood risk within the management unit.

### Potential works in the next 10 years

A 5.5ha area of habitat could be created if maintenance is stopped and active intervention taken e.g. a breach and possibly new channels with the landowner's agreement. Also, a short length of defence may be required to protect the road if this occurs. The upper end of the site is subject to fluvial floods which will need to be considered in any appraisal of habitat creation options. Also, the landowner has expressed that this approach is unlikely to suit their management plans for the land.

### Natural and Historic Baseline Environment

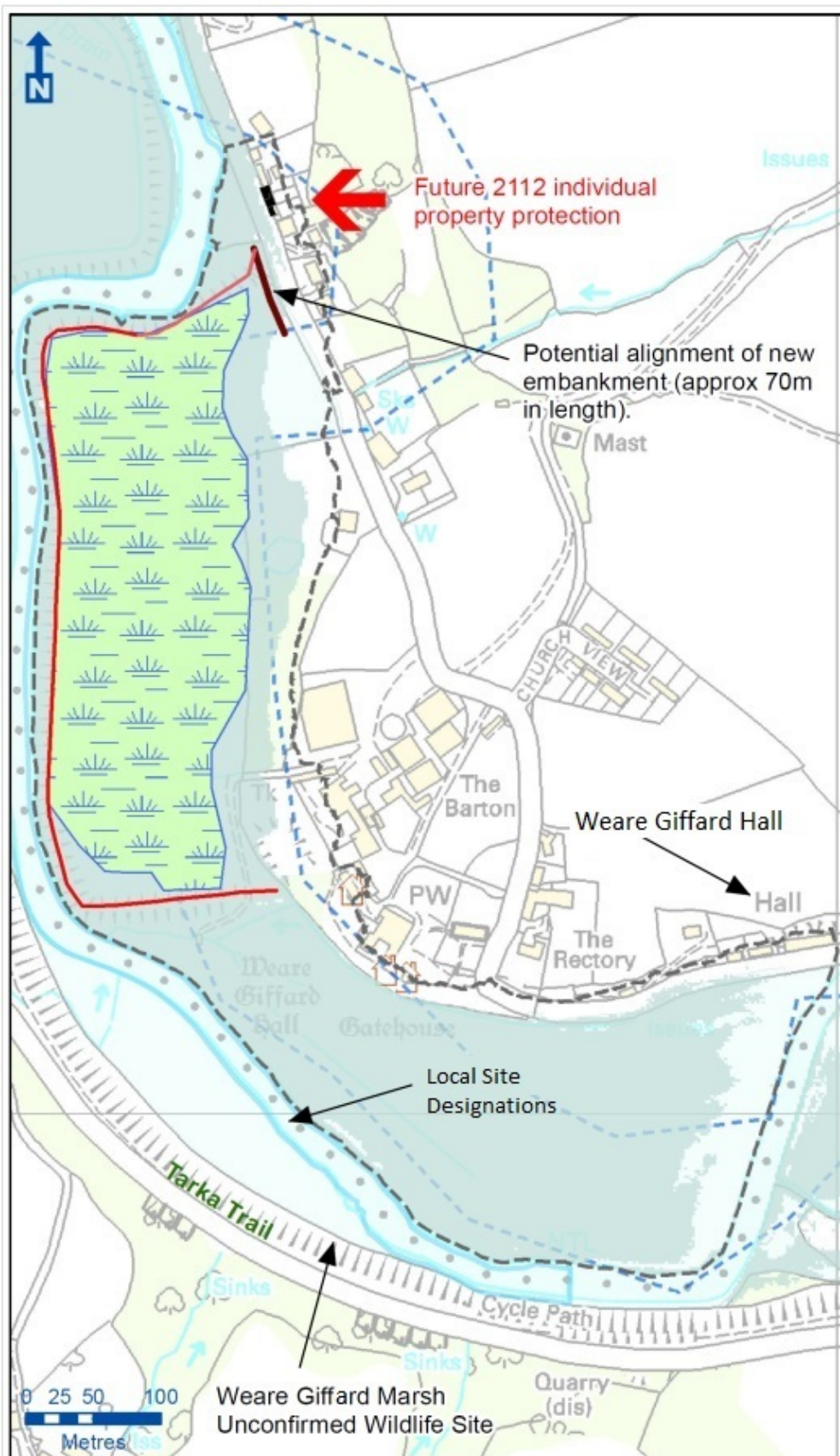
There are 3 listed buildings in Weare Barton associated with the Weare Giffard Hall. The hall was home to the Fortescue Family in 1454 and it is believed that a manor existed on the hall site in Saxon times. The hall is now used as a village hall for Weare Giffard Village which is located further south.

### Potential Environmental Impacts, Mitigation and Opportunities

We believe the listed buildings are outside of the floodable area if the defences are allowed to breach. However, further investigation will be required to ensure that the buildings will not be affected by either fluvial or tidal flooding either now in the future with sea level rise.

There will be loss of Grade 4 agricultural land if intertidal habitat options were pursued. This will need landowner support.

There will be a change in views for the residents of Weare Barton and the Weare Giffard Hall if the pasture field is changed to an intertidal habitat. This will need to be assessed.



# Management Unit 12 – Halfpenny Bridge

Environmental  
Priority Site

Key Information				
Size (ha)				
(a) management unit	6			
(b) floodable area (0.5% AEP)	5.2			
Number of properties at risk	Total	Residential		Commercial
(a) undefended floodplain (0.5% AEP)	0	0		0
(b) defended floodplain (2012)	0	0		0
Area of agricultural land within the floodable area (ha)	5.2			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	493	0	493	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3 & 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Environment Agency			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 6 ha and there are no properties at risk from a tidal/fluvial flood event. The majority of the defences are embankments and are currently maintained by the Environment Agency.*

## Existing flood defences

There are currently approximately 500m of raised man made defences, mostly embankments located adjacent to the River Torridge. No properties are at risk from a tidal event today or in the future.

## Potential management approach

Potential opportunity for habitat creation following application of the maintenance protocol. It is not likely to be economically viable to maintain defences. The defences already have a low crest level and are therefore likely to overtop frequently and therefore intertidal habitat behind the defence may already be forming. The preferred management approach is therefore to investigate the potential to create habitat or withdraw maintenance from the site in consultation with the land owner. The road to the west of the habitat creation area is low enough to flood and may require defending which will add a significant cost. A project should decide the balance of benefit.

## Potential works in the next 10 years

Investigate and explore the habitat creation opportunity with the owners of the land behind the defences and our partners, as up to 3ha area of intertidal habitat could be created.

## Natural and Historic Baseline Environment

Weare Giffard Marsh is an Unconfirmed Wildlife Site as it was assessed to be potentially suitable as the BAP habitat Floodplain Grazing Marsh.

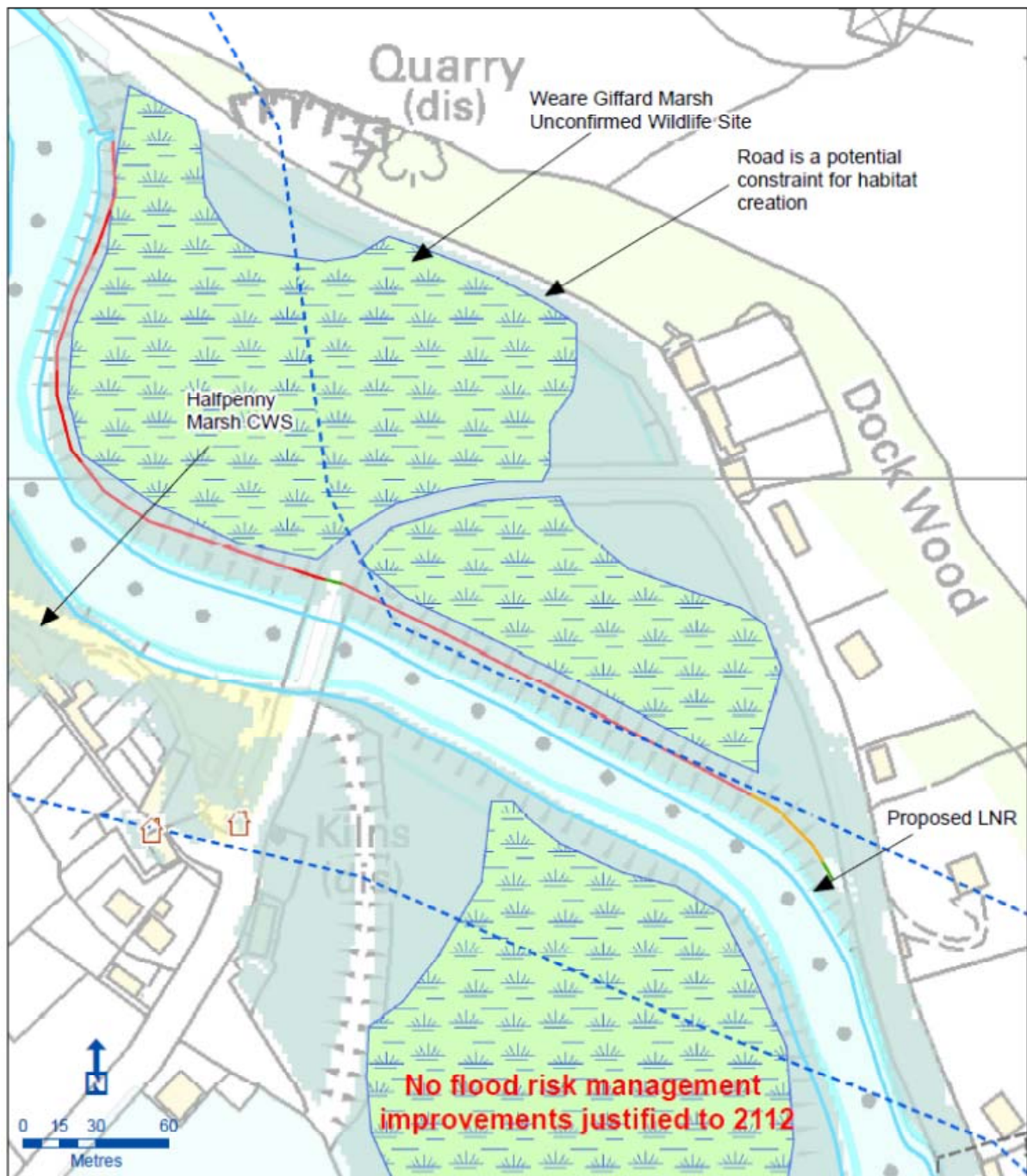
The Weare Giffard Bridge (or Halfpenny Bridge) was built in 1835 to provide an access for the residents of Weare Giffard across the River Torridge

## Potential Environmental Impacts and Opportunities

Allowing the area to flood may create intertidal habitat. However, it would also lead to a loss of coastal and floodplain grazing marsh and Grade 3 sand 4 agricultural land which would require landowner support.

The access road to the Weare Giffard Bridge is high enough so that the bridge can still be used. However, the views from the approach road to the bridge could be altered if the site was allowed to tidally inundate.





# Management Unit 13 – Salterns

Environmental  
Priority Site

Key Information				
Size (ha)				
(a) management unit	19			
(b) floodable area (0.5% AEP)	16.2			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	16.2			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	1,248	0	1,248	0
Worst defence condition	Good			
Agriculture Land Classification	Grade 4			
Current standard of protection	Varies, Minimum 10% AEP (1 in 10 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 19 ha and there are no properties. The majority of the defences are embankments and are privately maintained.*

## Existing flood defences

There is over 1.2km of privately maintained raised embankment along the River Torridge frontage, protecting agricultural land behind.

## Potential management approach

Potential opportunity for habitat creation (15ha) following application of the maintenance protocol. The preferred management approach is to discuss the opportunities with landowners.

## Potential works in the next 10 years

Discuss the above approaches with landowners and explore the environmental and economic benefits.

## Natural and Historic Baseline Environment

The Management Unit is agricultural with pasture fields intersected with hedges. The southern boundary of the fields is bounded by lines of trees which obscure views to the area from the farm to the east and Greenacres house to the south.

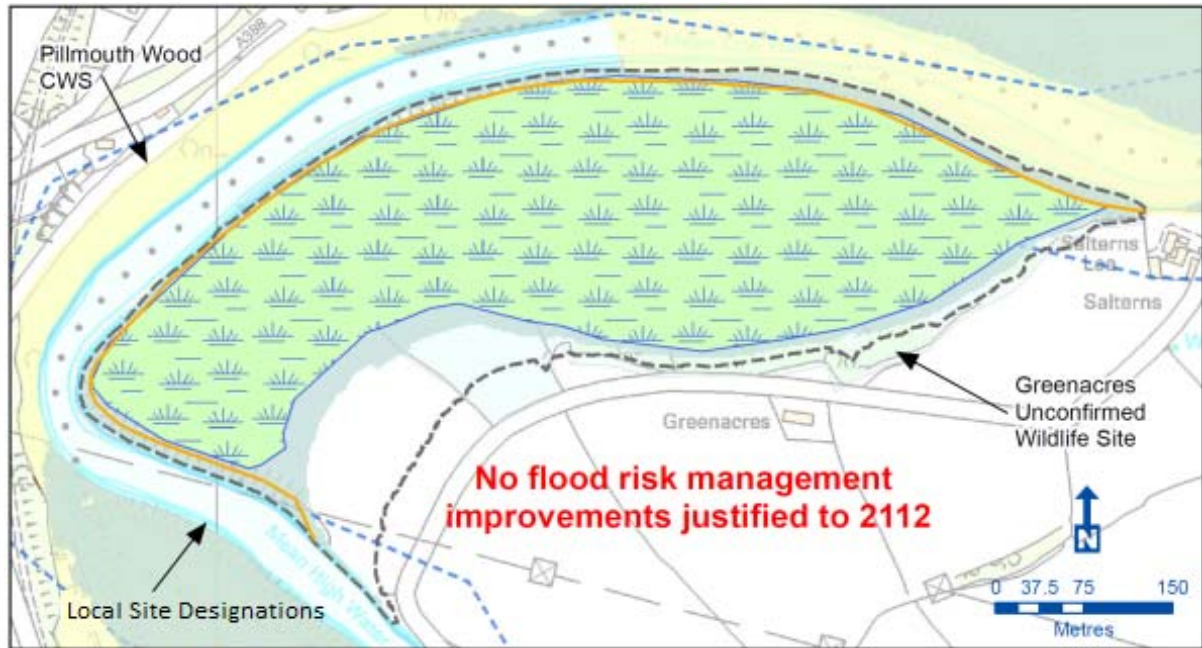
A small section of the Torridge CWS is within the Management Unit designated for its estuary and saltmarsh habitats. Approximately two thirds of the site is also considered as an Unconfirmed CWS (Greenacres) described as brackish grazing marsh with ditches or rough grassland.

## Potential Environmental Impacts, Mitigation and Opportunities

Creation of habitat will lead to a change in the agricultural Grade 4 land and can only be considered in consultation with the landowner who is currently not in a position to cease maintenance of the defence.

Creation of 15ha of habitat could lead to an extension of the Torridge CWS. However, it may also lead to a loss of grazing marsh. The benefits of habitat creation will need to be evaluated a project is progressed. It should be noted though that this site has retained remnants of tidal creeks and rises to higher ground to the south, so offers a site with diverse habitat creation opportunities.





## Management Unit 17 – Bideford Right Bank (East-the-Water)

FCRM Priority

Key Information				
Size (ha)				
(a) management unit	29			
(b) floodable area (0.5% AEP)	17.2			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	12	10	2	
(d) defended floodplain (2012)	12	10	2	
Area of agricultural land within the floodable area (ha)	6.6			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	1816	1004	812	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Local Authority, Environment Agency, Private			
Essential infrastructure within floodable area	None			

*This Management Unit is within East-the-Water and is urban, however; there are only 12 properties at risk in East-the-Water if the defence fail, as the land rises steeply behind the defences. The properties at risk are all situated by Riverside Wharves, which is planned for redevelopment.*

### Existing flood defences

The majority of East-the-Water is protected by raised land tying into a concrete capping beam at Ethelwynne Brown Close Further south there are earth embankment defences, some of which have been set back from the River Torridge channel to provide space for the creation of intertidal habitat.

### Potential management approach

This unit has been identified as a FCRM Priority Site with works potentially required within the next 10 years. There is one section of low defence level adjacent to the car park which appears to be low according to the level data which is influencing its categorisation. However, a level survey check is recommended to confirm this before planning a project.

### Potential works in the next 10 years

New detailed level survey data may be obtained and if required the low wall may be raised.

### Natural and Historic Baseline Environment

The Tarka Trail runs along the western length of the management unit. The south west coast path crosses Bideford Bridge to continue north.

There is a proposed LNR (pLNR) just to the west of the management unit at Seven Oaks. The pLNR will be designated as an LNR, subject to an agreement that makes provision for conservation of the estuarine habitats, including saltmarsh restoration and development of walkways (Torridge District Council Local plan policy BID24). Torridge Estuary CWS is upstream of Bideford Bridge. Potential development of the site at Riverside Wharf/Brunswick Wharf will be supported by Torridge District Council subject to the provision of recreation facilities (e.g. cycle routes and access to existing resources) and good design.

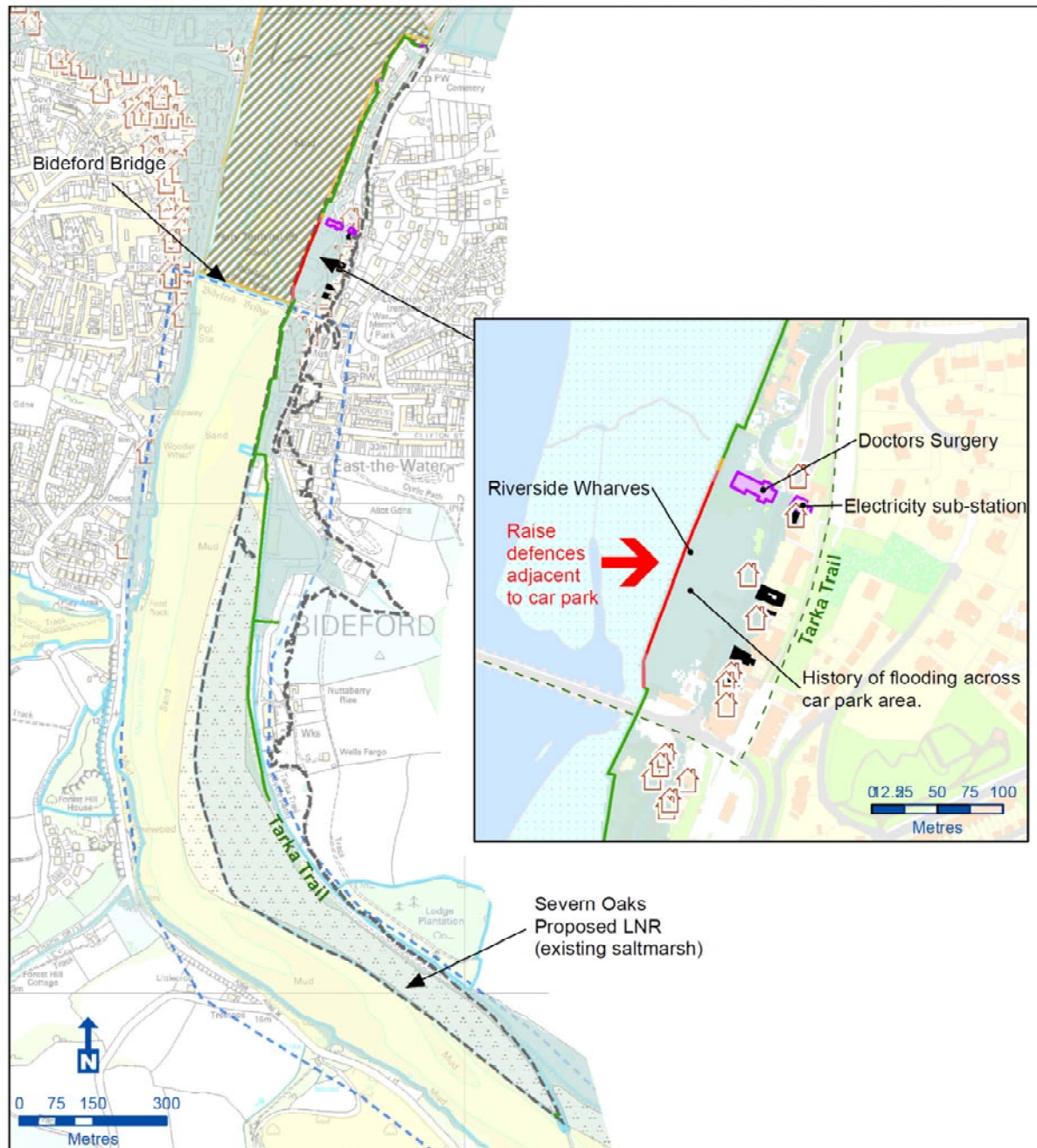
There are a number of listed buildings within the management unit.

### Potential Environmental Impacts, Mitigation and Opportunities

Maintaining the current defences will ensure that the properties, national paths and listed buildings will not be affected. There is an opportunity to work with developer at the Riverside Wharf to ensure that the development is designed to manage flood risk and to upgrade the defences.

# Management Unit 17 – Bideford Right Bank (East-the-Water)

FCRM Priority



# Management Unit 18 – Pillhead (Salterns)

Not current  
FCRM Priority  
IPP

Key Information				
Size (ha)				
(a) management unit	71			
(b) floodable area (0.5% AEP)	52			
Number of properties at risk	Total	Residential		Commercial
(a) undefended floodplain (0.5% AEP)	0	0		0
(b) defended floodplain (2012)	0 (1 residential in long term)	0		0
Area of agricultural land within the floodable area (ha)	52			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	408	0	408	0
Worst defence condition	Good			
Agriculture Land Classification	Grade 2, 3 & 4			
Current standard of protection	Varies, Minimum less than 5% AEP (1 in 20 annual probability)			
Defences managed by	Local Authority			
Essential infrastructure within floodable area	None			

*This Management Unit is predominantly rural and there are no properties at risk at the present time. However, by 2112 this increases to 2 properties at risk. The A386 is a major constraint within the management unit.*

## Existing flood defences

The defences comprise of a 408m long embankment on which the A386 extends, which is a major road into the eastern side of Bideford. There is a small amount of tidal exchange through a flapped outfall which is intended to compensate for habitat loss as a result of the new road construction.

## Potential management approach

No properties are at risk at the present time, however, 2 properties are vulnerable in the future. The A386 road is at risk from tidal flooding at the present time. The preferred management approach is for Torridge District Council to continue maintenance in the short term and potentially consider flood risk management options around the road or individual property protection in the future (2112). There is also significant potential for intertidal habitat creation through regulated tidal exchange beneath the A386 with the landowner's agreement.

## Potential works in the next 10 years

No change in the current maintenance of the embankment. Discuss with landowner the potential for habitat creation opportunity through regulated tidal exchange (RTE) as 40ha area of habitat could be created. The current landowner is unwilling to consider habitat creation.

## Natural and historic Baseline Environment

The Management Unit is agricultural with a small drainage channel running through the fields. The Mount Pleasant Estate is located to the north of the Management Unit.

The Tarka Trail passes to the west of the management unit on the riverward side of the A386 road, which is a primary route in Devon from Plymouth to Appledore.

Pillhead Valley is an Unconfirmed Wildlife Site as it may contain grazing marsh.

## Potential Environmental Impacts, Mitigation and Opportunities

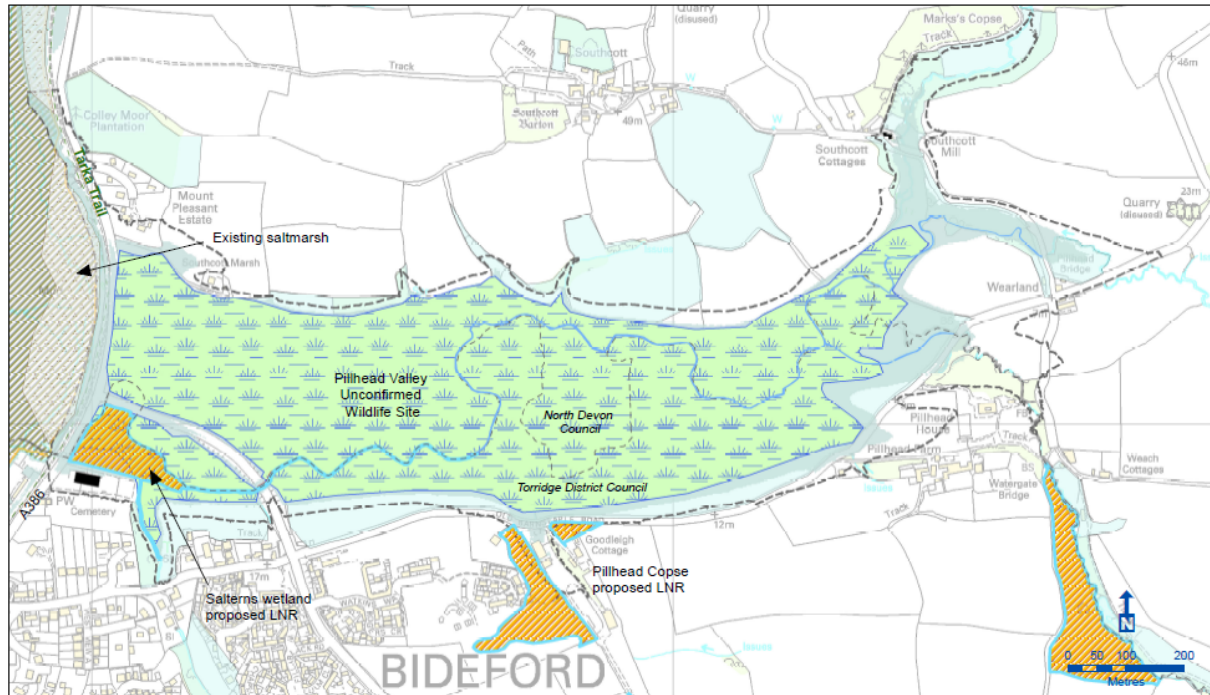
Maintaining the defences will protect the Tarka Trail and road. Allowing water into the Management Unit by regulated tidal exchange will create habitat. However, major works to ensure that the road and recreational value of the defence is not lost will be required.

If habitat creation occurred there would be over a 50% loss of the Grade 2 land and the majority of the Grade 4 land and therefore will require landowner support.



