PACCo Promoting Adaptation to Changing Coasts
Promouvoir l'Adaptation aux Changements Côtiers

Interreg France (Channel Manche) England
European Regional Development Fund

Environment Agency

East Devon Pebblebed Heaths Conservation Trust

Promoting Adaptation to Changing Coasts (PACCo) Task 4: Lower Otter Socio-economic Evaluation

Assessing and quantifying the socio-economic benefits from adaptive management of estuarine sites (Work Package 2)

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Contents

Foreword

The Promoting Adaptation to Changing Coasts (PACCo) project is cross-border initiative which is financially supported by the INTERREG VA France (Channel) England project co-financed by the European Regional Development Fund.

The broad aim of PACCo is to demonstrate that it is possible to work with stakeholders in estuarine regions to deliver a range of benefits for people and the environment by adapting pre-emptively to climate change. It has a total value of €27m, with €18m coming from the European Regional Development Fund (ERDF).

The project focuses on two pilot sites: the lower Otter Valley, East Devon, England and the Saâne Valley in Normandy, France.

For more information see: Promoting Adaptation to Changing Coasts (pacco-interreg.com)

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Executive Summary

PACCo Project Background

The Promoting Adaptation to Changing Coasts (PACCo) project is a collaborative cross-channel initiative that is financially supported by the Interreg V A France (Channel) England programme. The main aim of PACCo is to show how it is possible to work with stakeholders in estuarine regions to deliver a range of benefits for people and the environment by undertaking a properly managed adaptation to climate change.

PACCo considers two nature-based estuary restoration initiatives which share many similarities and face similar challenges. One site is in the lower Otter Valley in East Devon, England, and the other is in the lower Saâne Valley in Normandy, France. By researching and reviewing the lessons from these two projects, PACCo will create a guide for the sustainable management of coastal and estuarine areas. This guide will be transferable to other sites where coastal and estuarine adaptation is needed.

This report was prepared under Work Package 2 of PACCo, which examines the socio-economic impacts and benefits of these two pilot projects. Under this work package, the following two important and complementary research elements have been undertaken:

- **An assessment of the Natural Capital and Ecosystem Services:** This has evaluated the natural capital (and other) assets at the restoration sites and the ecosystem services flows that are likely to change post implementation.
- **A review of stakeholder opinions and perceptions:** Via visitor surveys, this has assessed the views and perceptions of stakeholders that will be affected and benefited by these coastal and estuarine adaptation measures.

Undertaking a Socio-economic Evaluation (Lower Otter)

This overall socio-economic evaluation report for the Otter project is the fourth main document produced under Work Package 2 of PACCo. It builds on three earlier reports, the 'Methods Review', the 'Standardised Protocol', and the 'Baseline Report' that were produced throughout 2021 and 2022. These preceding reports provided background on the Lower Otter and Saâne Valley projects, described the Natural Capital Accounting (NCA) approach, and assessed the baseline scenario for the Lower Otter. The restoration scenario accounting has now been combined with the baseline report to create an overall socio-economic evaluation report for the Lower Otter Restoration Project (LORP).

An NCA approach involves measuring changes in the stock of natural assets (e.g. extent of a given habitat) and describing the benefits (ecosystem services) that arise (e.g. carbon storage). This approach is now widely advocated as a tool for managing the environment and supporting national and international economies that rely on natural capital.

This report describes the two scenarios which have been assessed for LORP, by following the steps outlined in the Standardised Protocol. The natural and other applicable assets

for the study area have been described and forecast, and an assessment of the benefits and values of ecosystem services undertaken, using best available data and evidence-based assumptions. Not all benefits/services which are expected to arise could be valued or monetised, and thus, this NCA represents a partial assessment. This is typical for NCAs, as not all gaps tend to get filled, nor do all the possible benefits tend to get valued; amongst others for reasons related to double counting, data gaps and because some benefits may be very difficult to assign a value to. A 60 year accounting period has been applied, and costs and benefits discounted over time, following HM Treasury guidance.