# Management Unit 18 – Pillhead (Salterns)

Not current  
FCRM Priority  
IPP





# Management Unit 20 – Tapeley Park (Salterns)

Environmental  
Priority Site

Key Information				
Size (ha)				
(a) management unit	7			
(b) floodable area (0.5% AEP)	3.1			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	3.1			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	658	0	658	0
Worst defence condition	Good			
Agriculture Land Classification	Grade 3			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

***This Management Unit is predominantly rural and there are no properties at risk at the present time. The majority of the defences are embankments and are privately maintained.***

## Existing flood defences

The majority of the frontage is protected by a private embankment though there is a short length of masonry wall (33m) at the northern extent of the management unit. The embankment and masonry walls are not classified as a flood defence; however they do prevent regular tidal flooding further inland.

## Potential management approach

The potential management approach is to explore the habitat creation opportunity with the landowner. A secondary potential option is to apply the maintenance protocol to establish the most sustainable future for these low value defences. However, there may be a small risk to property in the long term so this should be confirmed by a detailed project at a later date.

## Potential works in the next 10 years

The opportunity for habitat creation could be explored with the landowner. 5ha area of

## Natural and Historic Baseline Environment

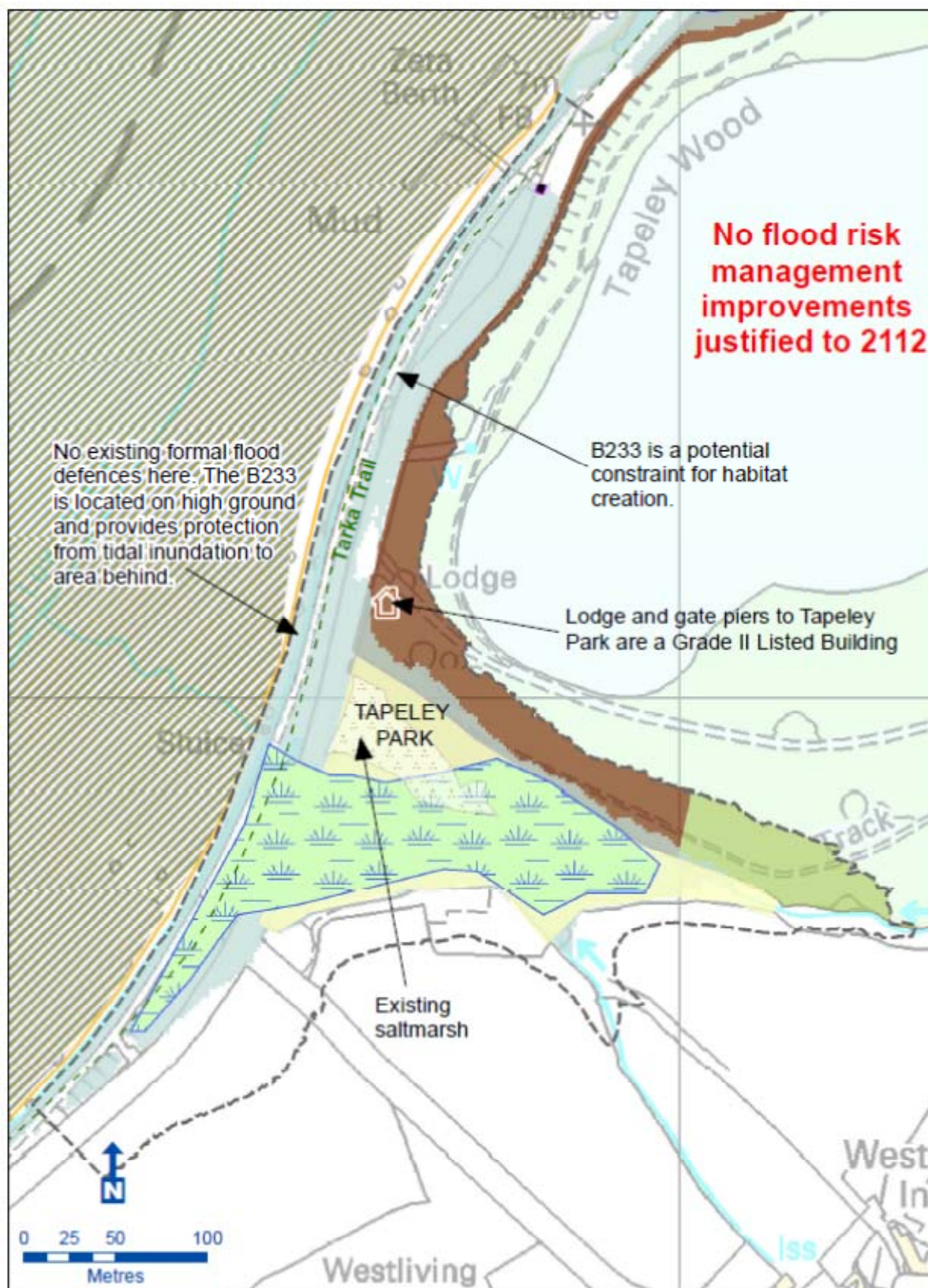
Tapeley Park is a Registered Park and Garden and is part of the Christie Estates. The Stately Home and Gardens are open to the public. The Lodge and Gate piers to Tapeley Park are Grade II Listed Buildings. Tapeley Park House is accessed via a wooded road from the B3233 which runs to the west of the Management Unit. Some of the woodland to the south of the track is ancient woodland.

## Potential Environmental Impacts, Mitigation and Opportunities

If the defences are able to breach to create intertidal habitat, a small area of the ancient woodland and Tapeley Park could become inundated with brackish water potentially leading to adverse impacts. Impacts on the listed building are unlikely but this should be confirmed with detailed study. If habitat is proposed in this location then the woodland and park may require protection.

The potential area to be inundated is within the South Yeo Fields CWS designated for its saltmarsh, tall herb vegetation and semi-improved neutral grassland. The proposed intertidal habitat may complement the CWS but the impacts to the site would need to be explored in detail.

There will be a loss of the Grade 3 Agricultural land which will require support from the landowner.



# Management Unit 23 – Yelland (Instow Barton)

FCRM Priority  
Habitat Creation

## Key Information

Size (ha)				
(a) management unit	184			
(b) floodable area (0.5% AEP)	80			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	12	0	12	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	80			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	3,286	156	3,130	0
Worst defence condition	Poor			
Agriculture Land Classification	Grade 3 and 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency Private and Local Authority			
Essential infrastructure within floodable area	None			

***This Management Unit is approximately 184 ha and approximately 12 properties and an electricity sub-station are at risk now because the defences are in a poor condition.***

### ***Existing flood defences***

A disused earth railway embankment (now the Tarka Trail) forms the flood defence in the east of the unit and is the responsibility of the Local Authority. Currently these defences are assessed as being in 'poor' condition and although the SoP is greater than 0.5% AEP (1 in 200 annual probability) properties are at risk because of the condition of the defences.

### ***Potential management approach***

The preferred management approach is to investigate flood risk management improvements to the length of poor embankment, to improve its condition in the short term. In 2112 several additional properties, including the electricity sub-station, appear to be at flood risk due to sea level rise and the former landfill site may become subject to greater erosive pressure. Both of these risks will need to be evaluated at this time.

### ***Potential works in the next 10 years***

Complete investigation works in partnership with North Devon Council on the length of the poor defences at the eastern end of the site.

Explore the potential to create 10ha of intertidal habitat to the west of the site with the landowner by breaching a section of the defence in the west end of the management unit, with cut off bank to isolate flooded area from the rest of the management unit.

### ***Natural and Historic Baseline Environment***

The Tarka Trail runs across the centre of this management unit overlooking the estuary to the north and Yelland to the south. The North Devon Cricket Ground is situated within the management unit and the Pavilion at the site is a Grade II Listed Building, comfortably outside the floodable area. Land at the east end of the site was the East Yelland Power Station

### ***Potential Environmental Constraints, Opportunities and Proposed Mitigation***

The Tarka Trail could be at risk if the defences in the eastern end remain in poor condition and undertaking repairs will extend the life of the path.

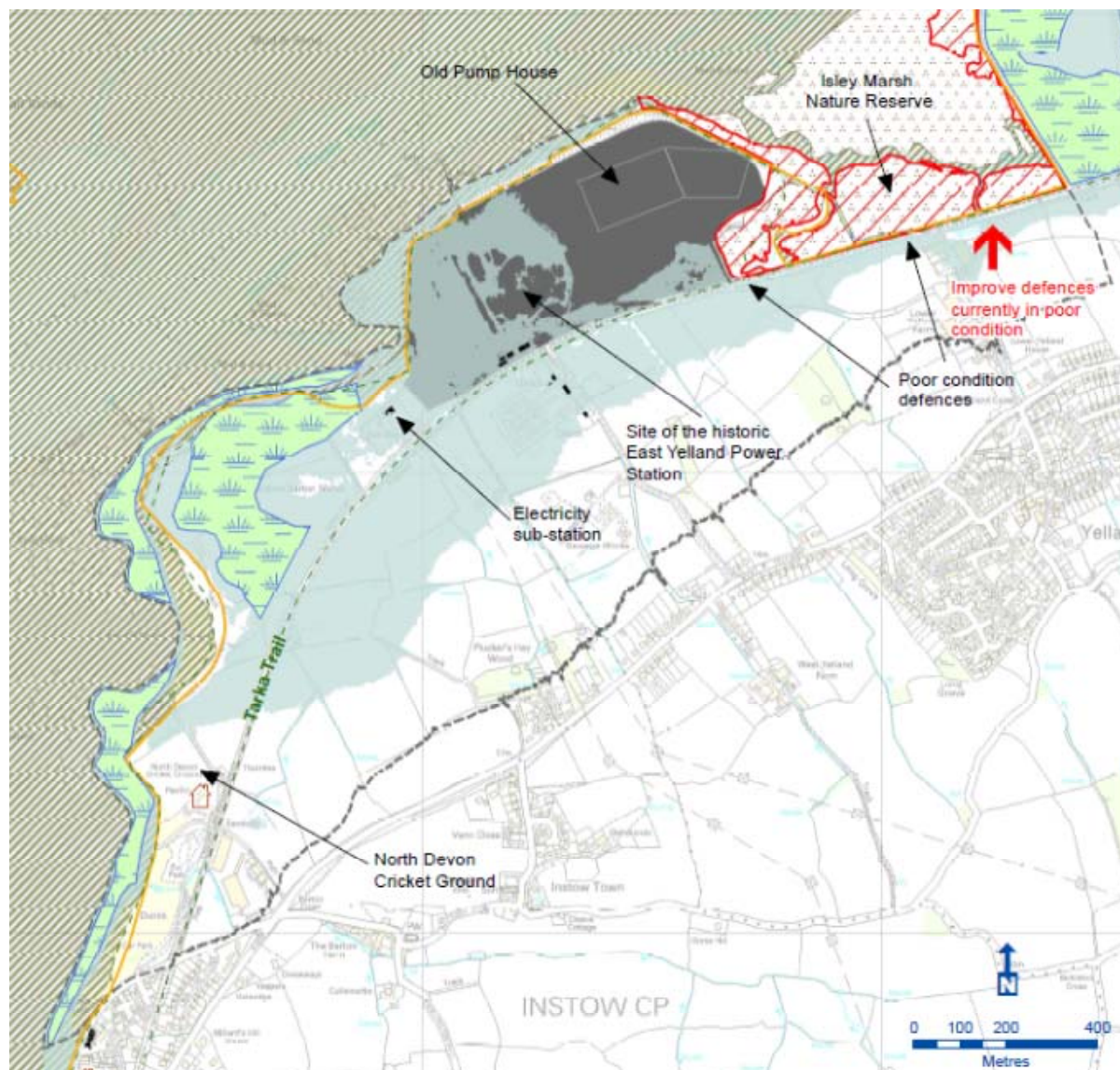
There are some moorings proposed near to the Management Unit and a site allocation for a holiday camp and housing (Refer to Figure 2, Appendix A) which could provide a source of partnership funding.

In the future, consideration will need to be given to the residents affected by flooding due to sea level rise and the potential contaminated land impacts from exposing the cinder and asbestos from the East Yelland Power Station



## Management Unit 23 – Yelland (Instow Barton)

FCRM Priority  
Habitat Creation



# Management Unit 21 – South Yeo

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	9			
(b) floodable area (0.5% AEP)	4.8			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	2	2	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	4.8			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	365	36	329	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3			
Current standard of protection	Greater than 0.5%AEP (1 in 200 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 9 ha and there are no properties at risk now but 2 commercial properties are at risk in the future by 2062.*

## Existing flood defences

The majority of the raised defences consist of earth embankments, though there is also a short length of masonry wall. All the defences are privately maintained with the worst condition assessed as fair.

## Potential management approach

Discuss habitat creation with landowners, if it becomes desirable considering that if the area is inundated that 2 properties may be at risk in 2062 which may require individual property protection by 2062.

## Potential works in the next 10 years

Discuss habitat creation opportunity with landowners– 5ha area of habitat could be created however, it is known that the current landowner is not planning to their land in this way.

## Natural and Historic Baseline Environment

Tapeley Park Registered Park and Gardens is to the south of the Management Unit. Surrounding the parkland is ancient woodland.

2 Listed buildings both unaffected directly: A limekiln on Instow Beach to the north and South Yeo Farmhouse to the east.

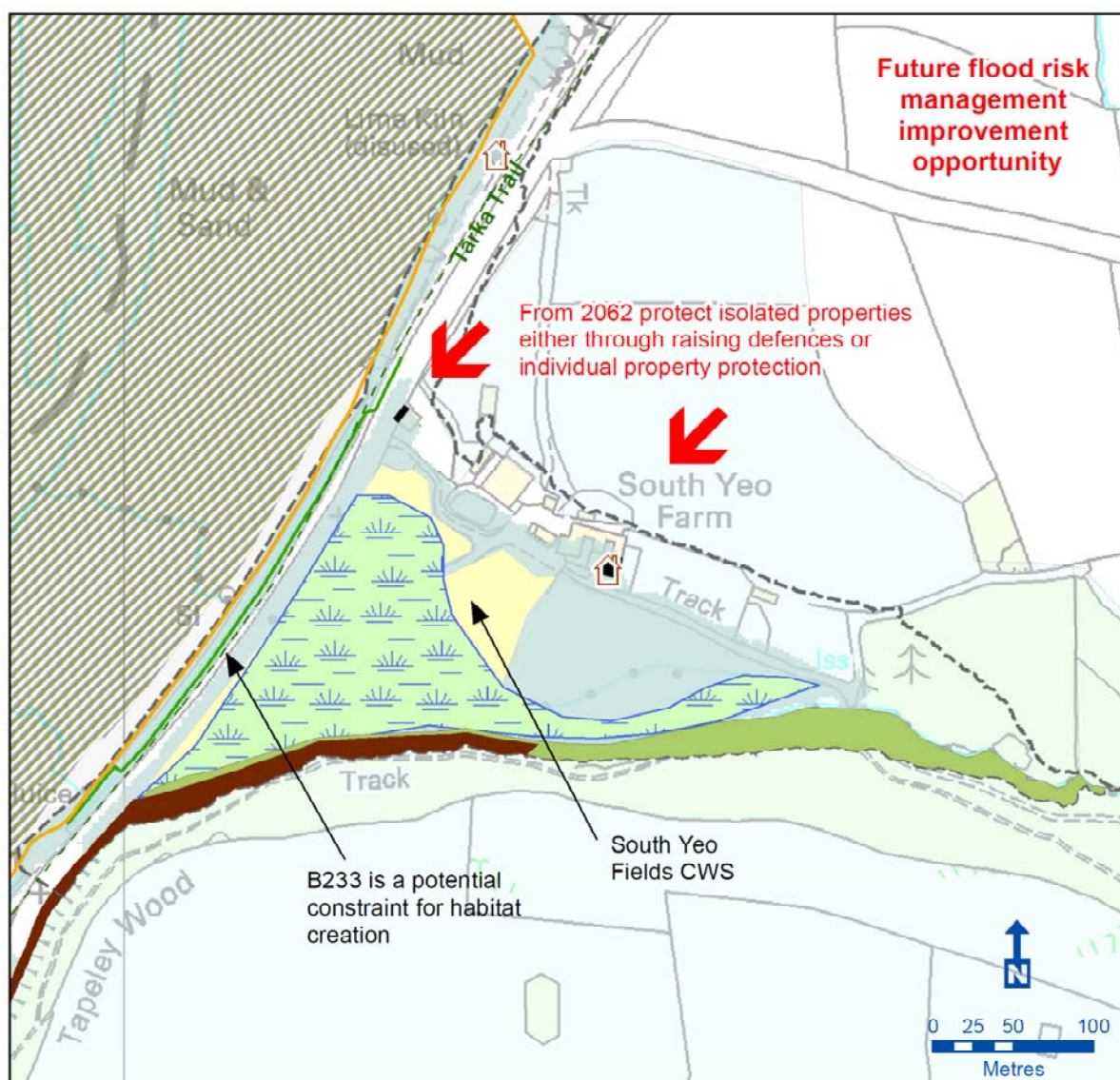
The unit is within the South Yeo Fields CWS designated for saltmarsh, tall herb vegetation and semi-improved neutral grassland

## Potential Environmental Impacts, Mitigation and Opportunities

The South Yeo Fields CWS will be inundated. The proposed intertidal habitat may complement the CWS but the impacts on the site would need to be explored in detail.

If the defences are able to breach to create intertidal habitat a small area of the ancient woodland and Tapeley Park could become inundated with brackish water potentially leading to adverse impacts. If habitat is proposed in this location then the woodland and park may require protection. Similarly the road would need protection.





Key Information				
Size (ha)				
(a) management unit	129			
(b) floodable area (0.5% AEP)	71			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	0	0	0	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	71			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	2,636	162	2,474	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3 & 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency, Local Authority and Private			
Essential infrastructure within floodable area	None			

***This Management Unit is approximately 129 ha and there are no properties. The majority of the defences are embankments.***

### ***Existing flood defences***

The majority of the defences consist of earth embankments of which 2,256m are the responsibility of the Environment Agency and the remaining 218m are privately maintained. There is also a short length of masonry wall (162m) which the Environment Agency maintain. The worst defence condition is fair.

### ***Potential management approach***

Opportunity for creation of 40ha of habitat if appropriate following application of the maintenance protocol as a secondary option to be explored in detail in consultation with the landowners. There are no properties to protect in this floodable area. We would need to monitor the impact on the Tarka trail and potentially protect it.

### ***Potential works in the next 10 years***

There is an opportunity to create 40ha of intertidal habitat.

### ***Natural and Historic Baseline Environment***

Home Farm Marsh is owned by the Gaia Trust who are undertaking low intensity farming to

enhance the biodiversity of the former high intensity dairy unit. The land is in conservation management through a farm tenancy and volunteer support. In 2003, 18.5ha of permanent pasture dominated by native grasses with wetland scrapes and ponds were created at the site

Home Farm Marsh lies between Salt Pill Duck Pond and the RSPB's Isley Marsh Reserve. Home Farm Marsh is a CWS designated for its grazing marsh, arable land, brackish ditches, small areas of saltmarsh and its birds and plant interest.

The Tarka Trail borders the site to the south.

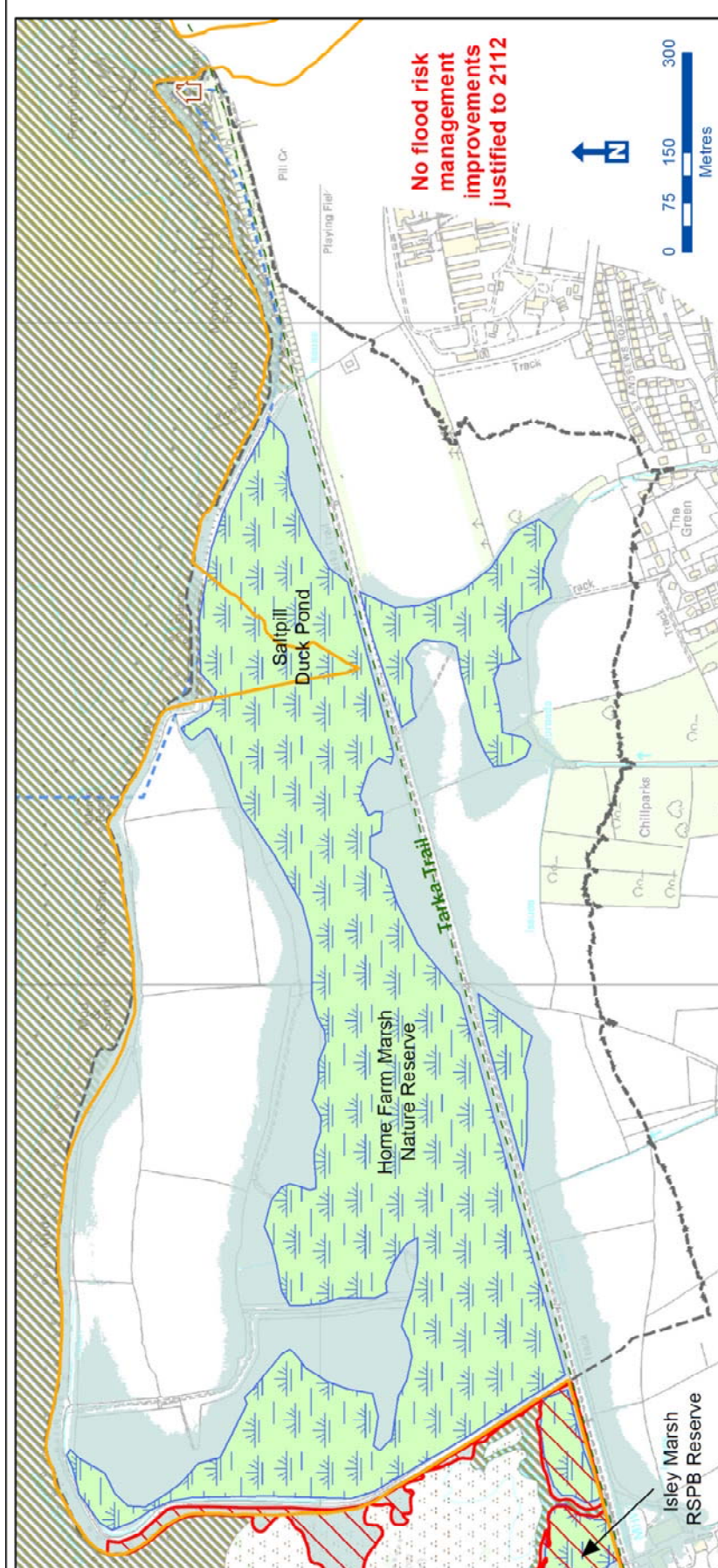
### ***Potential Environmental Impacts, Mitigation and Opportunities***

We will need to investigate impacts to the Tarka Trail if the defences are to be abandoned and undertake sufficient mitigation to retain the access route through this location.

Natural England have a Higher Level Stewardship agreement in place for this site with the Gaia Trust for managing the wet grassland for estuarine bird interest and would support salt marsh creation.

# Management Unit 24 – Fremington (Home Farm Marsh)

Environmental  
Priority Site





# Management Unit 26 – Hollowcombe (Penhill)

Environmental  
Priority Site

Key Information				
Size (ha)				
(a) management unit	145			
(b) floodable area (0.5% AEP)	93			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	30			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	2,222	85	2,137	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 2 & 5			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Local Authority			
Essential infrastructure within floodable area	None			

***This Management Unit is approximately 145 ha in area and there are no properties at risk today, although there will be one property at risk in the future. The majority of the defences are embankments and are maintained by the local authority.***

## ***Existing flood defences***

The Tarka trail extends along the top of the old railway embankment which forms the primary flood defence in this Management Unit and is maintained by the Local Authority. There is also a short section of masonry wall near Fremington Quay.

## ***Potential management approach***

Potential opportunity for habitat creation following application of the maintenance protocol. There are no properties to protect in this floodable area until 2112. Therefore the local authority could review the site and in the future consider individual property protection, although maintenance of the Tarka Trail would by default maintain the defence here.

## ***Potential works in the next 10 years***

Habitat creation opportunity – 25ha area of habitat could be created. Natural England have completed a feasibility study on the site focussing on 8.5ha of potential habitat creation with the full support of the two landowners. The proposals involve opening two culverts to allow unregulated tidal exchange. The culverts will be lined with a concrete pipe to ensure that the Tarka Trail can be maintained. There are power lines across the Management Unit which will require protection or diversion. The next steps for this project are to commission detailed design of the proposals and then construction.

## ***Natural and Historic Baseline Environment***

Behind the Management Unit is a high ridge north of Bickington, which is an area being looked at for growth of Barnstaple with views over the River Taw. The Tarka Trail bisects the management unit.

## ***Potential Environmental Impacts, Mitigation and Opportunities***

Saltmarsh is already present in the Management Unit and therefore any potential creation is limited to landward of the dismantled railway line.

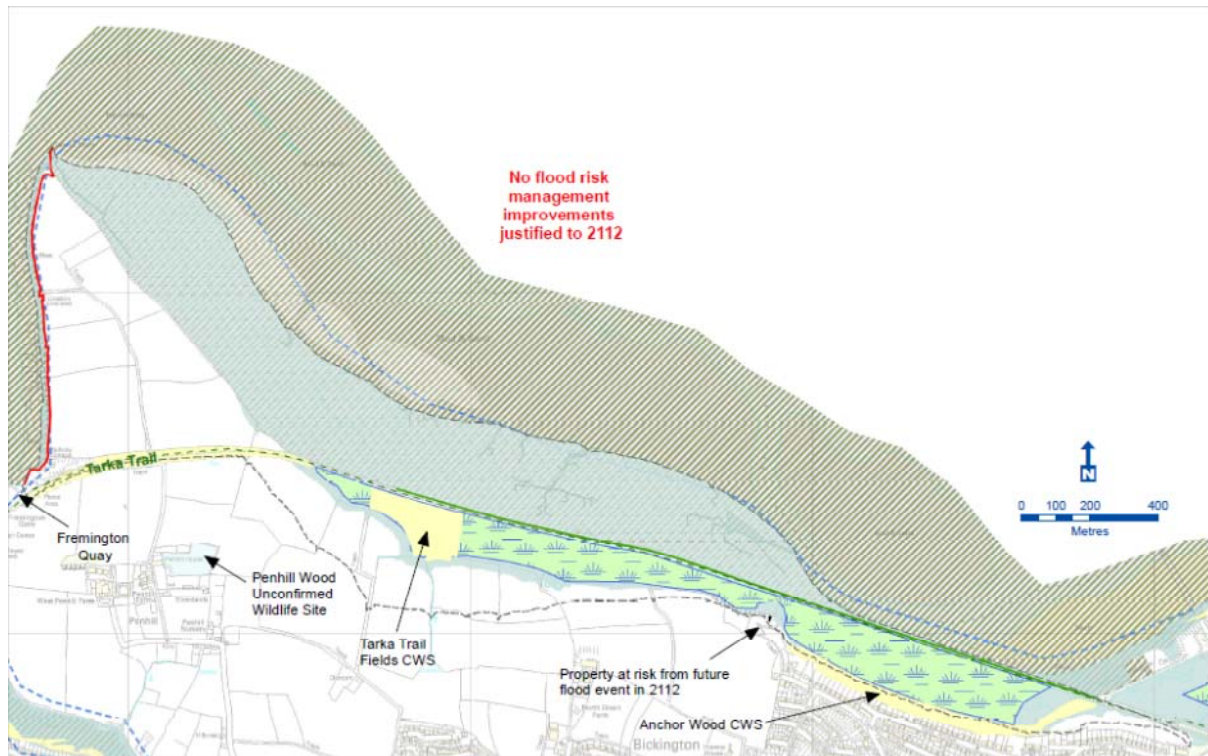
The new intertidal habitat may also cover the Tarka Trail Fields CWS which is designated for its grazing marsh, notable plant species and its network of ditches, some of which are brackish. Allowing this area to flood more frequently could have an impact on the notable plant species which we will have to investigate further. In addition, we will need to consult with the landowners of the agricultural land regarding loss of grazing habitats.

One property is located adjacent to the intertidal habitat creation area which will not be at additional flood risk until 2112 when predicted sea level increases occur. In the short term however, this property would experience a changed landscape towards the river up to the disused railway line. Consideration of landscape changes to any proposed development on the ridge north of Bickerton which is identified as an area for growth would also need to be evaluated in an EIA.



# Management Unit 26 – Hollowcombe (Penhill)

Environmental  
Priority Site



# Management Unit 27 – Sticklepath

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	49			
(b) floodable area (0.5% AEP)	20			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	90	72	18	
(d) defended floodplain (2012)	0 (rising to 73 residential and 24 commercial by 2112)	0	0	
Area of agricultural land within the floodable area (ha)	4.1			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	1,403	491	912	0
Worst defence condition	Fair			
Agriculture Land Classification	NA			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency and Local Authority			
Essential infrastructure within floodable area	Sewage treatment works and 2 electricity sub-stations			

**There are no properties currently at risk within this Management Unit; however by 2112 there will be 97 properties at risk.**

## Existing flood defences

The majority of the defences are embankments and provide a good SoP to properties behind. The defences are currently maintained by the Environment Agency and Local Authority.

## Potential management approach

No management works required today. However, FCRM works will be required in the future to manage the flood risk to 97 properties.

## Potential works in the next 10 years

Explore potential for intertidal habitat creation through regulated tidal exchange. A 2ha area of habitat could be created with landowner agreement.

## Natural and historic environment

The Management Unit was reclaimed in the 18<sup>th</sup> and 19<sup>th</sup> centuries. There is an area of existing saltmarsh to the north of the management unit which is within the Anchorwood Bank CWS notified for its saltmarsh and semi-improved calcareous grassland.

There is a warehouse which was known as the old Slaughterhouse in Station Road which is a Grade II listed building.

The South West Coast Path runs through the management unit crossing the River Taw over Long Bridge.

There are three historic landfill features in the unit:

- Seven Brethren Former Landfill Site
- Taw Wharf
- Land adjacent to Railway Sticklepath Hill

The land to the west of the A36 and north of the A3125 is being considered as a potential freshwater habitat creation site by Devon Wildlife Trust.

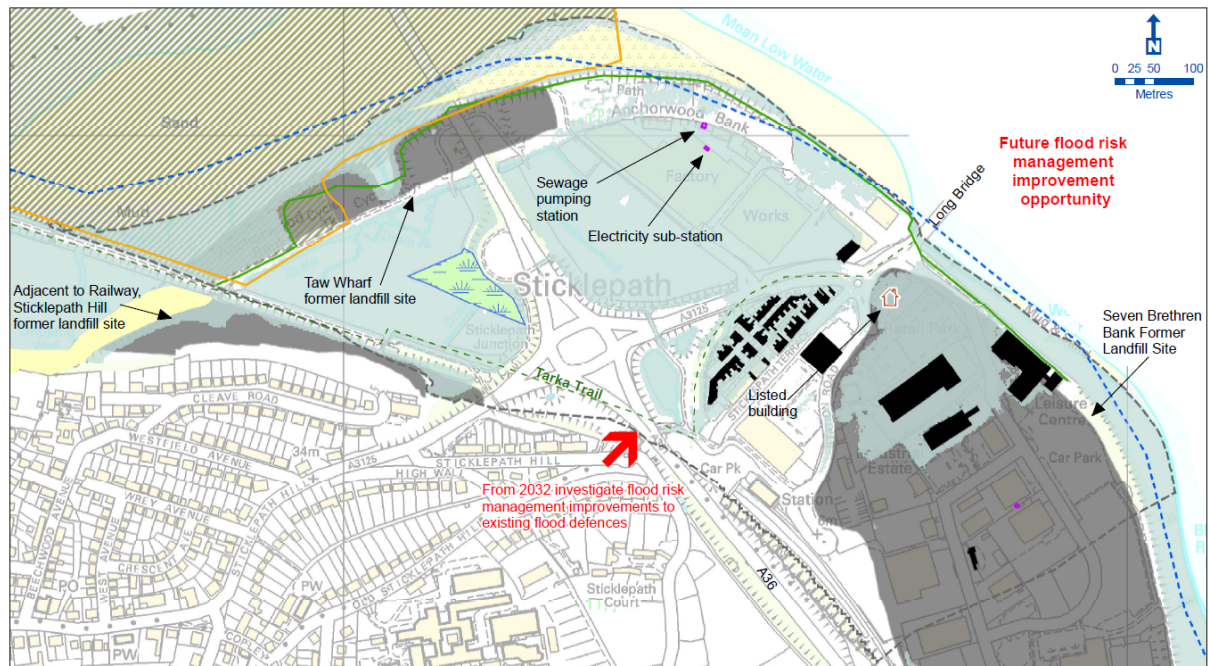
## Potential Environmental Constraints, Mitigation and Opportunities

The works proposed to maintain the flood defences in this Management Unit in the future will lead to beneficial effects by reducing flood risk to the South West Coast Path, the listed warehouse building, the landfill sites and the at risk properties.

Regardless of any proposed flood defence works, the CWS to the north of the site is likely to be inundated more frequently in the future because of sea level rise, encouraging further intertidal habitat creation. Our proposed management approach will not prevent this from occurring.

# Management Unit 27 – Sticklepath

Not FCRM Priority  
Habitat Creation



# Management Unit 28 – North of A39

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	31			
(b) floodable area (0.5% AEP)	7			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	3	3	0	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	3.3			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	578	7	571	0
Worst defence condition	Good			
Agriculture Land Classification	Grade 3 and 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency and Local Authority			
Essential infrastructure within floodable area	Electricity sub-station			

**This Management Unit is predominantly rural, there are no properties at risk today within the flood cell from a tidal flood event. However; with climate change in the future three properties are at risk.**

## Existing flood defences

The majority of the defences are embankments and are maintained by either the Environment Agency or Local Authority.

## Potential management approach

FCRM works will not be required in this area until 2112. We do not need to wait to explore the opportunity for habitat creation.

## Potential works in the next 10 years

A 2ha area of intertidal habitat at Lady Wrey's Marsh could be created with landowner agreement. However, this would be a difficult location to do so as existing outfalls are quite small and there are several pylons serving the electricity sub-station opposite. There's also a tunnel beneath the railway.

## Natural and Historic Baseline Environment

The south of the Management Unit is predominantly rural. However; to the north of the unit is the Tarka Tennis Centre, a recycling centre and waste transfer station.

To the north of the site is the former Severn Brethern Bank Landfill Site which is where the existing recycling centre is situated. The landfill site was established in 1961, the tipping was stopped and permission for the recycling centre was granted in 1976.

The Devon and Dartmoor HER shows potential palaeochannels next to tennis court from when saltmarsh was reclaimed in the 18<sup>th</sup> and 19<sup>th</sup> centuries.

The area is listed in the North Devon Local Plan as the proposed Severn Brethren Regeneration Area where landscape and environmental measures will be incorporated into any future development. There is also a proposed freight interchange for this area.

## Potential Environmental Impacts, Mitigation and Opportunities

Undertaking FCRM works in the future will mean that the properties, tennis courts, recycling centre and former landfill site will not be subject to increase flood risk.

The area between the railway and the river is poor quality amenity land and could benefit from improvement.

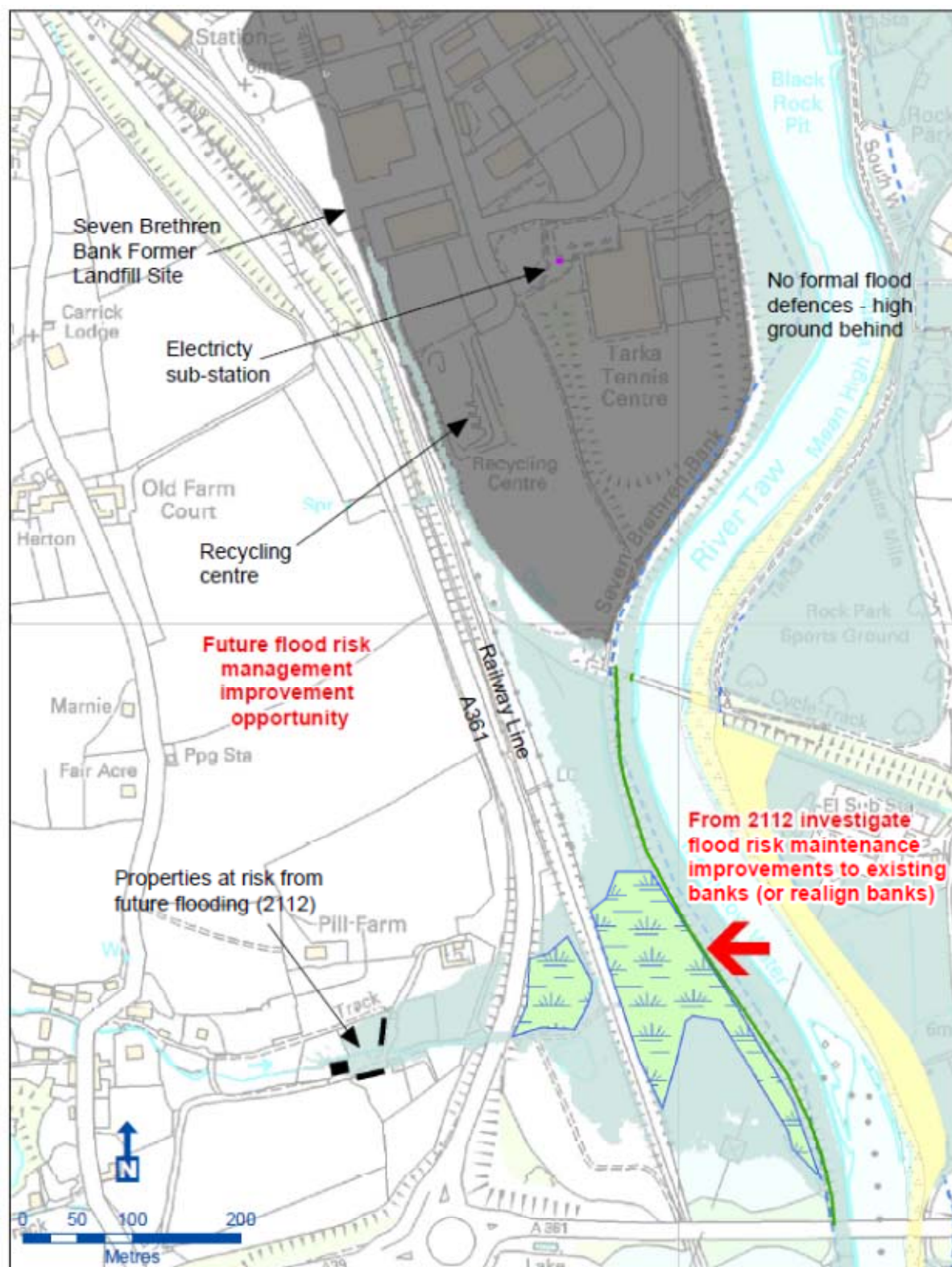
Consideration to any contamination issues will also be required for any appraisal scheme to allow the bank to breach because of the proximity of the former landfill site.

An archaeological assessment would be required as the site has a high potential for unknown archaeology as the land has been reclaimed.

The A361 and railway line runs across the management unit. Habitat creation is likely therefore to only be feasible with Regulated Tidal Exchange.

There is an opportunity to explore habitat creation measures with the North Devon Council as part of the regeneration plans for the site, however this would be an expensive site on which to create habitat.





# Management Unit 29 – South of A39

Environmental  
Priority Site

Key Information				
Size (ha)				
(a) management unit	10			
(b) floodable area (0.5% AEP)	7			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	5			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	609	43	566	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3 & 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency and private			
Essential infrastructure within floodable area	None			

***This Management Unit is approximately 10 ha and there are no properties at risk now or in the future.***

## ***Existing flood defences***

The majority are earth embankments maintained by the Environment Agency. There is also a bridge abutment which is listed as a raised defence and is maintained privately. The outfall beneath the embankment has failed and habitat has already established on the landward side of the railway.

## ***Potential management approach***

Opportunity for 5ha of habitat creation following application of the maintenance protocol, which incorporates further investigation and consultation with the landowner. There are no properties to protect in this floodable area. Therefore we could potentially withdraw maintenance. We would need to monitor the impact on the railway embankment and potentially protect it. We could also formalise an agreement with NE and the landowner to formally recognise the habitat which has already developed.

## ***Potential works in the next 10 years***

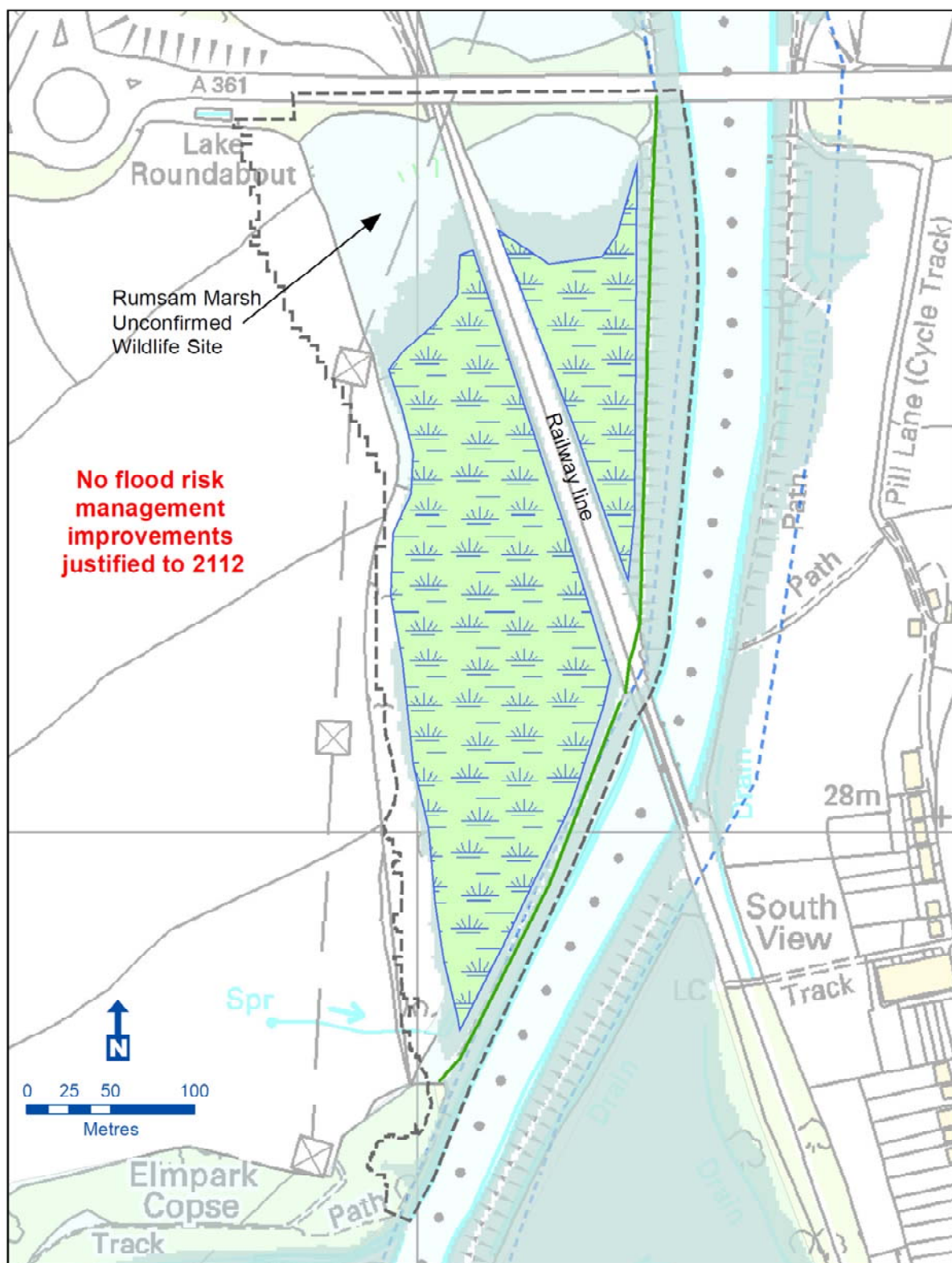
Explore the implications for removing maintenance of the defences with the landowner of the protected agricultural land to establish whether there is an opportunity to create 5ha of intertidal habitat, although the field riverside of the railway line was assessed as unsuitable in 2010 for habitat creation.

## ***Natural and historic environment***

There is an unconfirmed CWS called Rumsam Marsh in the Management Unit, the boundary for this site is undefined. This is potentially classified as BAP habitat floodplain grazing marsh

## ***Potential Environmental Constraints, Mitigation and Opportunities***

None to the proposed works.



Key Information				
Size (ha)				
(a) management unit	4			
(b) floodable area (0.5% AEP)	1.8			
Number of properties at risk	Total	Residential		Commercial
(a) undefended floodplain (0.5% AEP)	0	0		0
(b) defended floodplain (2012)	0	0		0
Area of agricultural land within the floodable area (ha)	1.8			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	90	0	90	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3 & 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

***This Management Unit is rural and there are no properties at risk now or in the future. The existing defences are embankments and are privately maintained.***

#### ***Existing flood defences***

The defences consist of a 90m stretch of embankment along the River Torridge frontage, which is currently in fair condition.

#### ***Potential management approach***

Opportunity for 1ha of habitat creation following application of the maintenance protocol incorporating further investigation and landowner agreement. Discuss habitat creation opportunity with landowners by withdrawal of maintenance if habitat creation here is desirable.

#### ***Potential works in the next 10 years***

Habitat creation opportunity – 1ha area of habitat could be created.

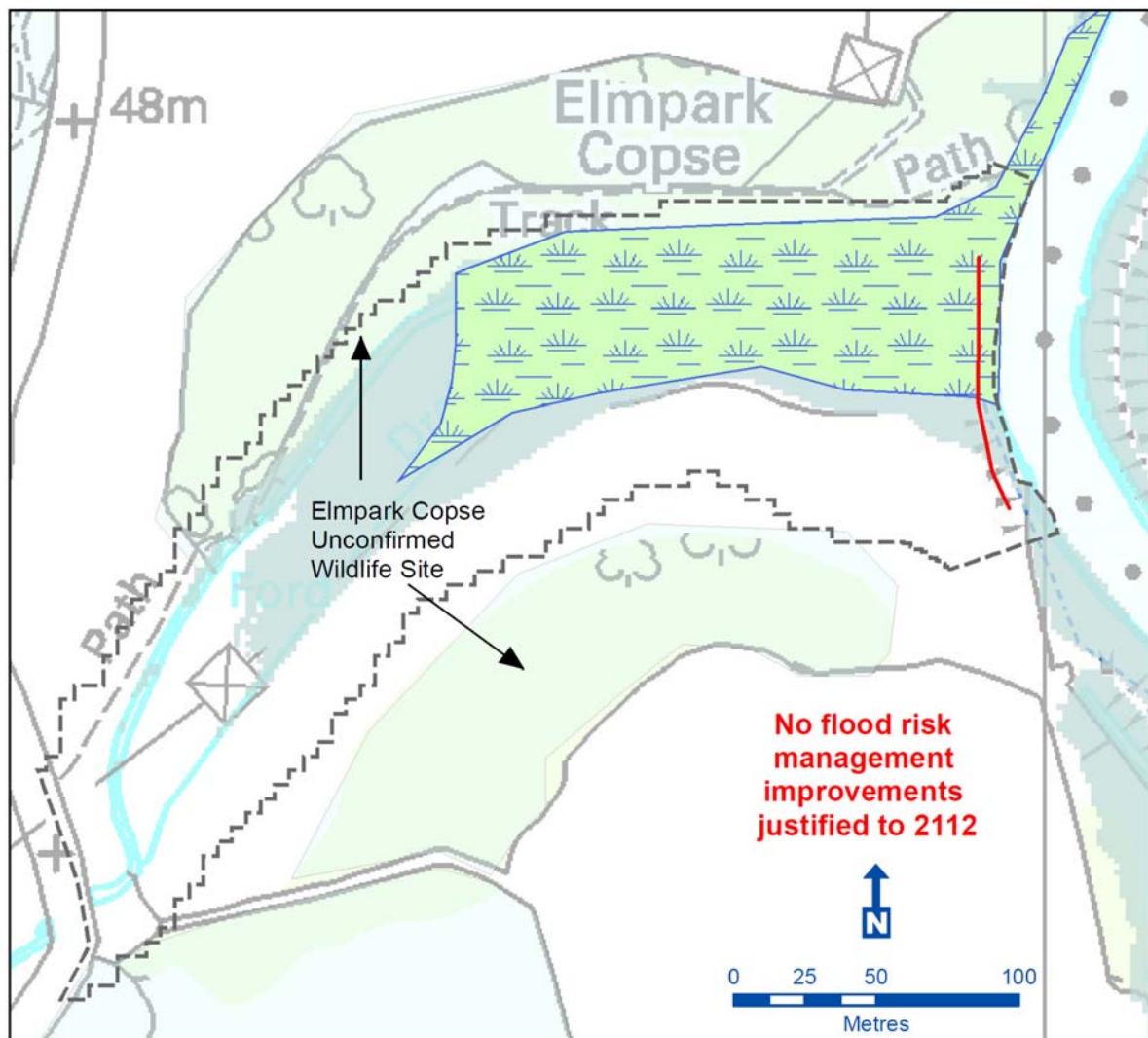
#### ***Natural and Historic Baseline Environment***

The Management Unit is along a small stream south of Elmpark Copse which is an unconfirmed CWS.

#### ***Potential Environmental Impacts, Mitigation and Opportunities***

There will be a loss of Grade 3 and 4 agricultural land which will need to have landowner support.





Key Information				
Size (ha)				
(a) management unit	8			
(b) floodable area (0.5% AEP)	5.4			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	0	0	0	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	5.4			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	675	0	675	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annaul probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

***This management unit is approximately 8 ha and there are no properties.***

### ***Existing flood defences***

675m privately owned, raised earth embankment

### ***Potential management approach***

Potential opportunity for habitat creation following application of the maintenance protocol. Discuss intertidal habitat creation opportunity with landowners. However, the landowners have not preferred to pursue opportunities for habitat creation to date.

### ***Potential works in the next 10 years***

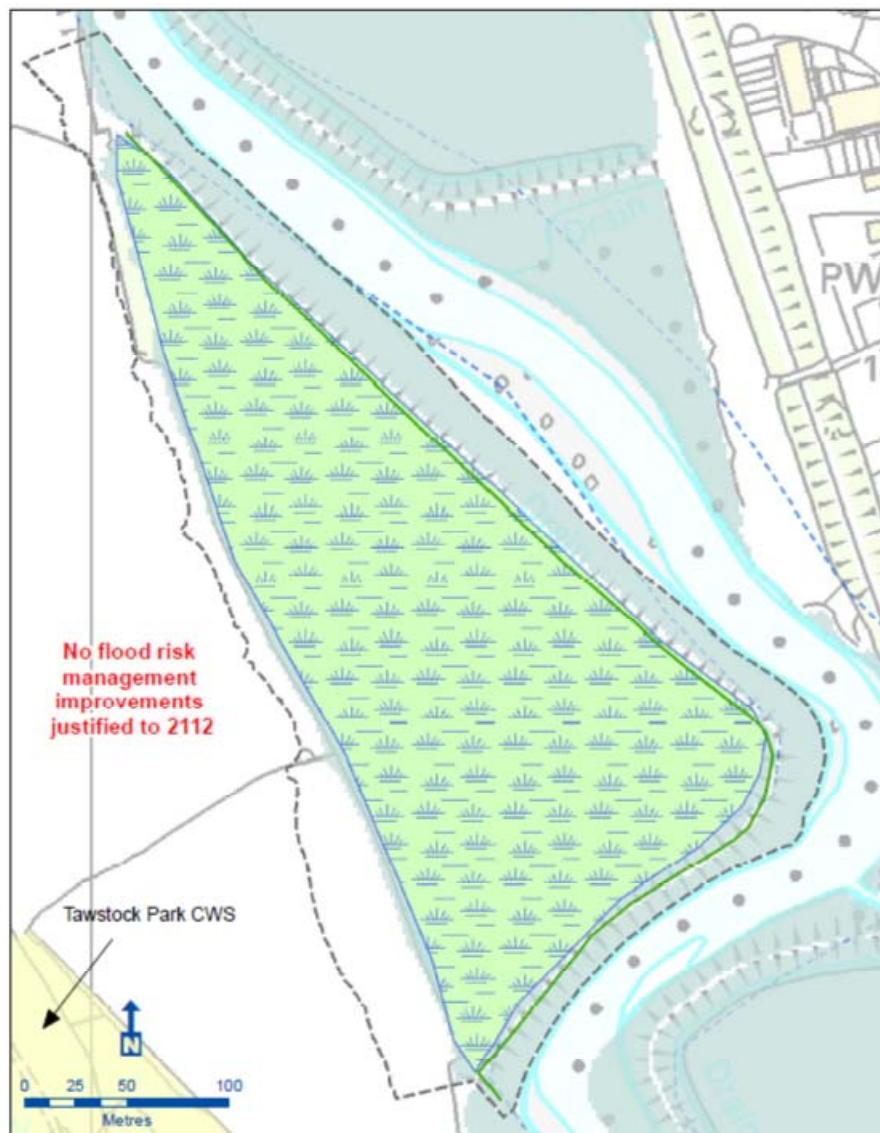
5ha area of intertidal habitat could be created if the landowner is supportive.