Under the baseline scenario, the situation pre-LORP continues for 15 years, before an unmanaged breach occurs (in reality, the risk of this occurring sooner would be high). The restoration scenario meanwhile envisages the implementation of LORP. With LORP, it is important to point out that the project's intertidal habitats are being created as (coastal squeeze) compensatory habitats to enable the Environment Agency to continue to manage flood risk for thousands of properties in the Exe Estuary. The net benefit of this has previously been estimated at over £350 million. Thus, substantial additional off-site benefits result from LORP being implemented, which could not be included in this NCA.

For this report, the (partial) socio-economic assessment which has been undertaken concludes that, over 60 years, the gross natural capital present value (PV) of the 'baseline' scenario is at £23.6 million. The LORP / restoration scenario has a higher gross natural capital PV60 of almost £35 million. The natural capital benefits associated with the LORP / restoration scenario are therefore substantially higher (50%) than those calculated for the baseline scenario. Of the benefits which could be monetised, the benefits related to the welfare value of recreational visits were valued most highly, followed by physical health benefits, water quality and carbon sequestration related benefits.

LORP's total net asset value PV60 (derived by summing natural capital values with income flows and deducting scheme costs) has been calculated as being lower than that of the 'baseline' scenario. There are several reasons for this, not all of which are related to natural capital. For example, substantial proportions of the LORP costs relate to infrastructure construction which is not directly linked to natural capital uplift (e.g. road works). Also, comparing LORP with a baseline scenario where there is an unmanaged breaching means that the resulting natural capital (habitats) and thus benefits are fairly similar to the LORP outcome. Managed realignment is however a way of working with / helping natural processes in a controlled fashion so as to enhance benefits and reduce risks. This is clearly demonstrated in the total natural asset value improvement (when compared to the baseline) of *circa* £11.2 million described above. This is despite many of the benefits or services related to LORP's natural assets not having been monetised.

Furthermore, the NCA's benefit estimates are broadly conservative, whereas the scheme costs will include contingencies and optimism bias. Also, it is likely that the impacts of unmanaged breaching would be much more costly than has been assumed for this NCA. Thus, the results of this partial NCA underestimate the full value of LORP and its value relative to an unmanaged breach scenario. Nevertheless, the NCA is helpful in identifying the multiple and significant benefits of such projects, and the methodology developed in this study can be used and built upon as our knowledge of benefits improves.

1. PACCo Project Background

1.1 Introduction

The Promoting Adaptation to Changing Coasts (PACCo) project is a collaborative cross-channel initiative that is financially supported by the Interreg V A France (Channel) England programme. It has a total value of €26m, with €17.8m coming from the European Regional Development Fund (ERDF). Of this, £6.6m was contributed to construction works on the Lower Otter Restoration Project. The main aim of this initiative is to show that it is possible to work with stakeholders in estuarine regions to deliver a range of benefits for people and the environment by undertaking a properly managed adaptation to climate change.

PACCo considers two initiatives that share several similarities and are facing comparable challenges. One site is in the lower Otter Valley in East Devon, England and the other is in the lower Saâne Valley in Normandy, France (see Figure 1). The hydrodynamic and ecological functioning of these two locations is adversely affected by historical human modifications. These functions will be further threatened by climate change as will the value of these areas for local communities and visitors.