### ***Natural and historic environment***

The site is near the Tawstock Park CWS, designated for its potential neutral grassland habitats. The boundaries for the site are undefined as investigation is required to see whether it should be designated.

### ***Potential Environmental Constraints***

Breaching the defences will result in the loss of Grade 4 Agricultural land which will need to have the support of the landowner.



Key Information				
Size (ha)				
(a) management unit	79			
(b) floodable area (0.5% AEP)	39			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	39			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	1732	0	1732	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

***This Management Unit is approximately 79 ha and there are no properties at risk now or in the future. The majority of the defences are embankments and are privately maintained.***

## Existing flood defences

1.7km of earth embankment, privately maintained.

## Potential management approach

There is an opportunity to create 25ha of habitat if supported by further detailed study and with landowner agreement following application of the maintenance protocol, if appropriate to these private defences.

## Potential works in the next 10 years

25ha area of intertidal/floodplain habitat could be created if the landowner was supportive. Would need to monitor railway line and protect if required.

## Natural and historic environment

The Management Unit is within the Tawstock – Newbridge Marsh Unconfirmed Wildlife Site which is classed as a possible floodplain grazing marsh however, this is not certain and the boundary is not defined.

The Management Unit is adjacent to the Straypark Wood CWS which is lowland semi-natural woodland partly replanted with conifers. To the east of the woodland is an area of Ancient Woodland which extends into the management unit.

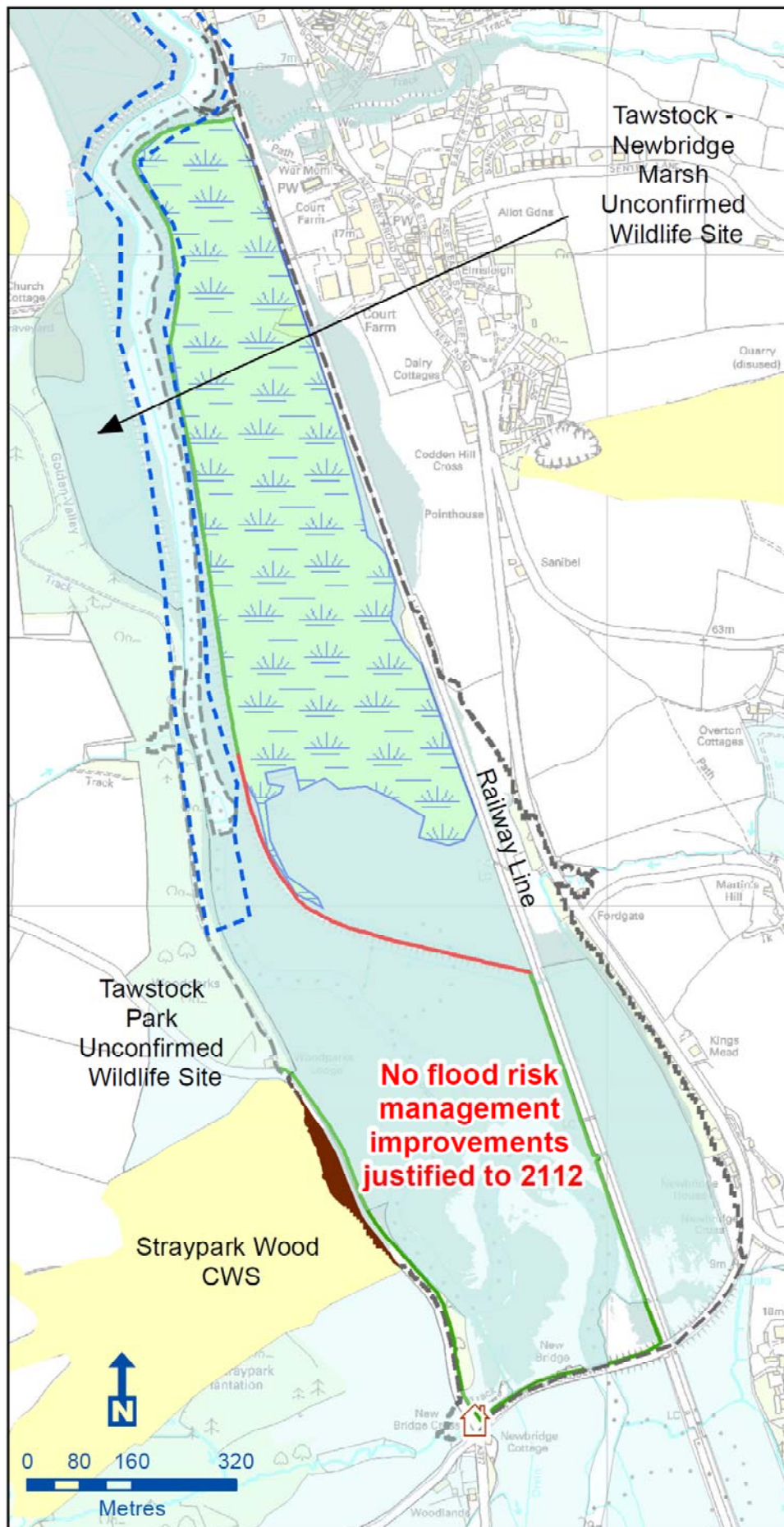
## Potential Environmental Constraints

There will be a loss of Grade 4 agricultural land if intertidal/floodplain habitat was created.

Potential impacts to the unconfirmed Wildlife Site are unknown and will need to be evaluated once the habitats at the site are known.

Ancient woodland and the CWS will not be affected by the proposed intertidal habitat.





# Management Unit 32 – Tawstock

Environmental  
Priority Site

## Key Information

Size (ha)				
(a) management unit	8			
(b) floodable area (0.5% AEP)	7.7			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	7.7			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	529	0	529	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 8 ha and there are no properties. The majority of the defences are embankments and are privately maintained. This area is also vulnerable to fluvial flooding.*

### Existing flood defences

Earth embankments (529m) privately maintained.

### Potential management approach

There is an opportunity to create 5ha of habitat depending on the outcome of further study and landowner agreement following application of the maintenance protocol, if appropriate for these private defences.

### Potential works in the next 10 years

5ha of intertidal habitat could be created if the landowner is supportive.

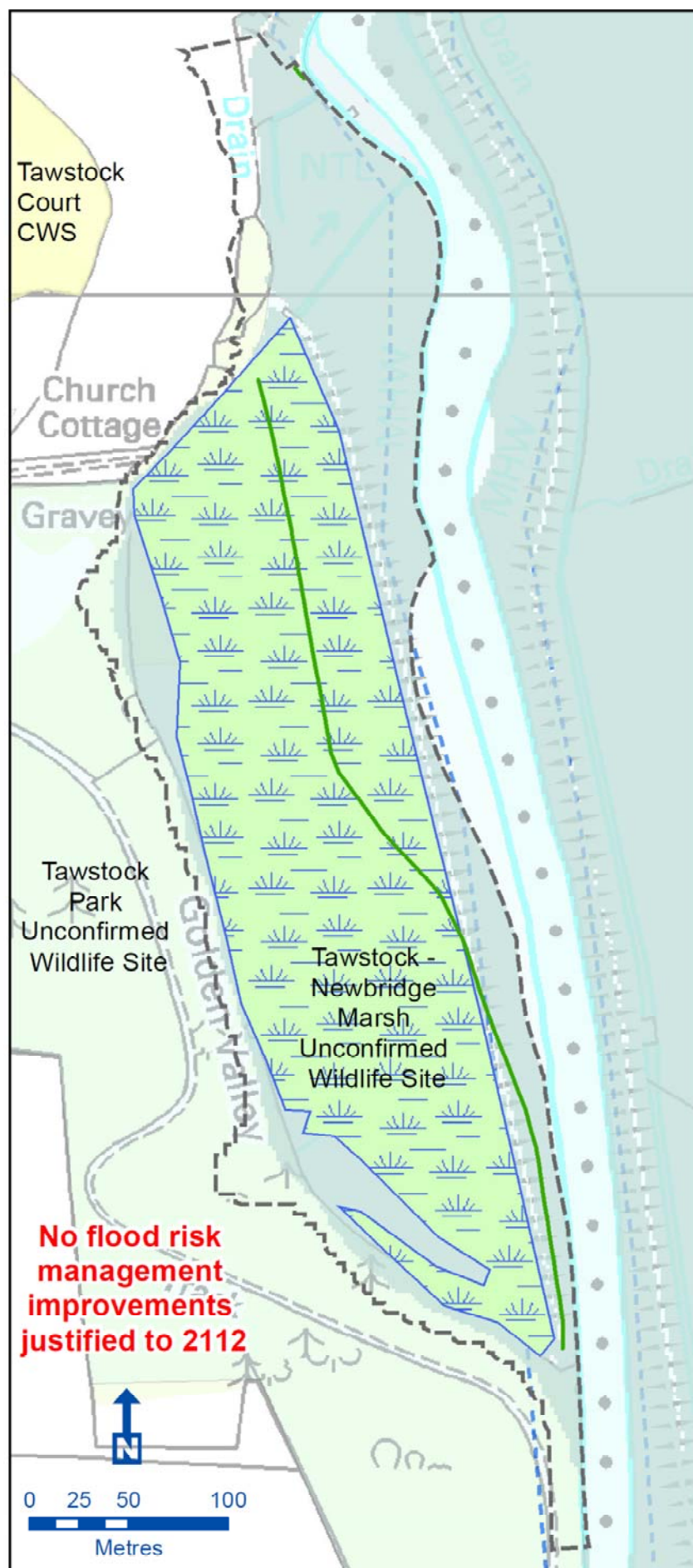
### Natural and Historic Baseline Environment

The Management Unit is within the Tawstock – Newbridge Marsh Unconfirmed Wildlife Site which is classed as a possible floodplain grazing marsh. However, this is not certain and the boundary is not defined.

### Potential Environmental Impacts, Mitigation and Constraints

There will be loss Grade 4 agricultural land if intertidal habitat options were pursued. This will need landowner support

Potential impacts to the unconfirmed Wildlife Site are unknown and will need to be evaluated once the habitats at the site are known.



Key Information				
Size (ha)				
(a) management unit	9.4			
(b) floodable area (0.5% AEP)	6.4			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	0	0	0	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	6.4			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	613	37	576	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 9 ha and there are no properties at risk. A railway embankment defines the limit of the floodplain.*

### Existing flood defences

The raised defences in this management unit are all embankments which are currently privately maintained.

### Potential management approach

Opportunity to create 5ha of habitat if supported by further study and with the agreement of the landowners following application of the maintenance protocol. Discuss habitat creation opportunity with landowners. We will need to consider the integrity of the railway embankment which will become the primary flood defence.

### Potential works in the next 10 years

5.3ha of intertidal habitat could be created if the landowner is supportive.

### Natural and Historic environment

The fields are used for agriculture and are bounded to the east by a railway embankment blocking any views from the properties to the east of the embankment to the Management Unit.

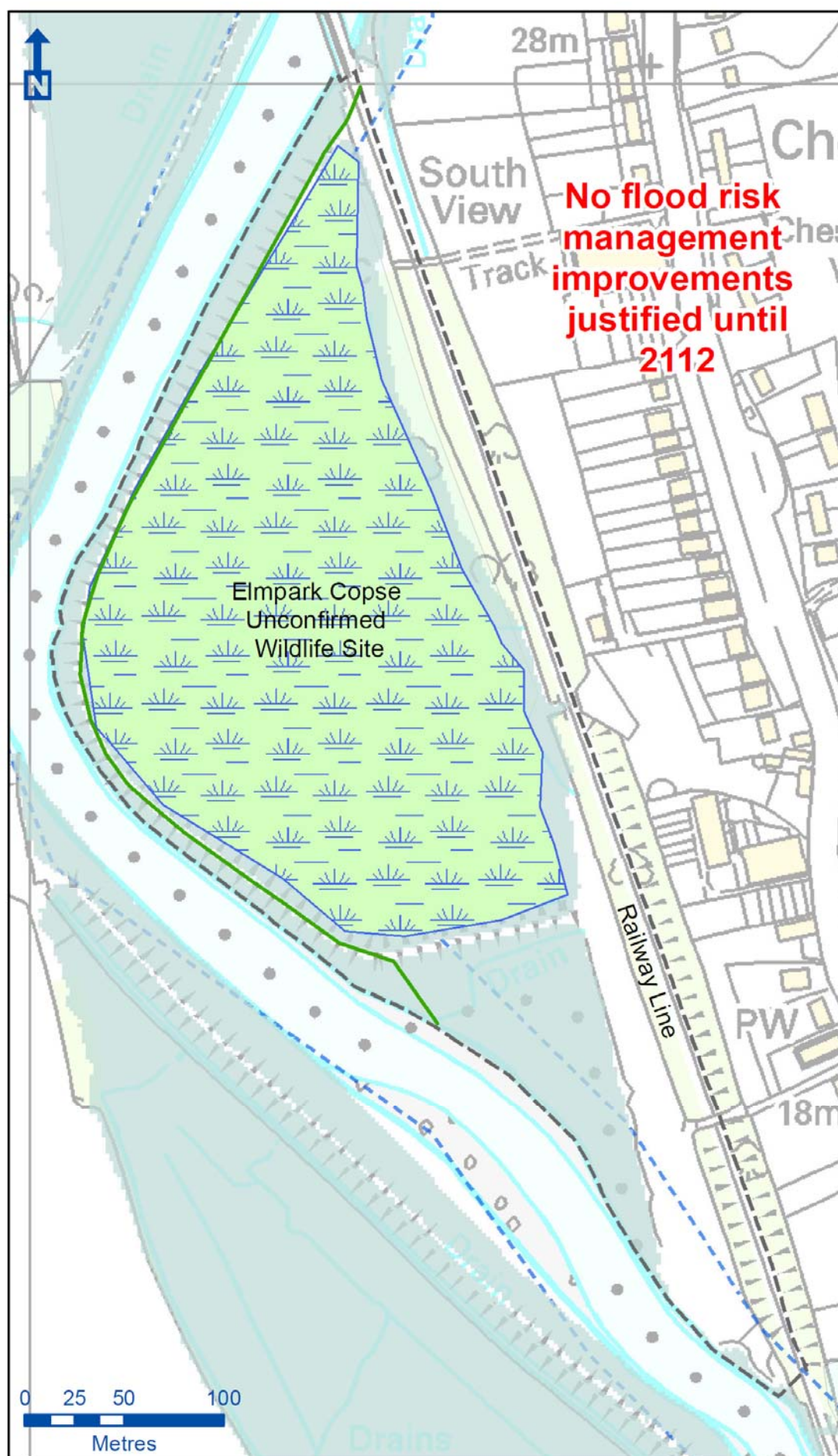
There is a Devon unconfirmed wildlife site called Elmpark Close, which has potentially semi-improved neutral grassland. However, the boundary of this site is unknown.

### Potential Environmental Constraints

There will be a loss of Grade 4 agricultural land and the landowner would need to be supportive of this.

There may be potential impacts to the unconfirmed Wildlife Site, which would need to be evaluated once the habitats at the site are known.





# Management Unit 36 – North Chestwood

Environmental  
Priority Site

Key Information				
Size (ha)				
(a) management unit	4			
(b) floodable area (0.5% AEP)	1.3			
Number of properties at risk	Total	Residential		Commercial
(a) undefended floodplain (0.5% AEP)	0	0		0
(b) defended floodplain (2012)	0	0		0
Area of agricultural land within the floodable area (ha)	1.3			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	399	33	366	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Environment Agency and private			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 4 ha and there are no properties. The majority of the defences are embankments.*

## Existing flood defences

The majority of the defences in this management unit are earth embankments and are typically in 'good' condition, however there are some locations assessed as being in 'fair' condition. The defences are maintained both by the Environment Agency and also by private landowners.

## Potential management approach

Opportunity for a small area of habitat creation with landowner agreement, following application of maintenance protocol. We will work with the landowners at the site to review the maintenance arrangements to determine whether inputs can be reduced or ceased. There may be potential for intertidal habitat creation opportunities within the Management Unit.

## Potential works in the next 10 years

0.5ha of intertidal habitat could be created.

## Natural and Historic Baseline Environment

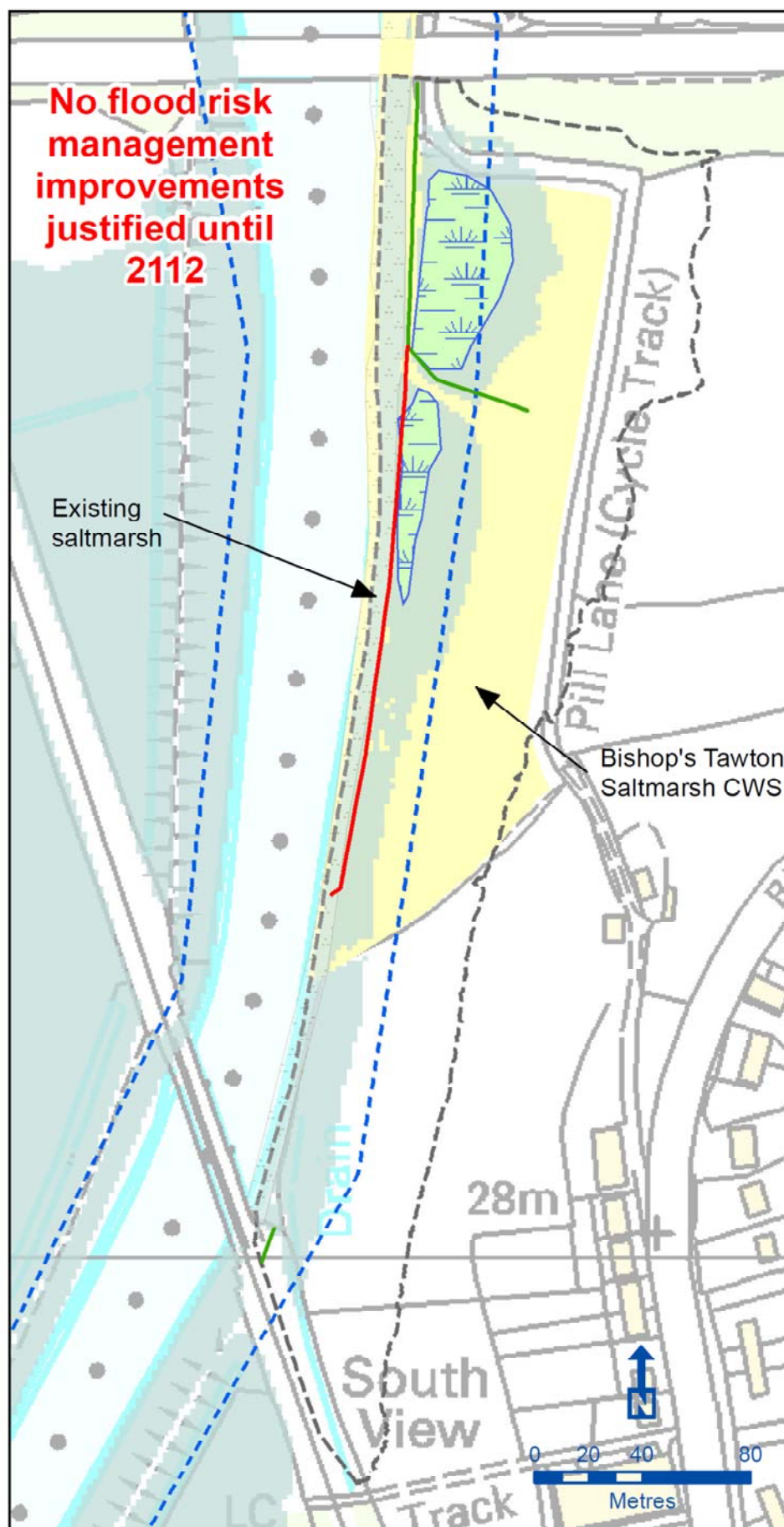
The Bishops Tawton Saltmarsh CWS is within the Management Unit which is comprised of saltmarsh, semi-improved grassland, a watercourse and species-rich hedge bank.

Pill Lane Cycle Track runs to the east of the Management Unit but will not be affected by any habitat creation works.

## Potential Environmental Impacts, Mitigation and Opportunities

There would be loss of Grade 4 agricultural land which will need landowner support.

Change to the CWS is unlikely to be significant as the CWS is partly designated for its saltmarsh habitat. However, this would need to be evaluated during an EIA process of the proposed project.





# Management Unit 37 – Rumsam

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	8			
(b) floodable area (0.5% AEP)	3.6			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	1	1	0	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	3.6			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	520	0	520	0
Worst defence condition	Good			
Agriculture Land Classification	Grade 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency			
Essential infrastructure within floodable area	Electricity sub-stations and sewage pumping station			

***This Management Unit is approximately 8ha. No properties are at risk. Defences may need to be reviewed by 2112 to protect the sewage pumping station.***

## Existing flood defences

All the defences are embankments and are currently maintained by the Environment Agency. The defences are currently assessed as being in 'good' condition.

## Potential management approach

Maintenance work could be reduced or withdrawn in view of the value of assets protected. This would mean that the defences, currently in good condition would gradually degrade. Unless positive habitat creation actions were taken, the habitats may not revert to intertidal for up to 50 years. The sewage treatment works and electricity substation are likely to need additional protection by 2112 and would be stranded on high ground during high tidal events.

## Potential works in the next 10 years

Apply the maintenance protocol and if appropriate then discuss with the land owner the potential to create 1.3ha area of habitat in the longer term as the condition of the defences decline. Note that there are plans to improve the defence here, reducing flood risk to the sub-station. There would be additional benefits to public access.

## Natural and Historic Baseline Environment

The Management Unit contains Bishops Tawton Saltmarsh CWS, which is comprised of saltmarsh, semi-improved grassland, a watercourse and species-rich hedge bank. The saltmarsh is a strip between the river edge and embankment.

There are three listed buildings in the Management Unit:

- Boundary wall to Pill House fronting Pill Lane Grade II
- Pill House Grade II\*
- Greendale Farmhouse Grade ii

Park School Railway Cutting (listed as landfill site) is in the north east corner of the management unit.

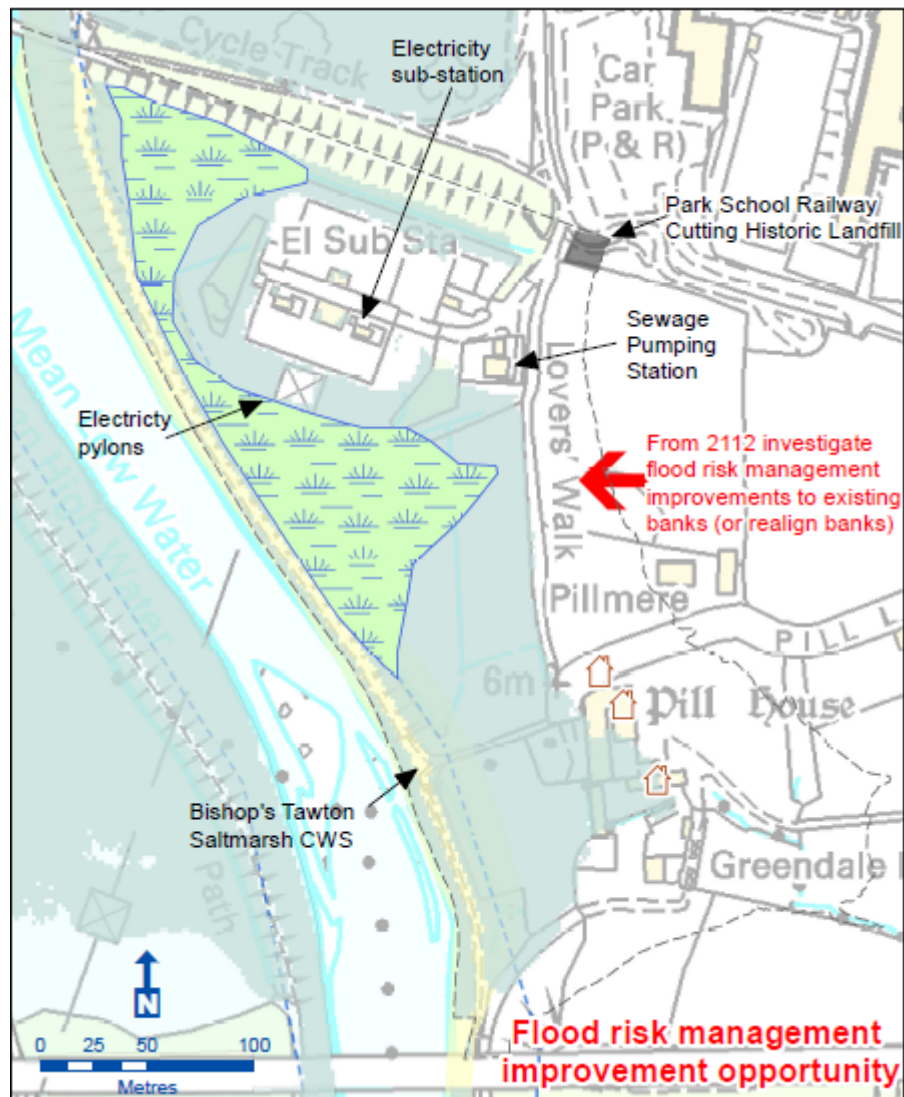
## Potential Environmental Impacts, Mitigation and Opportunities

There will be a loss of Grade 4 agricultural land which will require landowner support and the permissive footpath along the crest of the bank.

If 1.3ha of habitat can be created in the future then there is a possibility to extend the saltmarsh habitat in the CWS.

The three listed buildings are at risk from flooding as the condition of the defences deteriorates and sea levels rise and this will need to be investigated and mitigation such as a small ring bank may be required to protect them.





# Management Unit 42 – Pottington

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	115			
(b) floodable area (0.5% AEP)	54.5			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	19	6	13	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	50			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	1,988	0	1,988	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 3 and 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Environment Agency			
Essential infrastructure within floodable area	Electricity sub-station, Sewage Treatment Works			

*This Management Unit has defences that are in fair condition and offer a good standard of protection. With continued maintenance they are unlikely to need improvement until 2062.*

## Existing flood defences

These embanked defences protect 19 residential and 6 commercial properties as well as forming a water management role for Bradiford Water Bird Reserve.

## Potential management approach

Maintain defences along existing alignment and from 2062 investigate flood management improvements to existing banks (or realign banks). Regulated tidal exchange may realise 20ha of habitat creation, but it could detrimentally affect the freshwater bird reserve at Bradiford Water. There are also major services within the embankment which would need to be maintained.

## Potential works in the next 10 years

Maintain defences along existing alignment and investigate habitat creation opportunities.

## Natural and Historic Baseline Environment

There are four listed buildings within the Management Unit:

- Front garden wall and railings to Cedar Cottage Grade II
- Strand House Grade II
- Milestone immediately north of Bradiford Bridge Grade II
- Bradiford Bridge II

The Tarka Trail runs along the southern boundary of the management unit.

Bradiford Water is a Bird Reserve, situated at the west end of the Pottington Industrial Estate. The MU is on top of a surface water drinking water protection area (GB108050019990)

## Potential Environmental Constraints, Opportunities and Mitigation

There would be a loss of areas of Grade 3 and 4 agricultural land.

There will be a change of view for the Tarka Holiday Park, Ashford Inn Farm and Cottage and the Pottington Business Park from the habitat creation which will need to be assessed.

The listed buildings and electricity sub-station will not be affected by the habitat creation proposals.

If any works to the defences near to Strand House (north west tip) are proposed they will need to consider the setting of the listed structure and ensure that it is not adversely affected.

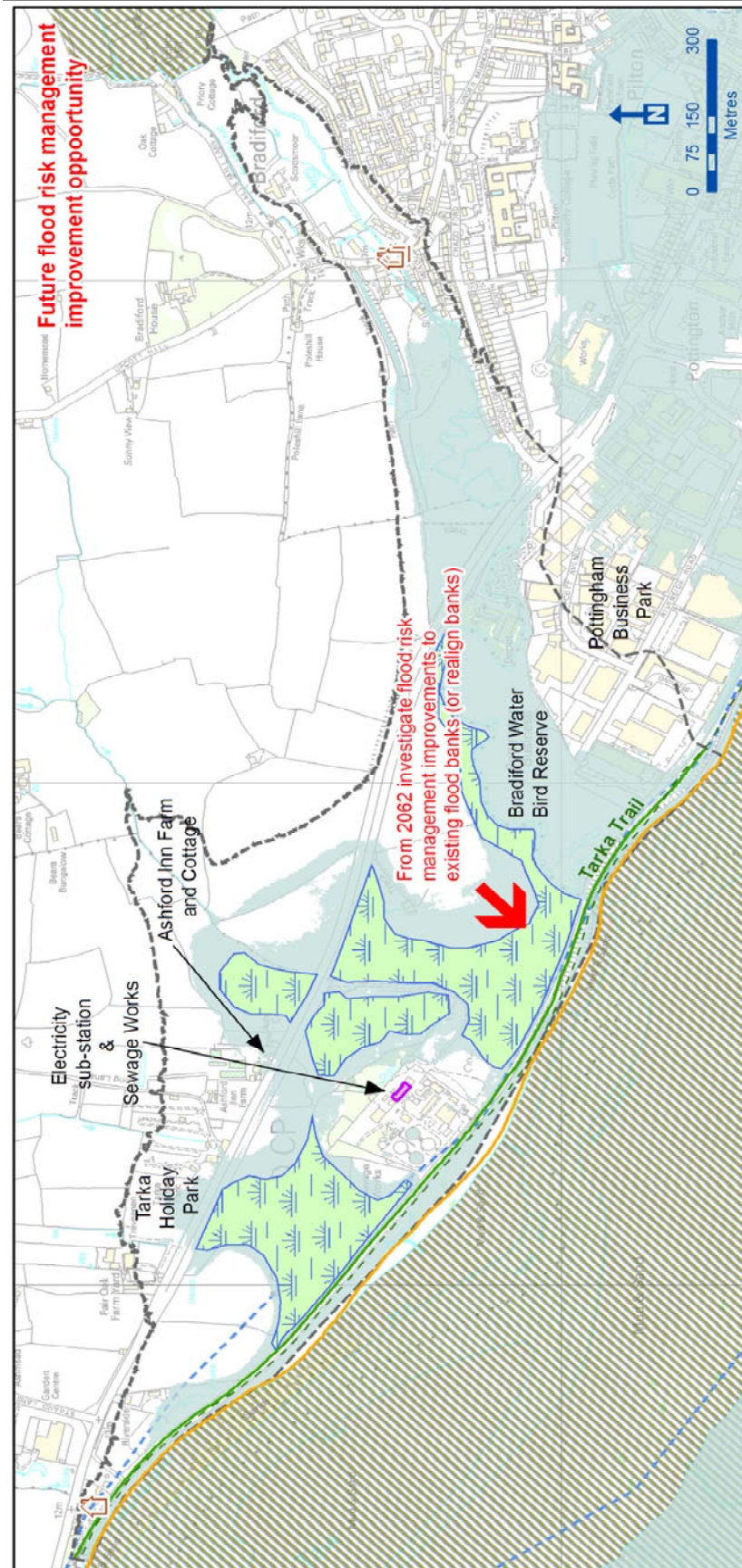
Creating intertidal habitat may have a negative impact on the Bradiford Water Bird Reserve (Devon Bird watching and Preservation Society) and the surface water drinking water protected area from the change of salinity which would require further investigation.

The Tarka Trail would need to be diverted or accommodated with a bridge if a breach in the defence was made. However, there are utilities within it.

The Bradiford Water waterbody is currently classified as Good under the WFD and any habitat creation proposals will need to ensure that this is maintained.

## Management Unit 42 – Pottington

**Not FCRM Priority  
Habitat Creation**



# Management Unit 43 – Chivenor

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	335			
(b) floodable area (0.5% AEP)	100			
Number of properties at risk	Total	Residential	Commercial	
(c) undefended floodplain (0.5% AEP)	1	0	1	
(d) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	59			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	2034	444	1590 (new secondary defence) 4765 (remaining frontline defence including length adjacent to the River Caen)	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 4			
Current standard of protection	Greater than 0.5% AEP (1 in 200 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	Electricity sub-station			

***This Management Unit is defended by privately owned defences in fair condition. Property (22 houses) is likely not to be at risk until 2034 (0.5%AEP).***

## ***Existing flood defences***

A new secondary defence (earth embankment) was constructed in 2010. The remaining coastal frontage is protected by earth embankments and a short stretch of concrete seawall. The defences extend from the coast along the River Caen.

## ***Potential management approach***

Advise the MoD of flood risk by 2032 and co-operate within funding limitations. Habitat creation opportunities could be explored immediately and a study has already been undertaken by Mr Spear and Natural England (Hyder Consulting (UK) Limited, 2012). The study has shown that habitat creation is feasible at the eastern section of the site which Mr Spear and another landowner own, although drainage issues will need some careful consideration.

## ***Potential works in the next 10 years***

23.7ha of salt marsh and 31.9 ha of freshwater habitat (comprising of existing and new reed beds and grazing marsh) could be created adjacent to the River Caen by breaching the defences and constructing new embankments. However, there are no economic drivers to do this. Natural England and Mr Spear have identified the next stages of the project and will continue to explore this opportunity.

## ***Natural and Historic Baseline Environment***

Within the Management Unit is the Chivenor Historic Landfill (RAF Chivenor) and Chivenor Airfield.

There is an unconfirmed Wildlife Site called Sewage Works Field in the unit which is comprised of grazing marsh. The boundary of this site is not defined. The management unit is within the Caen Valley Bat Sustenance Zone

There is evidence that the site was occupied from the Prehistoric period and therefore the potential for remains to be preserved is high. Two Linhays or barns are present as above ground remains along with a old stone barn.

The Tarka Trail runs along the northern boundary of the Management Unit. The Devon Heritage Coast to the west overlooks Chivenor. There is a public right of way (PRoW) along the River Caen.

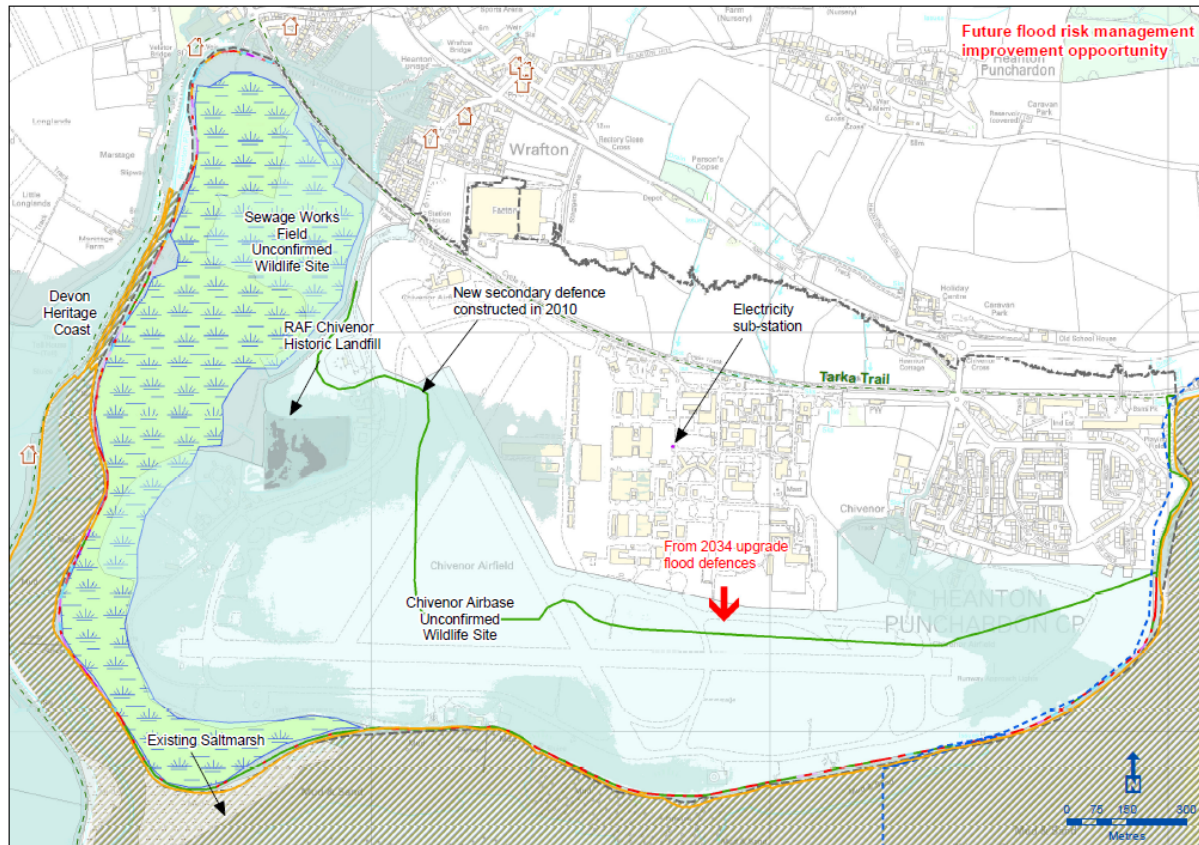
## ***Potential Environmental Constraints and Opportunities***

The feasibility study has undertaken environmental assessments of the proposals and identified a number of recommendations to avoid significant impacts including maintaining the PRoW along the River Caen, providing eel passage through any structures, archaeological watching brief for all ground breaking activities. Opportunities are also identified such as installing interpretation boards and bike stands.



# Management Unit 43 – Chivenor

Not FCRM Priority  
Habitat Creation



# Management Unit 45a – Braunton Marsh

FCRM Priority

Key Information				
Size (ha)				
(a) management unit	750			
(b) floodable area (0.5% AEP)	306			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	13	13	0	
(b) defended floodplain (2012)	13	13	0	
Area of agricultural land within the floodable area (ha)				
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	3,485	667	2818	0
Worst defence condition	Fair			
Agriculture Land Classification	Grade 2, 3 and 4			
Current standard of protection	Varies, Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Local Authority, Environment Agency Private defences			
Essential infrastructure within floodable area	None			

*This Management Unit is approximately 750 ha and there are 13 properties at risk.*

## Existing flood defences

The majority of the defences are earth embankments. However there are also short lengths of masonry wall and sheet piled wall. In the southern end on the management unit the defences consist of natural dunes, which in places are supplemented with rock groyne.

## Potential management approach

There are some uncertainties in the flood risk to the marsh due to lack of detailed records. To confirm the flood risk in the area, we will need to undertake a detailed modelling feasibility study. From the information obtained we do know it appears that any scheme is likely to involve a different approach to the maintenance of the defences to protect the isolated properties only. This approach will need to be agreed with the Internal Drainage Board and Braunton Marsh Commissioners as it would affect the grazing of this area.

## Potential works in the next 10 years

Recommend project to investigate identified flood risk management changes and to address risk to isolated properties near Braunton within Braunton Marsh.

## Natural and Historic Baseline Environment

The Management Unit is within the following environmental designations:

- North Devon AONB and Biosphere Reserve
- Braunton Burrows SAC / SSSI
- Braunton Swanpool SSSI
- Greenaways and Freshmarsh SSSI
- Caen Valley Bat Sustenance Zone
- Swanpool Marsh DWT Nature Reserve designated for freshwater reedbed, tall herb vegetation and willow carr.
- Part of the Taw and Torridge Estuary IBA and was added in 2000.
- North Devon Heritage Coast

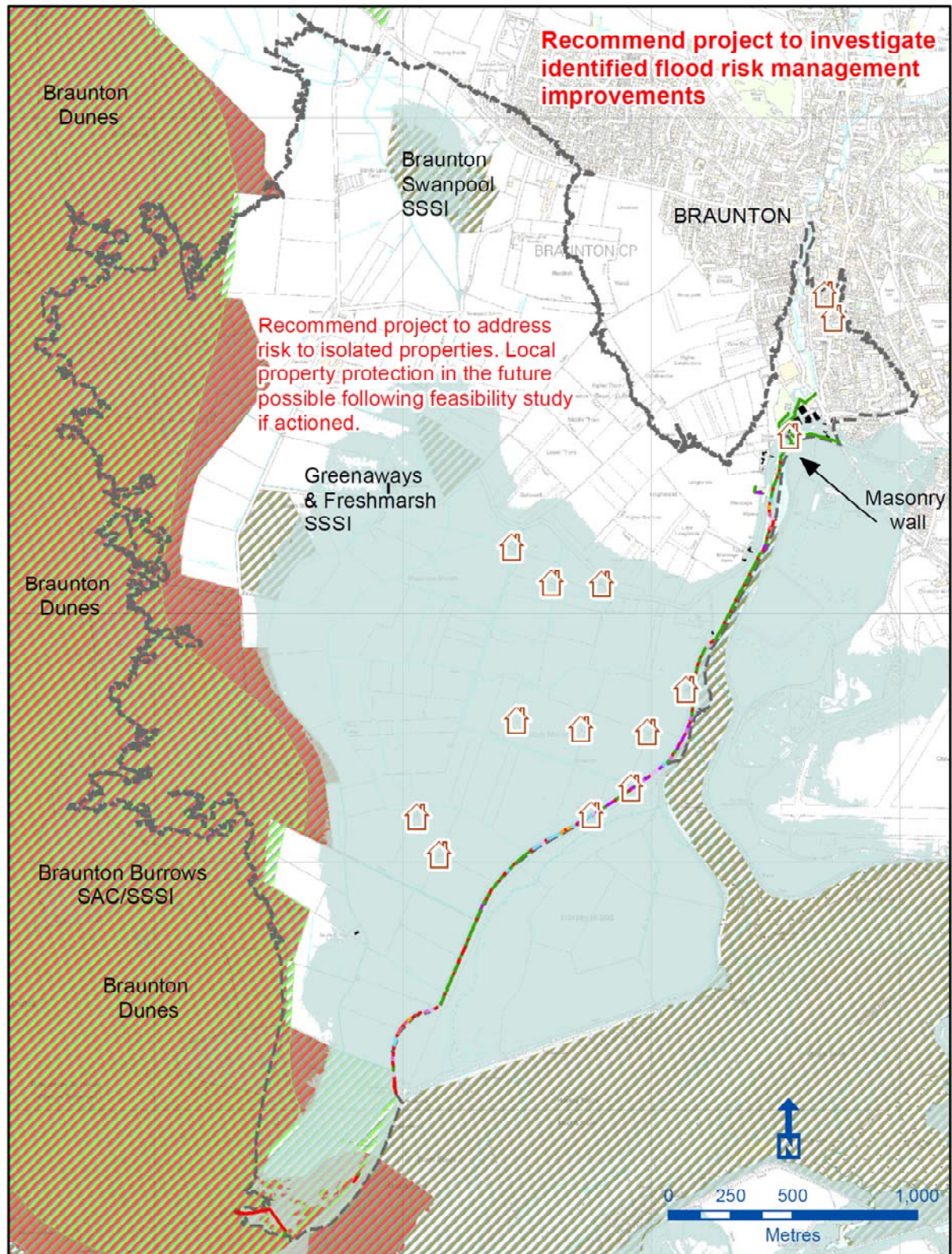
There are 14 listed buildings in the MU. Two cottages within Braunton Village are not at risk of flooding. The other 12 including Velator Bridge, the Great Sluice and a number of cattle sheds would be at risk of flooding if the defences were not in place.

The South West cost path runs along the western and eastern side of the Management Unit.

## Potential Environmental Impact, Mitigation and Opportunities

If maintenance of the defences is ceased then there is likely to be an impact on the designations listed above which will need to be assessed during an EIA of the proposals. Specifically the impact to the hydrological system of the marshes will need to be investigated so that mitigation measures can be implemented to ensure that the agricultural value of the site is not compromised.





# Management Unit 45b – Horsey Island

Not FCRM Priority  
Habitat Creation

Key Information				
Size (ha)				
(a) management unit	90			
(b) floodable area (0.5% AEP)	90			
Number of properties at risk	Total	Residential	Commercial	
(a) undefended floodplain (0.5% AEP)	1	1	0	
(b) defended floodplain (2012)	1	1	0	
Area of agricultural land within the floodable area (ha)	90			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	2,986	0	2,986	0
Worst defence condition	Poor			
Agriculture Land Classification	Grade 3			
Current standard of protection	Less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Private			
Essential infrastructure within floodable area	None			

**This Management Unit is protected by private defences. 1 property is at risk by 2062 approximately.**

The defences are earth embankments which are currently privately maintained. The flapped outfall leaks and has led to the creation of some intertidal habitat.

## Potential management approach

Defences are in a poor condition and probably overtop regularly, although this has not been reported to the Environment Agency, probably as these are private defences. Discuss habitat creation or the application of the maintenance protocol with landowners. From 2062 individual property protection may be required.

## Potential works in the next 10 years

There is the potential to create 82ha of intertidal habitat with negotiation with the landowner if desirable. Drainage of Braunton Marsh would need detailed investigation before proceeding.

## Natural and Historic Baseline Environment

Horsey Island CWS is designated for saltmarsh, tall herb vegetation, reedbeds and wet unimproved neutral grassland habitats. The Caen Valley Bat Sustainance Zone is in the north of the area. The whole unit is within the North Devon Heritage Coast and the AONB and Biosphere Reserve.

There are four listed buildings associated with the sluices on the flood embankment for Management unit 45a.

## Potential Environmental Constraints

Loss of grasslands to create intertidal habitat will need to be agreed with the landowner.

Any proposals will need to be assessed to show that the impacts from the loss of the grassland do not affect the ecology of the area including any bats foraging in the location. The standard of protection is already very low and the area is likely to be quite saline already. There is some saltmarsh currently mapped in the east of the unit.

The embankment for Horsey Island is likely to overtop leading to the listed buildings (largely barns) becoming flooded during large floods. This will not change if maintenance is withdrawn. Flooding may become more frequent over time with sea level rise and this will have to be investigated. IDB hold a list of all historical buildings on Braunton Marshes.

As the site is naturally forming an intertidal habitat and it is on an estuary, it is unlikely that there will be a noticeable change to the landscape of the heritage coast and AONB. However, this will need further investigation when details of a project are known at the site.

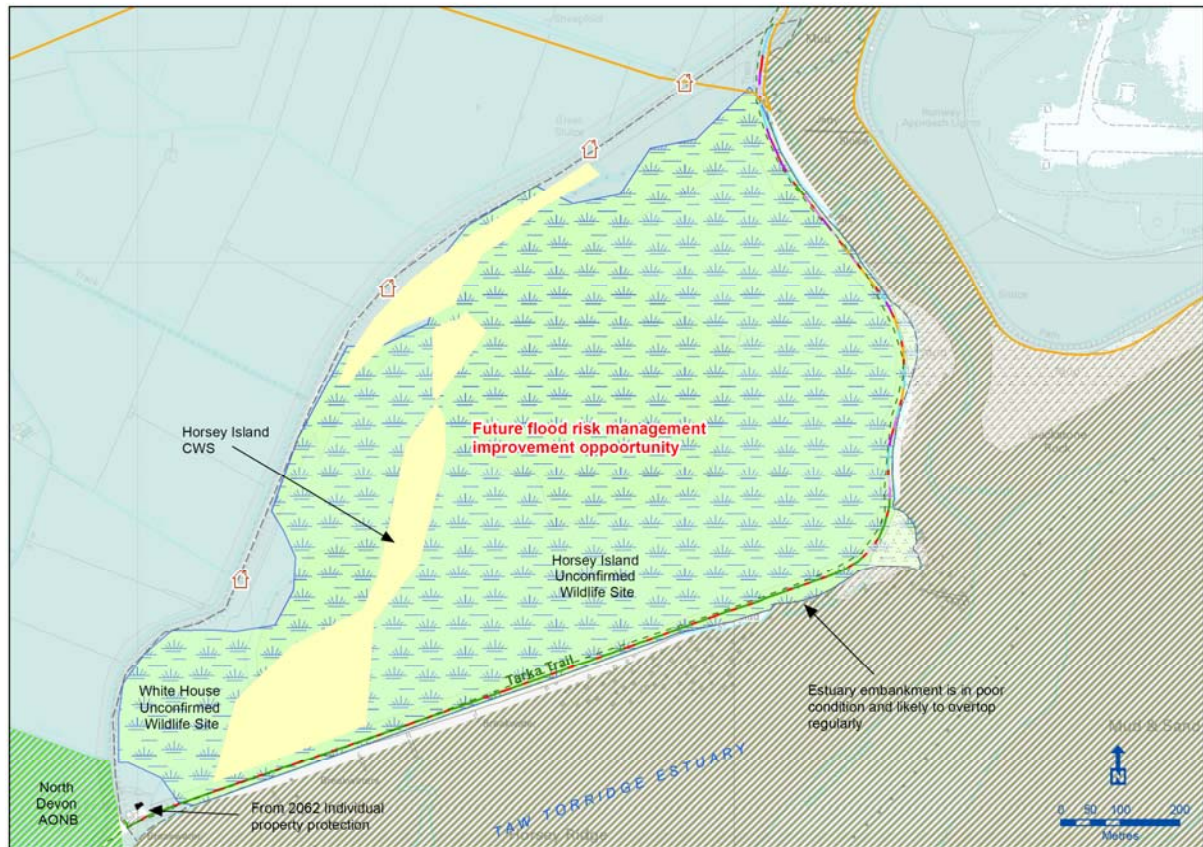
Water levels are retained by summer and winter penning regimes and are not pumped.

Natural England are reviewing 2 High Level Stewardship schemes in the area.



# Management Unit 45b – Horsey Island

Not FCRM Priority  
Habitat Creation



# Management Unit 46 – Crow Point

Not a Priority Site

Key Information				
Size (ha)				
(a) management unit	9			
(b) floodable area (0.5% AEP)	8			
Number of properties at risk	Total	Residential		Commercial
(a) undefended floodplain (0.5% AEP)	0	0	0	
(b) defended floodplain (2012)	0	0	0	
Area of agricultural land within the floodable area (ha)	0			
Length of defences (m)	Total	Hard	Soft	Natural
(a) management unit	517	517	0	0
Worst defence condition	Fair			
Agriculture Land Classification	NA			
Current standard of protection	Minimum less than 100% AEP (1 in 1 annual probability)			
Defences managed by	Environment Agency			
Essential infrastructure within floodable area	None			

***This Management Unit is approximately 9 ha and there are no properties.***

## ***Existing flood defences***

This management unit is the site of 517m length of rock armour, which is fixing the spit between the dunes to the coastal extent of Crow Point.

The blockstone was placed at least 30 years ago, to manage up-estuary water levels in Barnstaple. However, the rock is causing this SSSI unit to be in unfavourable, no change, condition as it is likely to be causing erosion of the dune system and the EA have an action to address the problem by removing the rock armour (assessed 30/1/13 by Natural England as having stabilised). Natural England are reviewing the data behind this and will communicate this with the appropriate authorities when ready.

7ha of intertidal habitat has developed in the lea of the rock in the inner estuary.

The recorded defence is in fair condition.

## ***Potential management approach***

It is proposed to withdraw maintenance from the rock armour. However, total removal of armour stone to improve the condition of the SSSI, is not currently recommended without further detailed coastal modelling as in flood defence and coastal erosion terms it may act as a breakwater for the inner estuary (this is further supported by the recommendations of SMP2). From review and interpretation of existing studies it seems removal of the rock may leave Yelland estuary frontage vulnerable to erosion from open coast wave action. In terms of the SSSI it would likely return an “unfavourable recovering condition”. In addition the local landowners would prefer for it to remain and the investment spent on other forms of local flood risk management.

Although, there is a need to remove the rock to improve the condition of the SSSI, it is not recommended without understanding the impact of removal on flood and erosion risk issues in the estuary and potential mitigation requirements. The rock armour is predicted capable of continuing to function as it does today until 2112.

Removal of the rock armour may attract funding under the Water Framework Directive.

### **Potential works in the next 10 years**

Carry out a coastal modelling study to establish the impact of removing the rock with a good degree of confidence should be carried out. This modelling should establish the likely evolution of the Crow Point area if the rock were removed (likely to drop to at or near bedrock level between the dunes and the tip of Crow Point). It should then review the migration of tidal flows and wave energy especially up the estuary and around Crow Point to establish wider impacts and potential solutions if unacceptable consequences are discovered.

### **Natural and Historic Baseline Environment**

Crow Point is within the Branton Burrows SAC/SSSI system and sections of it are within the AONB and the Heritage Coast.

Some of the MU is mapped as being the BAP habitat Mudflat and the land is not classed under the Agricultural Land Classification.

*Petalophyllum ralfsii* a European Protected Species has been recorded in the grid square just to the north of the management unit. This species is found in Branton Burrows in the humid slacks of the dune systems.

### **Potential Environmental Impacts, Mitigation and Opportunities**

Any changes to the SAC will need to be assessed under the Habitats Regulations. The site is already a muddy intertidal habitat and this will likely be lost but will likely contribute to a recovering SSSI. The muddy intertidal area is not natural here and is dependent on the rock armour at the expense of the health of the SSSI. Removal of this rock may allow the spit to form and change more naturally. The recommended modelling would be able to indicate the likely impacts with greater confidence.

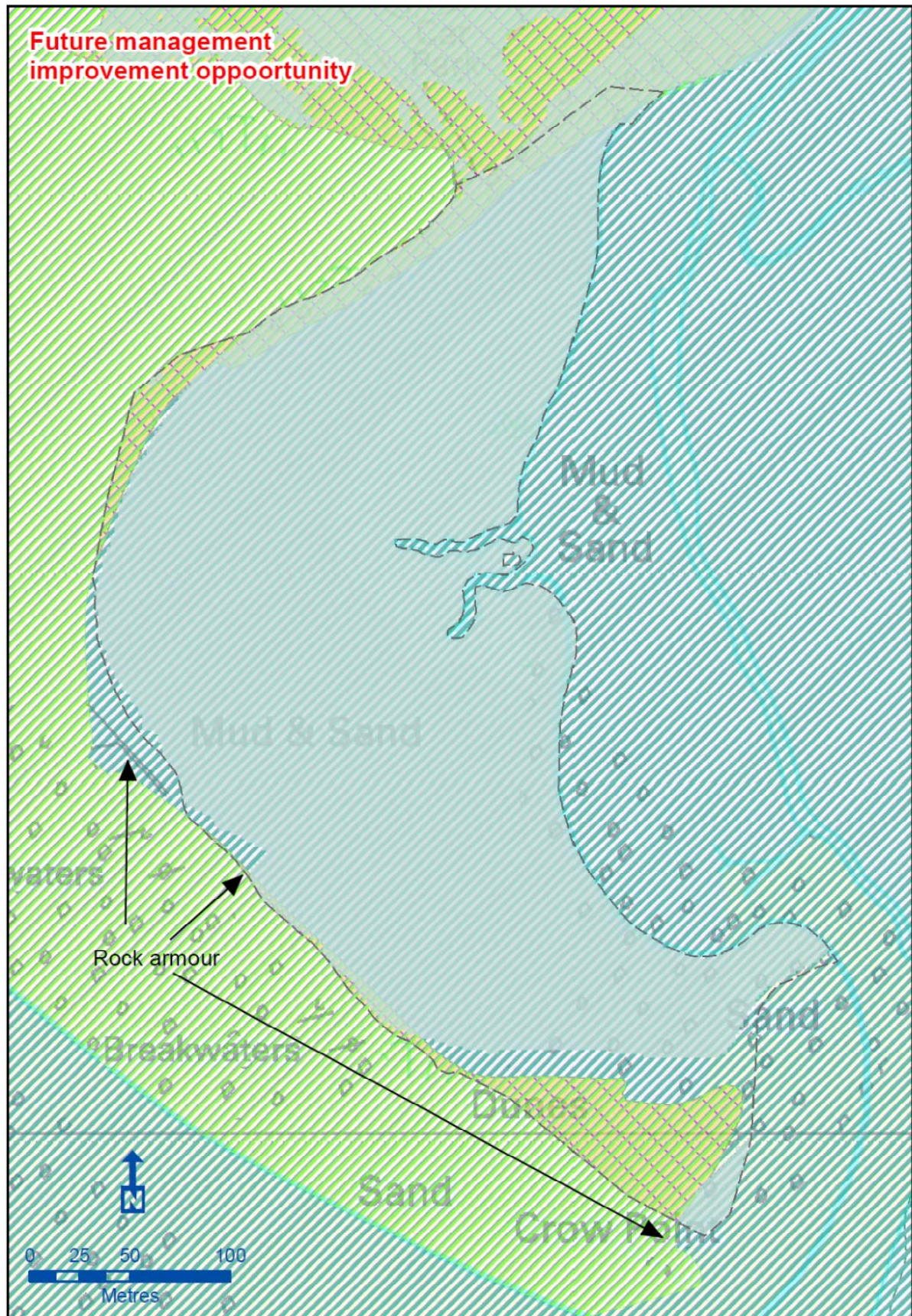


View of the bay looking towards the east. The saltmarsh is dominated by *Salicornia* spp. and expanding *Spartina anglica*; that on the right, hummocks of *Atriplex portulacoides* also present in 1980.

The view below, taken in September 2009 shows how narrow the point has become. By 30/1/13 this had evolved in to a wind blown breach.









# Appendix D – Identifying Potential Habitat Creation Sites

## **Habitat Site Selection Process (HSSP)**

### **1. Introduction**

This technical note outlines details of the methodology that has been used to identify potential habitat creation sites within the Taw-Torridge Estuary study area, as required as part of the wider Taw Torridge Coastal Management Study. The approach utilises Geographic Information Systems (GIS) and a methodology that was first developed to identify potential managed realignment sites around the Humber Estuary (Black & Veatch). This approach also builds on from a method reported within a Defra Guidance Document on suitability criteria for habitat selection (Report: R & D TECHNICAL REPORT II, FD1917).

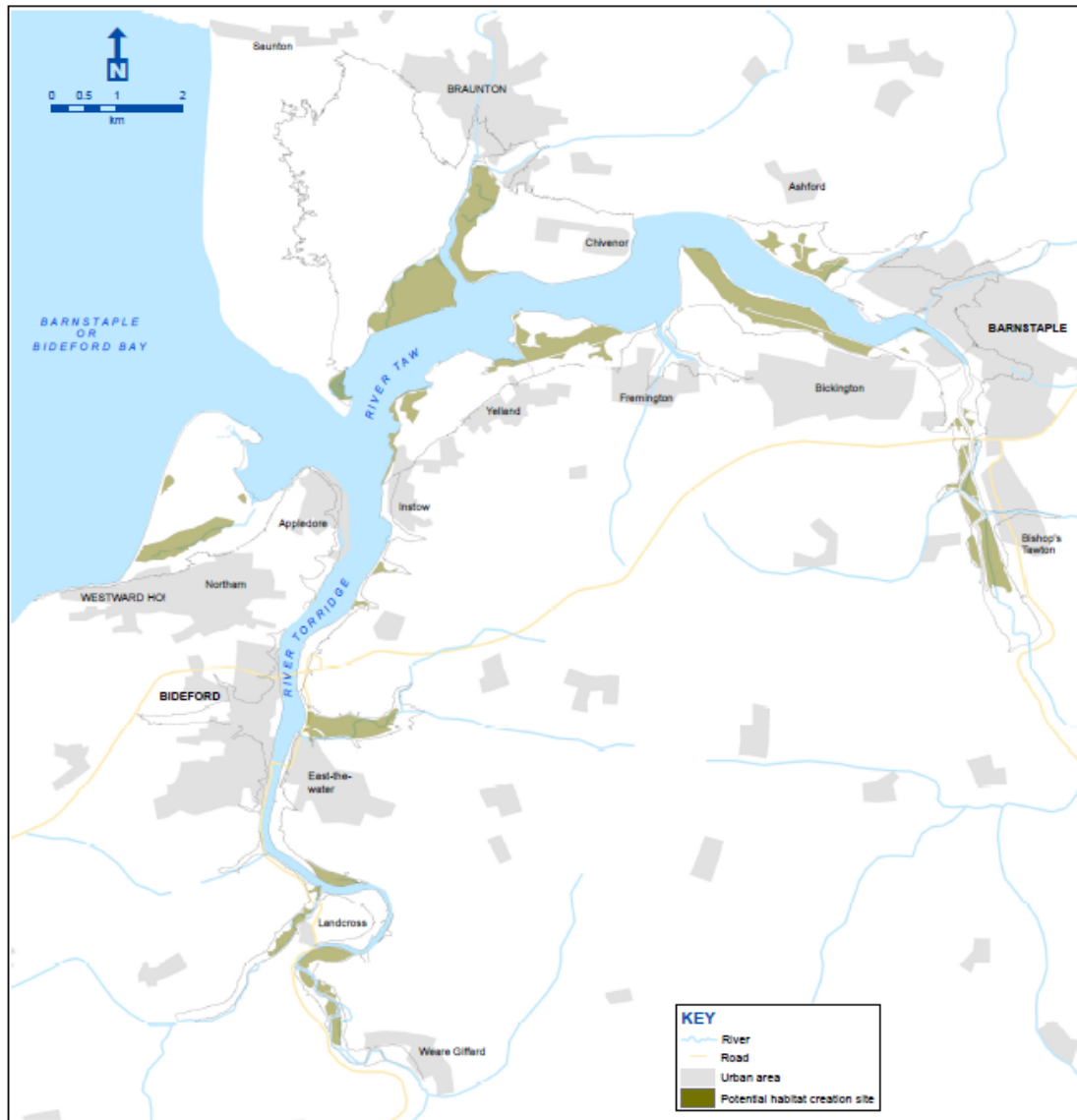
### **2. Overview**

The criteria used in the Habitat Site Selection Process (HSSP) are targeted towards the physical, chemical and ecological controlling factors of habitat creation. However, because multiple datasets can be compared using this method it has also been possible to import other socioeconomic, political or logistical constraints into the site selection process, such as Ordnance Survey spatial data (roads, footpaths), agricultural land grade, and conservation restrictions i.e. SSSIs, SACs etc.

The process we have used to inform site selection makes use of over 50 datasets. These provide detailed 'decisional criteria' on specific areas suitability for inclusion as a potential habitat site.

The datasets were collected, compiled and individually 'weighted'. The weightings were originally based on those used in the Humber Estuary Study but were later checked and reviewed by environmental experts for the Taw Torridge study (ref: meeting 10th January 2010).

Each of the 50+ weighted datasets were then merged into a single 'least score' database. This database identifies the final selection of potential habitat creation sites, see figure 1.



**Figure 1: Output of the least score database for the Taw Torridge Estuary.**

### 3. Methodology

The following section outlines the step by step process used in the HSSP.

#### 3.1 Collect, load and prepare the data

Data was collected from the various sources. All the data was converted to a suitable ESRI format. All existing raster datasets were converted and stored in their native resolution. For some datasets extra conversion, data derivation, or attribute selection was necessary.

#### 3.2 Determine Decision Criteria

The HSSP is based on the use of weights and influence, otherwise known as decision criteria, to make some datasets less attractive or more attractive within the site selection process. The weighting is undertaken through liaison with the experts to determine the weighting to apply to each of the 'decision criteria' datasets

#### 3.3 Apply Decisional Criteria

For the weighting process to function properly all the input data must be standardised to have the same coverage area.

All the raster datasets are prepared to 5m resolution to provide the necessary granularity to distinguish roads and rivers. Having a coarser (i.e. above 5m) resolution will result in the roads not being distinguishable. A finer resolution (e.g. lower than 5m) can be accommodated at a cost of the model having a longer processing time.

### 3.4 Create the least score database

Once all the data has been rasterised and the weightings determined the next step is to aggregate the decision criteria layers together to create a single least score database.

### 3.5 Data sets assessed

Ref_No	Source Dataset
1	Listed Buildings
2	Parks and Gardens
3	Protected Wreck Sites (England)
4	Scheduled Monuments
5	World Heritage Sites
6	Ancient woodland England
7	Areas of Outstanding Natural Beauty
8	Country Parks
9	Environmentally Sensitive Area Agreements England
10	Environmentally Sensitive Area Boundaries
11	Heritage Coasts
12	Local Nature Reserves
13	National Nature Reserves England
14	National Parks
15	National Trails
16	Possible Marine Special Areas of Conservation
17	Potential Marine Special Protection Areas
18	Ramsar Sites England
19	Sites of Special Scientific Interest England
20	Special Areas of Conservation England
21	Special Protection Areas England
22	Important Bird Areas
23	RSPB UK Reserves
24	Sites of Nature Conservation interest (SNCI)
25	Agricultural Land Classification
26	Historic Landfill
27	Properties
28	Roads
29	Railways
30	Slope
31	WaterCourses
32	BAP Habitats:-
33	Blanket Bog
34	Coastal & Floodplain Grazing Marsh
35	Coastal Sand Dunes
36	Coastal Vegetated Shingle
37	Deciduous Woodland
38	Fens
39	Lowland Calcareous Grassland



<b>Ref_No</b>	<b>Source Dataset</b>
40	Lowland Dry Acid Grassland
41	Lowland Heathland
42	Lowland Meadows
43	Lowland Raised Bogs
44	Maritime Cliff and Slope
45	Mudflats
46	Reedbeds
47	Upland Calcareous Grassland
48	Upland Hay Meadow
49	Upland Heathland
50	Saline Lagoons
51	Ground Level
52	Northam Burrows Golf Region
53	County Wildlife Sites
54	Regionally Important Geological Sites (RIGS)
55	North Devon Network Sites
56	North Devon Key Features
57	Cean Valley Bat Sustenance Zone
58	Devon Unconfirmed Wildlife Sites

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# Appendix E – Economics Methodology

The aim of the economic appraisal was to identify whether predominately public funds could be invested to manage the flood risk in the future. The key questions include:

- What is the preferred approach to flood risk management?
- What is the scale of the current risk and how will this change in the future?
- When should we intervene to reduce flood risk, considering that this can be through a combination of significant asset investment and regular maintenance of the assets?

The economic appraisal has focused on how the embankments and walls which protect much of the estuary today should be managed

### **Assessment of current and future risks and damages**

The outputs from the hydraulic model of the estuary have been used to assess the current and future flood levels in the estuary, as discussed in Appendix F. Many properties and large areas of agricultural land are protected by existing walls and banks which, in general, serve to reduce the probability of flooding significantly throughout the estuary.

An assessment has been undertaken to identify the location of the banks and walls (based on our asset information NFCDD), the current standard of service provided by the defence and the current asset condition. Regular maintenance of walls and banks is vital if the defences are to perform satisfactorily and appropriate maintenance has been assumed when considering the engineering performance of the defences in the future. However all assets do deteriorate over time, and we have used *Guidance on determining asset deterioration and the use of condition grade deterioration curves* Environment Agency 2009 (the asset deterioration guidance report), to understand how the defences will perform in the future.

Many flood banks and walls are in good condition in the estuary and with appropriate maintenance may perform satisfactorily for 75 years, based on advice from the asset deterioration guidance report. For those assets which are only in fair condition it is assumed that the engineering life is 50 years. Further detailed appraisal at project level will be able to refine this assessment.

Flood damage for each cell has been calculated using the Flood Damage Economic Model (FDEM) – refer to notes at the end of this Appendix. The model has effectively been run for each cell assuming that defences are not in place and then again assuming defences are in place. Over time defences become more vulnerable to being over topped due to sea level rise. This is taken into account in the analysis, which assumes that once over topped under severe events the defences have no significant impact on the corresponding flood level inland.

Economic damages have been considered for a wide range of receptors. However at this level of appraisal not all receptors are significant. Receptors and values are summarised below:



Receptor	Significant	Data Source and valuation
Property (both residential and commercial)	Yes	<p><i>The Benefits of Flood and Coastal Risk management: A Handbook of Assessment Techniques, 2010.</i></p> <p>Damages vary by property type and flood depth. Typically for residential property, flood damage is £30,000</p> <p>Residential property damage calculations include an allowance for Distributional Impacts (DI). The DI assessment allows for consideration of social equity and reflects that those on lower incomes suffer disproportionately from flooding when considered against those on higher incomes. In the study area the DI assessment increases residential damages on average by 23%. However this value varies from 0% to 42% depending on the cell.</p>
Agriculture	Yes	<p><i>The Benefits of Flood and Coastal Risk management: A Handbook of Assessment Techniques, 2010</i></p> <p>Environment Agency's land and property service</p> <p>A value of £315/Ha is assumed once the land is flooded. The market price for land is taken as £17,000/ha</p>
Emergency Services	Yes	<p>This represents the costs associated with responding to flood events.</p> <p>It is normal to take this as a proportion of the property damages and a standard value of 10.7% has been adopted (source <i>The Benefits of Flood and Coastal Risk management: A Handbook of Assessment Techniques, 2010.</i>)</p>
Traffic Disruption	No	Flooding is not considered economically significant based on the local road network. Where the loss of a road may be an issue this is considered on a case by case basis.
Risk to life	No	Not considered economically significant assuming appropriate flood warnings in place

FDEM is a Geographical Information System calculation model, produced for use primarily on Environment Agency projects, which uses ESRI GIS software tools to calculate the property damages in line with FCERM-AG guidance. The analysis includes the assessment of both residential and commercial property. FDEM compares flood water

levels with property threshold levels to generate flood depths; appropriate depth damages are then applied. FDEM calculates present value (PV) damages over the project life applying the latest Green Book discount rates.

The required data for FDEM to run includes property type (land use code), property threshold level, property area (for non-residential properties only), property valuation and flood levels for appropriate extreme flood events. The FDEM is then used to calculate the total flood damage contributed by each individual property.

Ordnance Survey (OS) Mastermap (the best available digital representation of what is on the ground) is used to provide FDEM with the location of buildings. The National Receptor Database (NRD) and OS Address Layer 2 datasets are then used to update Mastermap building polygons with land use information using Multi Coloured Manual<sup>2</sup> codes, floor areas and valuations. Although there are still undefined properties in the study area, they were identified and quantified. In the Taw-Torridge study area, just over 5,000 unmatched structures were identified. The majority of these were classified as non habitable, non permanent structures (typically sheds and out buildings) and were therefore excluded from any further analysis.

The depth damage data was taken from the Multi Coloured Manual and initially updated to December 2011 values using the Consumer Price Index. A ground level was assigned to each building within FDEM using filtered LiDAR data provided by the Environment Agency. In this case we used site knowledge and previous experience to inform the choice of threshold factors for properties; adding + 150mm for residential and non-residential properties.

All data within FDEM has been given a Data Quality Suffix (DQS). This scores the quality of each element of the data. This can be used for audit purposes and allowed us to focus on areas of poor quality data which may be significantly contributing to the damages.

### **Site screening**

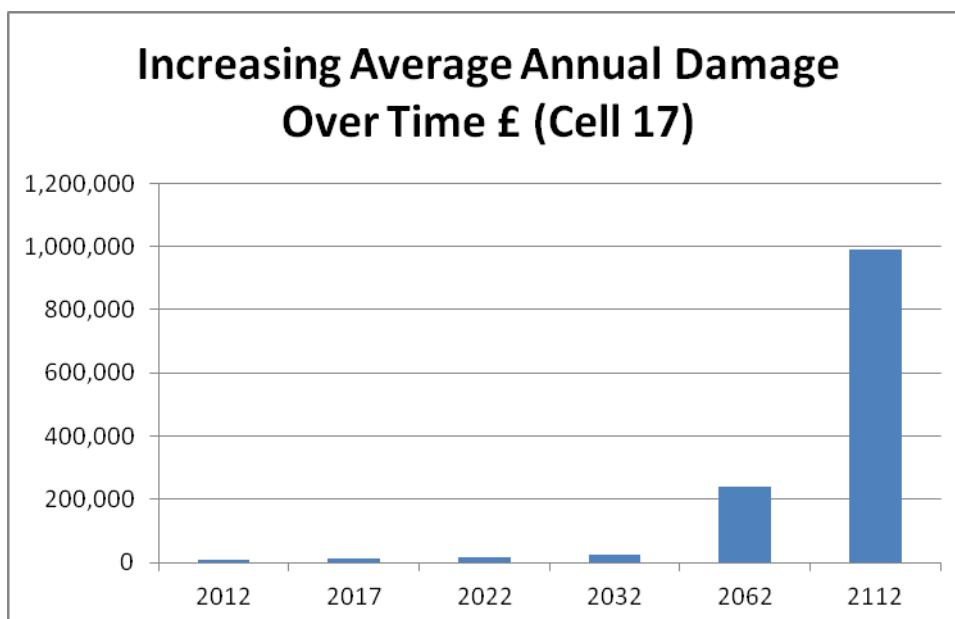
At this level detailed assessment of individual scheme options have not generally been undertaken. A screening exercise has been undertaken to determine whether economically any significant flood management works can be justified. This course screen aims to assess whether the benefits of the works are likely to be greater than the costs.

For the screening phase it is assumed that flood defences will be raised and structurally improved along their current alignment. Costs were established from the 'Flood Risk Management Estimating Guide: Unit Cost Database' and from recent similar work. In general it was assumed that bank raising and improvement costs were £2,000/metre and wall raising was taken as £5,000/metre. Costs of defence work were built up from drawings of the defences, the linear costs and maintenance costs. Maintenance costs have been taken as £3.11/linear metre of bank per year based on SAMP data. In general all costs are based on estimated outturn costs for similar type work.

The screening process then compared the cost of a major intervention with the likely benefits looking forward. This assessment has been undertaken for different future dates, as flood damages will increase due to increasing sea levels and asset deterioration. This is illustrated below for flood cell 17.

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<sup>2</sup> Multi Coloured Manual (MCM) more formally The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques, E Penning-Rowsell et al, 2010



Through the screening process and taking into consideration other environmental drivers and opportunities, each flood cell was sorted into different categories as discussed in the main report section entitled 'How we developed our potential options'.

#### Details of FCRM Priority Sites and Financing

From the screening and process, FCRM sites were identified where it appeared that there was likely to be work that could be justified in the short term (in the next 5 years). For these sites further work was undertaken to improve the understanding of benefits, costs and intervention phasing. In most cases the assessment identified priority sites where relatively modest work was justified in the short term with more significant improvements justified in the future. The data is summarised below and should be read in conjunction with the unit summary sheets.

At this level the scheme selection and scheme cost is indicative, based on strategic level assumptions. However further work was undertaken to identify where new defences were required or where upgrading of existing defences could be justified. Data from the NFCDD was used to assist with this assessment in conjunction with other local data where available. In most cases the works required focus on discrete areas where defences are currently too low or where asset condition would indicate that improvements could be justified. However no work was undertaken to optimise the standard of protection.

In general the benefit/cost ratios are relatively low reflecting the relatively few assets protected by long lengths of walls and banks.

Funding of the schemes will need to be met through a combination of public and private finance. Options for each cell are discussed below. In general a 50 year scheme design life has been assumed. It is expected that further major expenditure will be required after this time to reflect increasing sea levels and asset deterioration. Flood Defence Grant in Aid (FDGiA) has been assessed using the Partnership Funding Calculator. In general the value of FDGiA is driven by the economic benefits derived from the scheme, although the number of residential properties that benefit from the scheme are prioritised in the calculator. The scheme benefits have been estimated based on the expected performance of the scheme relative to the 'Do nothing' option derived through FDEM.

Flood Cell	1 Northam Burrows	3 Northam	17 Bideford Right Bank	23 Yelland (Instow Barton)	45a Braunton Marsh
Short term scheme cost £k	250	230	925	381	1,000
Present Value Scheme Cost £k (including maintenance)	n/a	278	1,066	634	1,269
Approximate Present Value Scheme Benefit £k	Cost to remove Northam Burrows former landfill estimated as £150 million	1,007	544	1,522	5,183
Nominal Benefit/Cost Ratio (without private contribution)	n/a	3.62	0.51	2.40	4.08
Indicative value of Flood Defence Grant in Aid £k	Not Known (see note 1)	71	52	85	288
Residual cost to be met through Partnership funding £k	Possibly 250	207	1,014	549	981
Scheme Details	Approximately 100m of rock armour to protect landfill site from erosion	110m of masonry wall raising	185m of quay wall raising	Improvements to 762m of existing bank to enhance structural condition	Works to address risk to isolated properties. Scope of work unclear due to modelling uncertainties
Partnership Funding Opportunities	In terms of the scheme to protect the landfill there are unlikely to be any private funding opportunities, and costs are likely to fall to the relevant Local Authority	Works would protect a sewage treatment works, providing opportunities for partnership funding	Private investment is essential to a value of at least £522k to make public investment worthwhile. An investment of about £1m would pay for the works	The defences generally protect commercial sites, so providing some opportunity for private funding	This site is complex, finance could be explored with relevant farm businesses

Note 1: Financing of the Northam Burrows works (in the short term just the landfill protection works) is complex depending on liabilities. FDGiA could be explored, but has not been attempted given the overall uncertainties.



# Flood Damage Economics Model (FDEM)

We have used the Black & Veatch FDEM system to calculate the property damages. FDEM is a Geographical Information System calculation model, produced for use primarily on Environment Agency projects, which uses ESRI GIS software tools to calculate the property damages in line with FCERM-AG guidance. FDEM compares flood water levels with property threshold levels to generate flood depths; appropriate depth damages are then applied. FDEM calculates present value (PV) damages over the project life (typically 100 years), applying the latest Treasury guidance (Green Book) discount rates.

The required data for FDEM to run includes property type (land use code), property threshold level, property area (for non-residential properties only), property valuation and flood levels for appropriate extreme flood events.

The FDEM is then used to calculate the total flood damage contributed by each individual property which is compared with the market value for each property. The lower of these two values is then taken forward through the economic appraisal.

## Property Data

Ordnance Survey (OS) Mastermap (the best available digital representation of what is on the ground) is used to provide FDEM with the location of buildings. The National Receptor Database (NRD) and OS Address Layer 2 datasets are then used to update Mastermap building polygons with land use information using Multi Coloured Manual<sup>3</sup> codes, floor areas and valuations. Although there are still undefined properties in the study area, we quantify them and identify where they are. In the Taw-Torridge study area, just over 5,000 unmatched structures were identified. The majority of these are classified as non habitable, non permanent structures and were therefore excluded from any further analysis.

## Depth Damage Data

The depth damage data was taken from the Multi Coloured Manual and initially updated to December 2011 values using the Consumer Price Index available from the Office for National Statistics. Below threshold flood damages were included within the appraisal for residential properties; below threshold flood damages do not apply to non-residential properties unless they are known to have a basement, so at a strategic level this was not applied.

## Threshold Levels

A ground level was assigned to each building within FDEM using filtered LiDAR data provided by the Environment Agency. In this case we used site knowledge and previous experience to inform the choice of threshold factors for properties; adding + 150mm for residential and non-residential properties.

## Write-off (Market) Values

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<sup>3</sup> Multi Coloured Manual (MCM) more formally The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques, E Penning-Rowsell et al, 2010

Write-off values for residential properties have been taken from the Land Registry (December 2011) using Devon County values; these values represent no risk regional values. Write-off values for the different classes of commercial properties are based on bulk average<sup>4</sup> and yield data available from the Department of Communities and Local Government.

### **Flood Type and Duration**

The flooding considered within the Taw-Torridge Strategy area is predominantly tidal. However, within the upper reaches of the River Taw and River Torridge, combined events have also been considered.

Depth damage data from the MCM is only available for tidal flood durations less than 12 hours as the water could leave the area at the time of low tide, therefore less than 12 hour flood duration figures have been used. The depth damage data for tidal flooding are higher than those for fluvial flooding as they take into account the additional damage caused to property by saline water.

### **Social Equity/Distributional Impacts**

Social Equity multipliers/ Distributional Impacts, based on the 2001 census data, have been included within this economic appraisal. Social equity values are automatically applied within the FDEM dependant on property location to ensure that the full economic case is provided in our appraisal. Damages are capped at regional market values which represent no risk values.

### **Data Quality and Audit**

All data within FDEM has been given a Data Quality Suffix (DQS). This scores the quality of each element of the data. This can be used for audit purposes and allows us to focus on areas of poor quality data which may be significantly contributing to the damages.

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<http://www.communities.gov.uk/planningandbuilding/planningbuilding/planningstatistics/livetables/tablescommercialindustrialfloors/>

# Appendix F – Water Levels and Confidence Limits

## **Taw Torridge Flood and Coastal Risk Management Study**

### **Water Level Data Summary**

## **F-1 Introduction**

This report provides a summary of the water level data that was available for this study. It discusses how the data was utilised to provide water level datasets for use in the Taw Torridge Estuary Coastal Management Study.

## **F-2 Extreme Tide Levels**

### **F – 2.1 2002 EWL Data**

In 2003 Royal Haskoning completed the 'Report on Regional Extreme Tide Levels'<sup>1</sup> on behalf of the EA. The report presented regionally consistent extreme tidal water level data, derived for sites throughout the EA's South-West region. Throughout this report and the Taw Torridge Estuary Management Study, this data is referred to as the 2002 EWL dataset.

Present day conditions within the report refer to 2002. Tide levels were determined for the mean low water spring tide, mean high water spring tide, the highest astronomic tide and the following extreme water levels: 1, 5, 10, 25, 50, 100, 250, 500 and 1000 years.

For all sites the principles of the Spatial Revised Joint Probability Method (SRJPM) proposed by the Proudman Oceanographic Laboratory (POL) in Report No.112<sup>2</sup> was used. Adjustments to these values were made using up to date site data. For coastal sites where sufficient reliable site-specific data was available, the 1-year tide level was derived utilising the Generalised Extreme Value (GEV) method. Where data for a site was insufficient or unreliable, the 1-year tide level was interpolated using a trend line between values for the nearest POL 112 stations and values for sites where a 1-year tide level could be derived from specific data.

For coastal sites between Avonmouth and Exmouth, the POL Report No.112 recommended that a growth factor be applied to the 1-year tide level to give appropriate extreme tide levels up to the 1000-year tide level.

For sites in estuaries, inlets and tidal rivers (including the Taw and Torridge estuaries), a 1-year tide level was derived using GEV analysis of the EA's SCOPE data where this was available. Where this was not available, 1-year tide levels were estimated from differences in tidal peak levels observed during high tide periods of September 1999 and September 2001. Extreme water levels up to the 1000-year tide level were obtained by applying the growth factor, as at the estuary mouth, to the 1-year tide level. The exceptions to this on the River Taw are Barnstaple and Bishops Tawton, where the range of tide levels was taken from an earlier correlation with Ilfracombe.

Table F-1 lists the confidence that can be placed in the extreme tide levels derived in the study, stated in the study report. Confidence limits were applied as follows:

- High - +/- 0.2m
- Medium - +/- 0.4m
- Low - +/- 0.6m



	Tide Levels			
	1-Year to 50-Year	Greater Than 50-Year	1-Year to 200-Year	Greater Than 200-Year
Appledore	Medium	Low	-	-
Yelland	Medium	Low	-	-
Barnstaple	-	-	High	Medium
Bishops Tawton	-	-	High	Medium
Braunton	-	-	Medium	Low
Bideford	Medium	Low		

**Table F-1: Degree of confidence in the 2002 extreme water levels**

## F-2.2 2008 EWL Data

In 2008 The Environment Agency started a study titled 'Improved Coastal Flood Boundary Conditions for the UK mainland and islands' (referred to hereafter as the 'Coastal Flood Boundary Conditions study'). It should be noted that this study started in 2008 but results and outputs were not published until 2010. Present day conditions within the study relate to design sea levels in the year 2008 and therefore datasets from this study have been referred to as 2008 EWLs throughout the Taw Torridge Estuary Coastal Management Study.

The purpose of the study was to provide an up-to-date scientifically robust national evidence base and practical guidance on appropriate design sea level and swell wave conditions around the country. The following outputs were developed:

- A consistent set of design sea levels, uncertainty data and design surge curves around England, Wales and Scotland;
- A Consistent set of design swell wave conditions around England, Wales and Scotland; and
- Practical Guidance on applying the above datasets.

Tide-level data recorded at 40 Class A gauge sites within the study area formed the basis of the analysis. Statistical analysis was completed for the Class A sites, and for a further five sites included as primary sites, to generate probabilities of predicted high tide and of skew surge. To provide full coverage of return period sea levels around the coastline, an interpolation method was used to determine return period sea levels between Class A and primary sites at approximately 2km spacings along a normal coastal chainage line.

The datasets developed represent extreme sea level values for still water levels only and reflect 'present day conditions' only, and do not include the effects of climate change, which need to be considered separately.

Full details of this study can be found in the study reports<sup>3 4 5 6</sup>.

As part of the Coastal Flood Boundary Conditions study, EWLs were not provided along the Taw and Torridge estuaries (or any other similar estuaries). This was a deliberate exclusion as it was recommended that individual studies would be required on each estuary to give any confidence in the EWLs derived. A separate assessment was therefore completed by the Environment Agency titled 'Extreme Tide Levels in Estuaries and Tidal Rivers in the South West Region'<sup>7</sup>. Within this assessment tide levels were calculated at Bideford, Weare Giffard, Braunton, Yelland, Barnstaple and Bishops Tawton. The following methodologies were applied to derive EWLs for each location:

- Bideford – The 1-year and 10-year EWLs for Bideford were calculated using data from the gauges at Kenwith Outfall. The form of analysis was the same as that adopted for the coastal gauge sites. The growth from the 10-year to 1000-year level was taken as being the same as applicable at the mouth of the estuary.
- Weare Giffard – Due to the strong influence of prevailing fluvial conditions, the higher levels recorded at the Weare Giffard gauge were compared to equivalent tide levels recorded at Kenwith Outfall, Bideford, to ensure that only tidally dominated events were

included in the analysis. A level to level relationship was derived, from which the results for Weare Giffard have been obtained.

- Braunton – Results for Braunton were obtained in the same way as for Bideford, making use of the Braunton gauge data as the local information.
- Yelland and Barnstaple – As no new data was available for Barnstaple since publication of the 2003 Report on Regional Extreme Tide Levels, the relationships between Ilfracombe, Yelland and Barnstaple defined in the 2003 study were utilised to provide EWLs for the 1-year and 10-year return events at Yelland and Barnstaple. The growth from the 10-year to 1000-year level was taken as being the same as applicable at the mouth of the estuary.
- Bishops Tawton – The only available data from Bishops Tawton were peak levels from 'Tidewatch' event monitoring which suggested levels at Bishops Tawton were 0.1m higher than at Barnstaple. This relationship was adopted for all return periods.

## F -3 Existing Studies

### F – 3.1 Torridge District Council Level 2 Strategic Flood Risk Assessment

The Torridge District Council Level 2 Strategic Flood Risk Assessment (SFRA) was completed by Hyder Consulting in 2010<sup>8</sup>. The purpose of the SFRA is to help deliver sustainable development by providing an assessment of all types of flood risk at a Local Planning Authority level and guide new development to areas where the risk of flooding is lowest. The study concentrated on the areas of Appledore, Bideford, Westward Ho! and Northam, and a full 2D hydraulic model was constructed using the Mike21 software.

Fluvial flows were calculated for the River Torridge at eleven locations using the Revitalised Flood Hydrograph method. Tide level data was taken from a number of sources. Low tide and 1-year water levels were taken from the 2003 Report on Regional Extreme Tide Levels<sup>1</sup>, whilst simulations of the 200-year and 1000-year tidal events were based on a tide curve for Westward Ho! (produced by the EA), combined with data from the Devon Tidal Flood Zone Project<sup>9</sup>, and corrected to the appropriate EWLs defined in the 2003 Report on Regional Extreme Tide Levels<sup>1</sup>. Sea level rise was applied to the 200-year and 1000-year EWLs in accordance with Defra's 100-year allowances applying at the time of the study. This equated to a rise in sea level of 1m.

The hydraulic model was run for a range of scenarios, including post construction conditions. Those scenarios modelled that were of interest to this study are listed below:

- Low Tide with 20-year fluvial flows
- 200-year tide with 20-year fluvial flows
- 200-year tide with 1-year fluvial flows
- 1-year tide with 100-year fluvial flows
- 1-year tide with 1000-year fluvial flows
- 1000-year tide including sea level rise with 1-year fluvial flows
- 200-year tide including sea level rise with 1-year fluvial flows

A review of the SFRA hydraulic model and its outputs was undertaken, which identified a number of inaccuracies with the hydraulic model and inconsistencies with the outputs.

### F – 3.2 Devon Tidal Flood Zone Project

The Devon Tidal Flood Zone, Areas Benefiting from Defences and Flood Risk Area Improvements project (hereafter referred to as the Devon Tidal Flood Zone project) was completed by Royal Haskoning in 2008. The scope of works included: a tidal flood zone review; wave transformation modelling; definition of tidal areas benefiting from defences; definition of flood warning flood risk areas; flood warning improvement look-up tables; and a PDF map viewer. Full details of the study can be found in the project report<sup>9</sup>.

No fluvial hydraulic modelling was undertaken on either the River Taw or River Torridge. However, EWL values were available for a number of sites around the Devon Coast defined in the 2003 Report on Regional Extreme Tide Levels<sup>1</sup>. This included the Mouth of the Taw, Appledore, Yelland, Barnstaple, Bishops Tawton and Bideford. EWLs for Weare Giffard were not included in the 2003 Report on Regional Extreme Tide Levels but further analysis was undertaken as part of the South West Tidal North Coast Tidal Flood Risk Mapping study<sup>10</sup> completed in 2004. As part of this study tide level data was provided by the EA to produce a water level relationship for the River Torridge, resulting in EWLs for Weare Giffard. No further details on the analysis undertaken are provided in the project report.

As part of the Devon Tidal Flood Zone project, additional intermediate EWL values were interpolated at 2km spacings using a simple linear interpolation.

## F – 3.3 Barnstaple 2D Modelling Study

The Barnstaple 2D Modelling Study was completed by Mott MacDonald in 2009. The scope of the project was to produce flood risk maps for various return periods for the Taw Estuary and its tributaries, to gain a better understanding of flood mechanisms and flood risk. The linked 1D/2D ISIS-Tuflow model extended from Home March Farm at Yelland to Bishops Tawton. Full details of the study are provided in the final study report<sup>11</sup>.

A number of fluvial and tidal events were modelled including:

- Fluvial –  $Q_{MED}$ , 5-year, 10-year, 20-year, 50-year, 75-year, 100-year, 100-year +20% and 1000-year.
- Tidal – 10-year, 20-year, 50-year, 75-year, 100-year, 200-year, and climate change scenarios for 2070 and 2115 for the 20-year and 200-year return periods only.

The fluvial events were modelled in combination with a 1-year tidal boundary, whilst the tidal events were modelled in combination with a  $Q_{MED}$  inflow. One joint probability event was modelled which incorporated a 100-year fluvial inflow combined with a 200-year tidal boundary. In this study the peak of the tidal curves coincided with the peak of the fluvial hydrographs at Barnstaple to give a 'worst case' scenario.

Peak fluvial design flows were taken from previous studies, namely the Devon Flood Hydrology Strategy<sup>12</sup> completed in 2007. Design hydrographs were derived using the Revitalised Flood Hydrograph method and default catchment descriptors. The resulting hydrographs were scaled to fit the peak flows defined in the 2007 study. The 5-year, 20-year and 75-year peak flows were not developed in the 2007 study and were therefore interpolated based on the growth curve from available peak flows.

EWLs were extracted for Yelland (the downstream boundary of the model) from the 2003 Report on Extreme Tide Levels<sup>1</sup>. EWLs were not available for the 20-year and 75-years events and were therefore interpolated from the other available EWLs using logarithmic regression analysis.

Due to a lack of flow and level data available for the study area, the final model was not calibrated. However, a sensibility check was undertaken for some of the tributaries including the River Taw and River Yeo, making use of data from the November 2000 event, and the Fremington Stream, making use of a predicted flood peak for the 1993 event. The sensibility checks concluded that the Rivers Taw and Yeo were replicating the flooding of the November 2000 event well and no adjustments were made to the model. However, the flooding observed on the Fremington Stream in the 1993 event was not replicated. This resulted in the design hydrographs for the Fremington Stream and Muddle Brook being altered upon agreement with the EA.

## F - 3.4 Braunton Flood Defence Improvements Study

The Braunton Flood Defence Improvements Study was completed by Halcrow Ltd in 2011. The purpose of this study was to assess the flood risk to Braunton from the River Caen, to identify the potential impacts of flood events and identify the annual probability of their occurrence.

A linked 1D/2D ISIS-Tuflow hydraulic model was constructed representing the River Caen from 10m upstream of Dean's Bridge at Church Street to its confluence with the Knowl Water, downstream of Velator Bridge. Possible improvement options were identified and modelled. Full details of this study are provided in the final study report<sup>13</sup>.



Peak fluvial flows for the River Caen were provided by the Environment Agency for the 10-year to 100-year events. Peak flows from Stoneybridge Flood Warning station (3km upstream of Braunton) were transposed to Braunton, with flows above the 100-year and below the 10-year events extrapolated from the available data. Hydrographs were created using the rainfall runoff method and scaled to fit the peak flows provided by the Environment Agency. The final study report acknowledges that there is a degree of uncertainty in the hydrology due to the need to transpose flows downstream from Stoneybridge and the relatively limited local flood data available in Braunton.

The same tidal boundary was used in all scenarios modelled. The study report does not provide any details on the origin of the level used as the downstream tidal boundary, but with a level of 5mAOD, this is somewhere between a MHWS and 1-year tide. The study report states that the study area is not tidally influenced, even when tidal and fluvial peaks are coincident. For this reason, the tidal boundary adopted is considered appropriate for the purposes of the study.

Historic flood data from the December 2004 event was used to verify the model. This included wrack marks, flood marks on properties and flood depths calculated during a previous study completed by Jacobs in 2007. This historic flood data was compared to the results of the 25 and 50-year models, concluding that the model may be underestimating out-of-bank flows in the town and therefore flood extents, or it may be that further significant flood sources or pathways were not represented. No changes were made to the model based on the verification process but this is considered acceptable based on the nature of the historic flood data available.

## F – 4 Final Datasets and Confidence Bands

### F – 4.1 River Taw - Mouth of the Taw to Yelland

The only datasets available for the River Taw between the Mouth of the Taw and Yelland are EWLs from the 2003 Report on Regional Extreme Tide Levels<sup>1</sup>, 2008 Coastal Flood Boundary Conditions study<sup>3 4 5 6</sup> and 2008 EA assessment Extreme Tide Levels in Estuaries and Tidal Rivers in the South West Region<sup>7</sup>. No hydraulic modelling has been undertaken along this reach.

It is appropriate to use the 2008 EWL dataset from the Coastal Flood Boundary Conditions study<sup>3 4 5 6</sup> at the Mouth of the Taw in preference to the 2002 dataset<sup>1</sup> as it utilises the most up-to-date data and analysis techniques. Whilst this dataset provides the best available estimates for the Mouth of the Taw, values are interpolated between the primary site at Ilfracombe and secondary site at Padstow, due to the lack of gauge data in the immediate area. For this reason a medium level of confidence can be placed in the values. As part of the 2008 study, confidence intervals were provided for each EWL. The confidence intervals for the Mouth of the Taw are shown in Table F-2.

EWL values for Yelland have been taken from the 2008 EA assessment Extreme Tide Levels in Estuaries and Tidal Rivers in the South West Region<sup>7</sup>. The 1-year and 10-year EWLs have been derived by utilising the level relationships defined in the earlier 2003 Report on Regional Extreme Tide Levels<sup>1</sup>. These EWL values have therefore been attributed a medium-low level of confidence. EWLs values in the 2008 EA assessment for events greater than a 10-year return period have been derived by applying the growth between the 10-year and 1000-year levels at the Mouth of the Taw, as it is acknowledged that the level relationship between Yelland and Ilfracombe is not valid for return periods above the 10-year event. Whilst this approach is sensible given the lack of gauge data at Yelland for events of a higher magnitude than the 10-year event, the growth at this location is unlikely to be the same as that at the Mouth of the Taw due to the change in estuary dynamics between the two locations. For this reason EWLs at Yelland above the 10-year event have been attributed a low level of confidence.

The final EWLs used for the Mouth of the Taw (chainage 224 in the national dataset) and Yelland can be seen below in Table F-2. It should be noted that these values incorporate a 0.02m increase in levels which represents sea level rise between 2008 and 2012, the date of this study. Discussion of how this sea level rise was calculated is included in section 0.

Return Period (Years)	EWL Location		
	Mouth of Taw (National Chainage 224) mAOD	Confidence Interval for the Mouth of the Taw mm	Yelland mAOD
1	5.04	+/- 100	5.22
10	5.27	+/- 100	5.41
20	5.34	+/- 100	5.48
50	5.43	+/- 100	5.57
75	5.48	+/- 100	5.62
100	5.51	+/- 200	5.66
200	5.58	+/- 200	5.73

**Table F-2: Final EWLs for the Mouth of the Taw and Yelland**

Water levels between the two EWL locations (the Mouth of the Taw and Yelland) have been derived from linearly interpolating between the two known EWLs at 200m intervals.

## F – 4.2 River Taw - Yelland to Bishops Tawton

Results from the Barnstaple 2D modelling study can be compared against three 2002 EWL locations (Yelland, Barnstaple and Bishops Tawton) and six EWL locations from the Devon Tidal Flood Zone project (TAW 6, TAW 8, TAW 10, TAW 12, TAW 14 and TAW 16). Comparison of results from the Barnstaple 2D model and the 2002 EWL values show that the model is predicting lower peak water levels at Barnstaple and Bishops Tawton, even though fluvial inputs are contributing to increasing total flow in the River Taw. For this reason a high level review was undertaken of the 2002 EWL data and the following points were noted:

- The report states that a high degree of confidence can be placed in the EWLs up to the 200-year event, and medium confidence thereafter.
- EWLs at Barnstaple '*were taken from an earlier correlation with Ilfracombe*'. This was analysis carried out by Posford Haskoning in 2000 as part of an FRA for proposed development at the Sticklepath area of Barnstaple. The analysis used a three-way comparison of coincident tide data from Barnstaple, Yelland and Ilfracombe. It provided return period tide levels at Barnstaple, substantiated by more extensive data available at the two other sites.
- High tides (>5m) were selected from the Barnstaple tide records. The corresponding high tides for Yelland were also obtained. These were plotted against each other to investigate the relationship and a best fit line applied, extrapolating water levels above those recorded. The same was done for Yelland and Ilfracombe.
- This resulting analysis gave a 10-year tide level of 5.8mAOD at Barnstaple, placing the 1981 event at around 1 in 10-years.
- At Bishops Tawton, monitoring on 27<sup>th</sup> September 1999 and observation of the high tide event of 13<sup>th</sup> December 1981 showed tide levels reaching 0.1-0.2m higher than in Barnstaple. For the purposes of the 2003 study, a rise of 0.13m from Barnstaple levels was adopted for all return periods at Bishops Tawton.

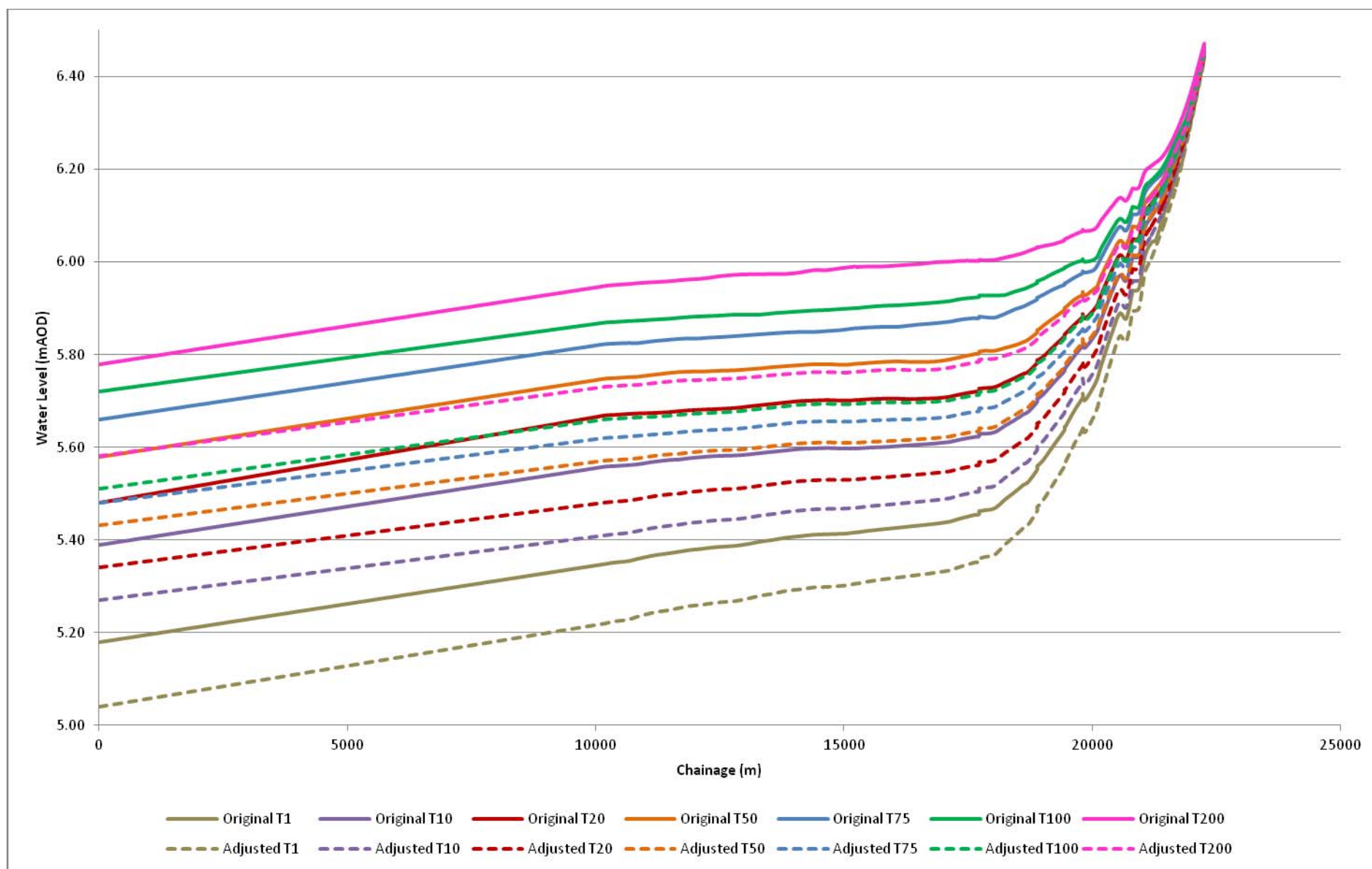
Based on the above high-level review it is likely that the 2003 study over-estimates EWLs for Barnstaple and Bishops Tawton, due to the way that the levels have been extrapolated. This could be substantiated by reviewing the tide gauge data for Barnstaple and undertaking further analysis but this is beyond the scope of this study.

When considering the new 2008 EWL values for Yelland, if these were applied as the downstream boundary of the Barnstaple 2D model, the model would continue to predict lower water levels at Barnstaple and Bishops Tawton compared to the 2008 EWL values.

Given the findings of the high level review of the 2002 EWLs and the fact that the Barnstaple 2D model provides a much better representation of the River Taw and joining tributaries between Yelland and Bishops Tawton, it was concluded that the results of the Barnstaple 2D model should be taken forward for use in the Taw Torridge Estuary Coastal Management Study.

It is acknowledged that the downstream boundary in the Barnstaple 2D model is based on EWL values from the 2003 Report on Regional Extreme Tide Levels<sup>1</sup>. As new EWL values have been published for the tidal reaches of the Rivers Taw<sup>7</sup>, it was concluded that these values should form the basis of the water level datasets used in this study. It was beyond the scope of this study to re-run the Barnstaple 2D hydraulic model with revised downstream boundaries. Therefore water levels between Yelland and Bishops Tawton were adjusted based on applying the relative differences between the set of modelled water levels and the 2008 EWLs at Yelland (the downstream boundary of the model, chainage 10,200 in Figure F-1F-1 below) to other points within the estuary. Prior to this adjustment the 2008 EWLs for Yelland were updated to reflect predicted levels for 2012, the date of this study. This update is described in more detail later.

The same adjustment formula was also applied to the River Yeo, Fremington Pill and Venn Stream as the River Taw.



**Figure F-1: Original and adjusted water levels from the Barnstaple 2D Modelling Study**

Due to the fact that a medium-low level of confidence can be placed in the 2008 1-year and 10-year EWLs for Yelland and a low level of confidence in the EWLs above this event, no more confidence can be placed in the adjusted water levels on the River Taw upstream of Yelland. It is also acknowledged that at Bishops Tawton and upstream, the confidence in adjusted water levels will decrease. This is due to the fact that water levels are more likely to be influenced by fluvial flows which have not been considered when adjusting water levels.

The final water levels between Yelland and Bishops Tawton and the confidence that can be placed in them can be seen below in Table F-3 and Table F-4 respectively.

Return Period (Years)	EWL Location		
	Yelland (mAOD)	Barnstaple (mAOD)	Bishops Tawton (mAOD)
1	5.22	5.31	5.83
10	5.41	5.47	5.90
20	5.48	5.53	5.93
50	5.57	5.61	5.97
75	5.62	5.66	5.99
100	5.66	5.70	6.00
200	5.73	5.77	6.03

**Table F-3: Final EWLs for Yelland, Barnstaple and Bishops Tawton**

Location	Confidence	
	1-Year to 10-Year Event	Above 10-Year Event
Yelland to Bishops Tawton	Medium to Low	Low
Bishops Tawton and Upstream	Low	Low

**Table F-4: Confidence in final water levels between Yelland and Bishops Tawton**

The Coney Gut diversion tunnel, Coney Gut overspill channel, Bradiford Water and Fremington Stream all have flapped outfalls on their downstream ends, preventing tidal inundation. For this reason they were excluded from assessment in this study, as it was not a requirement of the original scope to assess non-tidal or tide-locked reaches.

## F – 4.3 River Caen and Knowl Water

The Branton Flood Defence Improvements Study was preceded by a Pre-Feasibility Study in 2007<sup>14</sup>. The purpose of the pre-feasibility study was to assess the existing level of flood risk at two study locations, Branton town centre and the Velator Quay area, including an assessment of the standard of protection afforded at Branton Velator by the existing flood defences along the River Caen and Knowl Water.

The 2007 pre-feasibility report states that water levels along the Knowl Water are dominated by tidal water levels. An assessment of NFCDD undertaken as part of this study has indicated that the defence and bank levels along the Knowl River are sufficient to protect the vast majority of properties from flooding in the Wrafton area. For this reason it is considered appropriate to use the 2008 EWL dataset to extrapolate water levels in this area and not build a new hydraulic model of the Knowl Water.

A previous flood risk assessment undertaken by Hyder Marcus Hodges in 2006, referred to in the 2007 pre-feasibility report, indicated that water levels along the River Caen at Branton Velator are dominated by fluvial water levels. The assessment concluded that the 100-year fluvial event combined with a 2-year tidal event (the combination of events that instigate flooding in the area) does not overtop the defences, which have a level of 6.5mAOD, and that it would not be until more than 50 years hence that the defences would be overtopped. It can be concluded from this analysis that the Branton Velator area is not at risk from fluvial flooding and therefore fluvial flood levels do not require assessment in this study.



The Braunton Flood Defence Improvements Scheme did not consider combined fluvial and tidal events within the hydraulic modelling for two reasons:

1. Flooding in the town centre of Braunton was caused by fluvial inundation only; and
2. Flooding of the Braunton Velator area was unlikely due to the presence of the Braunton Tidal Defence Scheme which had been constructed to account for a combined tidal fluvial event.

This was an appropriate assumption for the purposes of the study. However, it does mean that there are only two tidal water level datasets available between Braunton and the confluence of the River Caen and River Taw. These are EWLs from the 2003 Report on Regional Extreme Tide Levels<sup>1</sup> and 2008 EA assessment Extreme Tide Levels in Estuaries and Tidal Rivers in the South West Region<sup>7</sup>.

Earlier in this project, defence levels in the Braunton Velator area were compared to the EWLs from the 2008 EA assessment<sup>7</sup> and potential future water levels that account for sea levels rise, to determine if the current defences protected all properties that were potentially at risk. The assessment concluded that the current defences would protect properties against a 1000-year tide into the long-term future. It is appropriate to use the 2008 EWLs<sup>7</sup> in preference to the 2002 values<sup>1</sup> as the 2008 assessment utilises the most up-to-date data and analysis techniques.

Within the 2008 EA assessment<sup>7</sup> there is only one EWL location on the River Caen, Braunton at Velator. Water levels on the River Caen between this location and the confluence with the River Taw have therefore been linearly interpolated between the documented level at Braunton and the interpolated level at the confluence of the River Caen and River Taw (using an interpolated value on the River Taw defined above). This technique provided intermediate water levels along the River Caen at 200m intervals.

The final EWLs used for the River Caen/River Taw confluence and Braunton can be seen below in Table F-5.

Return Period	EWL Location	
	River Caen / River Taw Confluence mAOD	Braunton mAOD
1-Year	5.20	5.31
10-Year	5.39	5.47
20-Year	5.46	5.53
50-Year	5.55	5.61
75-Year	5.60	5.66
100-Year	5.64	5.69
200-Year	5.71	5.75

**Table F-5: Final EWLs for the River Caen/River Taw confluence and Braunton**

The linear interpolation described in the step above was extrapolated to provide water levels on the River Caen upstream of Velator for a further 700m and on the Knowl Water upstream to Wrafton.

2008 EWLs at Braunton for the 1-year to 10-year events were calculated using data from the local Braunton gauge. The form of analysis (r-largest and GEV) was the same as adopted for the coastal gauge sites in the 2008 Coastal Boundaries study<sup>3 4 5 6</sup>. The growth from the 10-year to 1000-year level was taken as being the same as applicable at the Mouth of the Taw. For this reason the level of confidence that can be placed in water levels along the River Caen and Knowl Water varies between events and locations. The confidence placed in the interpolated water levels used in this study can be seen in the table below in Table F-6.

Location	Confidence	
	1-Year to 10-Year Event	Above 10-Year Event
River Taw at confluence with River Caen	Medium	Medium
River Caen – confluence with Taw to Velator	Medium	Medium-Low
River Caen – upstream of Velator	Medium-Low	Low
Knowl Water	Low	Low

**Table F-6: Confidence in final water levels along the River Caen and Knowl Water**

## F – 4.4 River Torridge – Appledore to Weare Giffard

### F - 4.4.1 Review of 2002 EWL Data

For the 2003 study, 1-year tide levels were derived locally for coastal locations, with the growth factors from the POL regional data used to determine higher values. For the Torridge estuary, the analysis completed to derive the 1-year tide level used just two sets of high spring tide data (from September 1999 and September 2001) to determine the rise in values up through the estuary (see Table F-7). Using so few events in the analysis provides results in which only a low confidence can be placed. This confidence reduces further for higher return period events where the growth factor from the estuary mouth is applied and local data is not used. The 2003 Report on Regional Extreme Tide Levels<sup>1</sup> states that confidence in the EWL values is medium for events below the 50-year return period and low for events above the 50-year return period. These confidence values are given ranges of +/-0.4m (medium confidence) and +/-0.6m (low confidence) respectively.

Location	Water Level (mAOD)		
	27 <sup>th</sup> September 1999	18 <sup>th</sup> September 2001	19 <sup>th</sup> September 2001
Westward Ho!	4.75	4.68	4.65 <sup>5</sup>
Appledore	-	4.67	4.82
Bideford Quay	4.60	-	-
Weare Giffard	5.28	5.00	5.15

**Table F-7: High spring tides used to derive 1-year tide levels in the Torridge estuary**

The above illustrates that a limited amount of data was used in this analysis, with the different events giving very different hydraulic profiles.

### F – 4.4.2 Review of 2008 EWL Data

As part of the EA's assessment Extreme Tide Levels in Estuaries and Tidal Rivers in the South West Region<sup>7</sup>, EWLs at Bideford for the 1-year and 10-year events were calculated based on gauged data. Levels in excess of the 10-year return period were taken from the growth curve for the mouth of the estuary. A higher confidence can be placed in the EWLs up to and including the 10-year return period, decreasing with events above a 10-year return period.

For Weare Giffard a number of tide events were assessed to relate the level at the Bideford gauge to that at Weare Giffard, as this area is highly influenced by fluvial water levels. A direct relationship was then used to give the range of levels at Weare Giffard. As recognised within the accompanying report, there will only be a low confidence in the EWLs defined for Weare Giffard due to the method used in the assessment and the fact that higher levels are likely to occur under fluvially dominated events.

### F- 4.4.3 Review of Devon Tidal Flood Zone Project

This assessment was based on a linear interpolation of the 2002 EWLs at Bideford and EWLs for Weare Giffard defined in the South West Tidal North Coast Tidal Flood Risk Mapping

<sup>5</sup> This seems unlikely and could be a data error. A value of 4.85mAOD seems more likely.

study<sup>10</sup>. The same level of confidence can be placed in these EWLs as for the 2002 EWL data, with confidence decreasing as you move upstream and as the magnitude of the event increases.

#### **F – 4.4.4 Review of Level 2 SFRA Model**

A review of the SFRA hydraulic model and its outputs was undertaken, which identified a number of inaccuracies with the hydraulic model and inconsistencies within the outputs. These are described below.

- At the downstream end of the Torridge estuary, the scenario representing the 200-year tide with a 1-year fluvial input produces water levels 70mm higher than the scenario representing the 200-year tide with a 20-year fluvial input. The reverse would be expected in this situation and given the area will be dominated by tidal conditions, it would be expected that the water levels would be almost identical.
- The data point for which there should be the most confidence is the EWL for Appledore, as it is derived from raw tidal data. However, this is where there is the greatest difference between the SFRA model results and the 2002 EWL dataset. Of the tidal events modelled, the SFRA model produces water levels 30-150mm higher than the 2002 EWL dataset. It is noted however, that further up the estuary, the two datasets are numerically closer.
- The SFRA model results give a much flatter hydraulic gradient up the Torridge Estuary compared to either the 2002 or 2008 EWL datasets. This may imply that the EWL values are overly conservative further up the Torridge Estuary. However, without further analysis of the 2002 and 2008 EWL datasets this cannot be confirmed, and analysis of this nature is beyond the scope of this study. It is noted however, that the EWL hydraulic gradient through the Torridge estuary is closer to that described by Pethick in his 2007 report<sup>15</sup>.
- Water levels fluctuate as you travel upstream along the River Torridge where a gradual increase would be expected.
- A time varying tidal boundary was applied to the western boundary of the model grid. All other boundaries were effectively modelled as a solid wall, with ground levels elevated to 200mAOD. Applying boundaries in such a way will mean that the estuary flow mechanisms will not have been represented, especially at the confluence of the River Torridge and River Taw, and the model will be unable to accurately represent the complex flow mechanisms that occur within estuaries.

The above indicates that the SFRA hydraulic model is inconsistent in its results. Whilst it may have been of an appropriate accuracy for the purpose of the SFRA study, especially at Westward Ho!, it does not give any higher accuracy than the 2002 and 2008 EWL datasets through the Torridge Estuary. In fact it may have a lower confidence applied to it for levels in Bideford and Appledore compared to Westward Ho!. For this reason the results from the Level 2 SFRA were not used within this study.

#### **F - 4.4.5 Final Water Levels**

It is appropriate to use the 2008 EWLs<sup>7</sup> in preference to the 2002 values<sup>1</sup> as the assessment utilises the most up-to-date data and analysis techniques.

Within the 2008 EA assessment<sup>7</sup> there are two EWL locations on the River Torridge, Bideford and Weare Giffard. Water levels on the River Torridge have therefore been linearly interpolated between the documented levels at Bideford and Weare Giffard and the interpolated level at the confluence of the River Torridge and River Taw (using an interpolated value on the River Taw). This technique provided intermediate water levels along the River Torridge at 200m intervals.

The final EWLs used for the River Torridge/River Taw confluence, Bideford and Weare Giffard can be seen below in Table F-8.

Return Period	EWL Location		
	River Torridge / River Taw Confluence mAOD	Bideford mAOD	Weare Giffard mAOD
1-Year	5.14	5.35	5.40
10-Year	5.35	5.54	5.60
20-Year	5.42	5.61	5.67
50-Year	5.51	5.70	5.76
75-Year	5.56	5.75	5.81
100-Year	5.59	5.79	5.85
200-Year	5.66	5.86	5.92

**Table F-8: Final EWLs for the River Torridge/River Taw confluence, Bideford and Weare Giffard**

The level of confidence that can be placed in water levels along the River Torridge varies between location and events. The confidence placed in the interpolated water levels used in this study can be seen in the table below in Table F-9.

Location	Confidence	
	1-Year to 10-Year Event	Above 10-Year Event
River Torridge – confluence with Taw to Bideford	Medium	Medium
River Torridge – Bideford to Weare Giffard	Medium-Low	Low
River Torridge – Weare Giffard	Low	Low

**Table F-9: Confidence in final water levels along the River Torridge**

Due to the strong influence of prevailing fluvial conditions at Weare Giffard, a second water level dataset was produced for the River Torridge in the vicinity of Weare Giffard based on fluvial flood levels. This provided an alternative set of water levels for the Weare Giffard area where the distinction between fluvial and tidal flooding is ambiguous. These fluvial flood levels were defined by assessing data from the Weare Giffard gauge, which suggested a 100-year fluvial flood level of 8.5mAOD. To provide fluvial flood levels downstream, the difference between the local ground level at the gauge and the 100-year fluvial flood level was added to local ground levels downstream to provide a 100-year fluvial water level profile. This pragmatic approach was agreed with the EA as the most cost effective way to produce levels for this area. It is however recommended that if further confidence is required in predicted water levels in this area, a more detailed assessment will be required. Due to the technique used to generate a fluvial water level profile, only a low level of confidence can be placed in these values.

## F – 5 Climate Change Considerations

Two documents were used to inform the application of climate change:

- Environment Agency. *Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities*. July 2011
- Defra. *UK Climate Projections science report: Marine & coastal projections*. June 2009

Whilst both tidal and fluvial flooding are being considered in this study, primary consideration is being given to tidal flooding and areas at risk from tidal flooding. For that reason, coupled with the fact that it is beyond the scope of this study to re-run any existing hydraulic models that consider fluvial flooding as the main source of flood risk, the decision has been taken to only consider increasing sea levels as a result of climate change.

### F – 5.1 Change to relative sea level rise

Projections for relative mean sea levels for any location around the UK coast are provided in UKCP09, where the projected uncertainty range of global sea level is taken directly from the most recent Fourth Assessment report of the IPCC<sup>16</sup>, which was downscaled for the UK.

Sea level rise projections have been made in UKCP09 for the Low, Medium and High emissions scenarios. Drawing on the methodology developed for the EA's Thames Estuary 2100 study, a High++ (extreme) scenario is also presented. This provides an additional amount of change above the likely range of current models. Whilst the High++ range is intended to provide an extreme but physically plausible range of change for those wishing to investigate contingency planning and the limits of adaptation, it is thought very unlikely that the upper end of the High++ scenario will be realised in the 21<sup>st</sup> century. The estimates of SLR to apply in the High++ scenario are presented below in Table F-10.

UKCP09 relative sea level rise projections are available for three emission scenarios, as change relative to 1990 for any year up to 2100. They are presented as central estimates of change for each emission scenario with upper and lower confidence bands.

The EA guidance published in July 2011 recommends that the central estimates of relative sea level rise from UKCP09 are not used as the change factor for investment decisions. Instead it is recommended that the upper confidence band (95 percentile) medium emission projection is used. See Table F-10 below.

	Sea level rise mm/yr up to 2025	Sea level rise mm/yr 2026 to 2050	Sea level rise mm/yr 2051 to 2080	Sea level rise mm/yr 2081 to 2115
High++ Scenario	6	12.5	24	33
Upper end estimate	4	7	11	15
Change factor	Use UKCP09 relative sea level rise medium emission 95% projection for the project location available from the <a href="#">user interface</a>			
Lower end estimate	Use UKCP09 relative sea level rise medium emission 50% projection for the project location available from the <a href="#">user interface</a>			

**Table F-10: Change to relative mean sea level rise (replicated from Table 5 in 'Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities', Environment Agency, July 2011)**

The July 2011 guidance recommends that when taking projections from UKCP09, change up to 2115 should be derived by extrapolating beyond 2100.

The approach recommended in the July 2011 guidance, is to undertake sensitivity analysis across the range of plausible change over the life of the assessment and identify adaptation



responses that may be required. The sensitivity analysis can then be used to refine options for a wider range of future change.

## F – 5.2 Approach adopted for the Taw Torridge Estuary Coastal Management Study

As per Table F-10 above, the Change Factor sea level rise projection has been taken to be the medium emission 95% projection. Water levels were adjusted based on increased sea levels predicted for this scenario. The epochs considered were: 2012 (present day), 2017, 2022, 2032, 2062 and 2112. It should be noted that the 2008 EWLs for the Mouth of the Taw, Yelland, Braunton, Bideford and Weare Giffard were updated to 2012 to represent the present day (date of this study) by adding 0.021m, which represented sea-level rise between 2008 and 2012.

The water levels produced as part of the Barnstaple 2D Modelling Study<sup>11</sup> were adjusted in the same way as for the baseline water level dataset, once future tide levels representing climate change at Yelland had been substituted as the downstream boundary condition. The future water levels defined for Yelland for the different epochs are shown below in Table F-11.

Epoch	Change Factor (Medium Emission 95 Percentile)						
	1-Year	10-Year	20-Year	50-Year	75-Year	100-Year	200-Year
Present Day (2012)	5.22	5.41	5.48	5.57	5.62	5.66	5.73
2017	5.25	5.44	5.51	5.60	5.65	5.69	5.76
2022	5.28	5.47	5.54	5.63	5.68	5.72	5.79
2032	5.34	5.53	5.60	5.69	5.74	5.78	5.85
2062	5.54	5.73	5.80	5.89	5.94	5.98	6.05
2112	5.97	6.16	6.23	6.32	6.37	6.41	6.48

**Table F-11: Change to relative sea level rise at Yelland for the Change Factor Scenario**

It is necessary to consider more extreme events to ensure that the decisions undertaken to invest in the 'priority sites' (defined as areas where significant work may be justified within the next 10 years) is logical given the possible evolution of the estuary under climate change. This is a 'no regrets' approach. Equally the possible lower rates of sea level rise should be considered, but it is unlikely that this needs to be quantified.

To gain an understanding of the potential magnitude of change that could be considered in this study, predicted water levels for the Mouth of the Taw for the different epochs under the Change Factor scenario, Upper End Estimate and H++ Scenario are detailed below in TableF-12, TableF-13 and TableF-14 below.

Epoch	Change Factor (Medium Emission 95 Percentile)						
	1-Year	10-Year	20-Year	50-Year	75-Year	100-Year	200-Year
Present Day (2012)	5.04	5.27	5.34	5.43	5.48	5.51	5.58
2017	5.07	5.30	5.37	5.46	5.51	5.54	5.61
2022	5.10	5.33	5.40	5.49	5.54	5.57	5.64
2032	5.16	5.39	5.46	5.55	5.60	5.63	5.70
2062	5.36	5.59	5.66	5.75	5.80	5.83	5.90
2112	5.79	6.02	6.09	6.18	6.23	6.26	6.33

**Table F-12: Change to relative sea level rise at the Mouth of the Taw for the Change Factor Scenario**

Epoch	Upper End Estimate						
	1-Year	10-Year	20-Year	50-Year	75-Year	100-Year	200-Year
Present Day (2012)	5.04	5.27	5.34	5.43	5.48	5.51	5.58
2017	5.06	5.29	5.36	5.45	5.50	5.53	5.60
2022	5.08	5.31	5.38	5.47	5.52	5.55	5.62
2032	5.14	5.37	5.44	5.53	5.58	5.61	5.68
2062	5.40	5.63	5.70	5.79	5.84	5.87	5.94
2112	6.08	6.31	6.38	6.47	6.52	6.55	6.62

**TableF-13: Change to relative sea level rise at the Mouth of the Taw for the Upper End Estimate**

Epoch	H++ Scenario						
	1-Year	10-Year	20-Year	50-Year	75-Year	100-Year	200-Year
Present Day (2012)	5.041	5.27	5.34	5.43	5.48	5.51	5.58
2017	5.071	5.30	5.37	5.46	5.51	5.54	5.61
2022	5.101	5.33	5.40	5.49	5.54	5.57	5.64
2032	5.207	5.44	5.51	5.60	5.65	5.68	5.75
2062	5.720	5.95	6.02	6.11	6.16	6.19	6.26
2112	7.208	7.44	7.51	7.60	7.65	7.68	7.75

**TableF-14: Change to relative sea level rise at the Mouth of the Taw for the H++ Scenario**

# Appendix F - References

- 1 Posford Haskoning (February 2003). *Environment Agency South West Region Report on Regional Extreme Tide Levels*.
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- 7 Environment Agency (May 2011). *Extreme Tide Levels in Estuaries and Tidal Rivers in South West Region*. Version 3 (Totnes Update).
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- 13 Halcrow, 2011. *Braunton Flood Defence Improvements*. Final Modelling Report.
- 14 Halcrow, 2007. *Braunton Flood Defence Scheme: Pre Feasibility Study*. Final Report.
- 15 Professor J Pethick, 2007. *The Taw Torridge Estuaries: Geomorphology and Management Report to Taw-Torridge Estuary Officers Group*.
- 16 Lowe, J.A., Howard, T. P., Pardaens, A., Tinker, J., Holt, J., Wakelin, S., Milne, G., Leake, J., Wolf, J., Horsburgh, K., Reeder, T., Jenkins, G., Ridley, J., Dye, S., Bradley, S., 2009. *UK Climate Projections science report: Marine and coastal projections*. Met Office Hadley Centre, Exeter, UK.

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# Appendix G – Risks to Achieving Desired Outcome

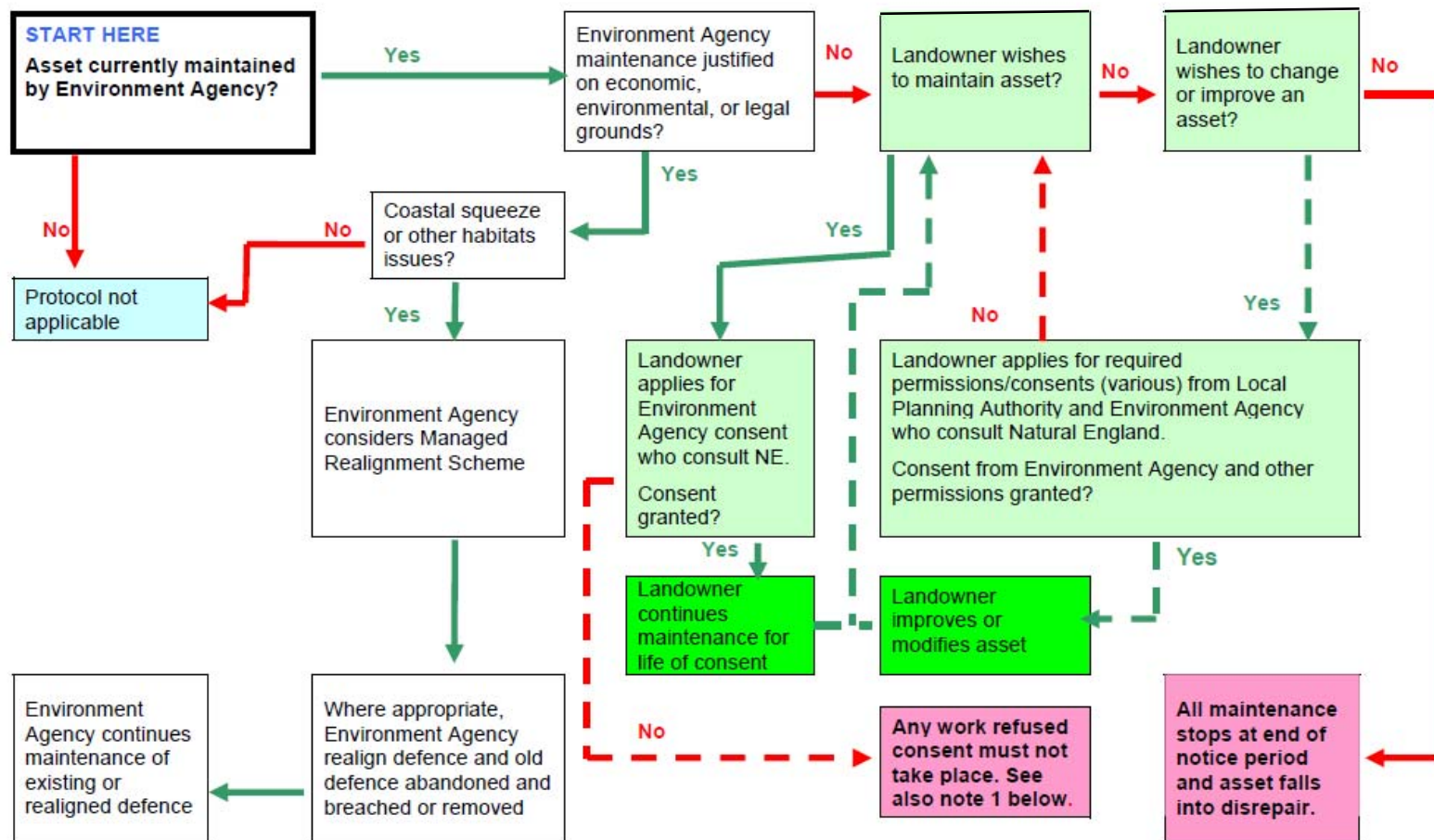


**General risks to successful outcome of potential future works:**

- Estimates of sea level rise may be amended in the future – this will only impact the programme it will not change the potential for works.
- The existing modelling used in this study varied greatly in the degree of confidence in it. Changes to the calculated water levels by any future modelling will again impact the potential programme but not the intent.
- Future potential policy change may place different emphasis on what are considered to be desirable outcomes.
- Availability of funding.
- Quality of baseline data notably asset condition, modelling, ground conditions.
- Additional data different to current.
- Actions of estuary management partners compromising success of schemes.
- Landowner agreements.
- Non-acceptance by key stakeholders.
- Ecological/archaeological considerations.

# Appendix H – Maintenance Protocol Flow Chart of Process – [from Appendix 9 to the Protocol for the maintenance of flood and coastal risk management assets \(England only\)](#)

[November 2011](#)



**Notes:**

- 1 Environment Agency consent will normally be granted for continuing like for like maintenance.
- 2 All references to Landowner in this chart include tenant or occupier as well as owner of the land occupied by an asset.

Note: Following on from this study we will seek to apply the Protocol in a strategic way to the locations identified. If the outcome is that maintenance is not economically justified, we would move on to the Consultation Stage. We will talk to landowners and others as part of this; the landowner might decide they will maintain the asset. We would discuss the various options including habitat creation where that is identified as a potential outcome. Only when there seems to be some agreement would we want to progress such projects.

# Appendix J – Implementation Health and Safety Issues

**Health & Safety issues to be considered prior to implementation should include but not be limited to:**

**[HSE Construction Design Management Red, amber and green lists](#)**

**Plus NEECA 2/WEM current Red amber green list**



## Appendix K – Pebbleridge Report (see separate report)

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## Appendix L – Landfill Report (see separate report)

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