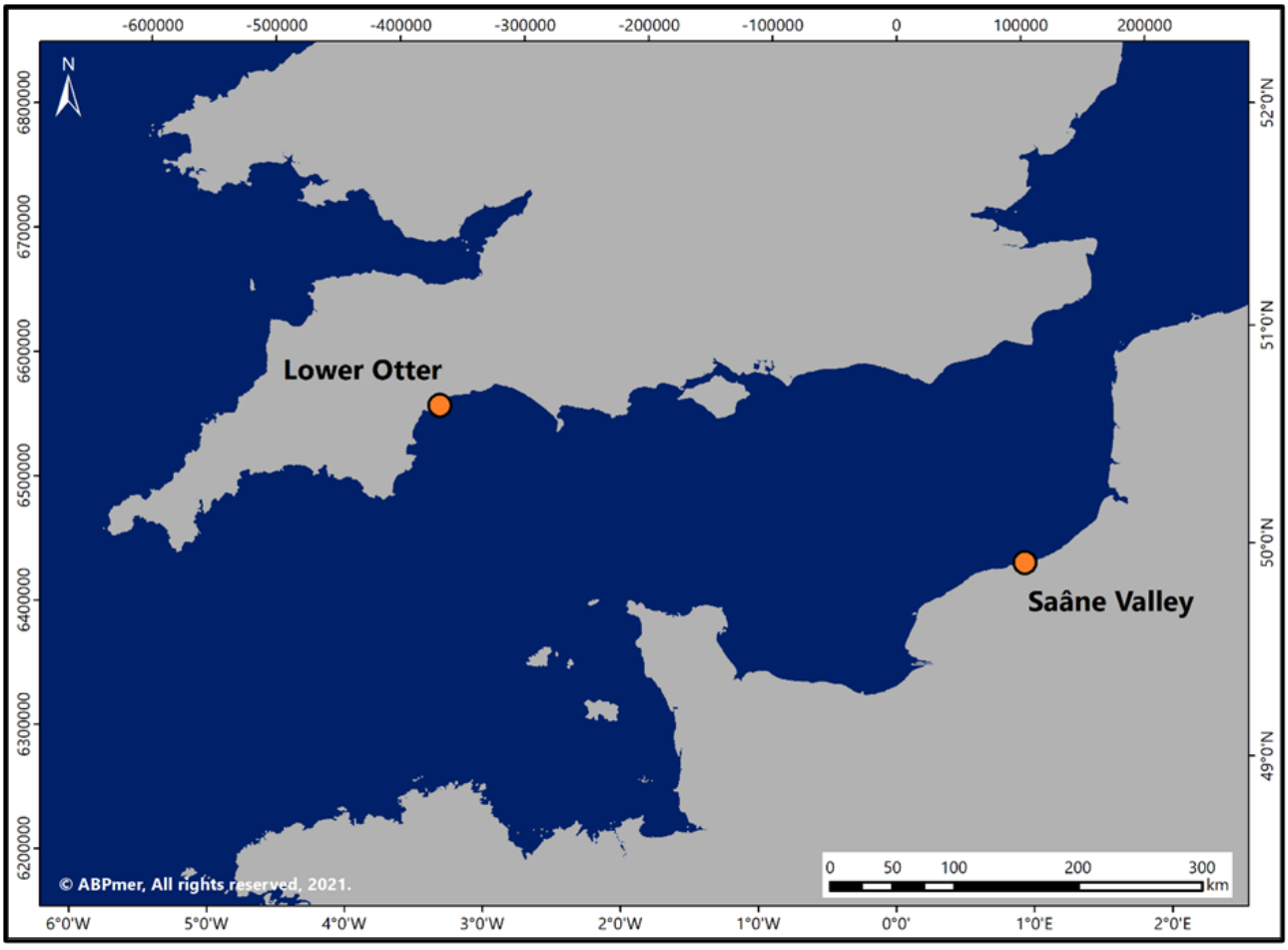

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Figure 1. Location of the Lower Otter and Saâne Valley projects sites

At these two locations, nature-based restoration projects are being implemented in response to existing problems and future climate change threats. These projects each involve a 'managed realignment' of existing flood embankment to create more naturally functioning hydrological regimes to meet the needs of local communities. Work on the Otter project started in Summer 2021, with the breach anticipated in Spring 2023. Further details about each of these two projects are included in the Methods Review (ABPmer, 2021a) and on websites[1] and other documentation for the projects.

1.2 Report structure

This report is structured according to the NCA steps outlined in the preceding protocol report (ABPmer, 2021b), which were as follows:

- **Define the study area(s).** The first stage of the assessment involves clearly defining the study area(s), as described in **Section 2;**
- **Examine the Nature Capital** Assets. This includes scoping, quantifying and assessing the condition of natural and other relevant capital assets (for both current and future scenarios), as described further in **Section 3;**
- **Determine management/maintenance cost**. This involves understanding the management and maintenance actions and fees currently, and in the future, as summarised **Section 4**; and
- **Assess ecosystem services and value benefits.** This includes scoping and defining relevant services, obtaining information on related goods, identifying valuation methods, and undertaking the valuations, where possible – see **Section 5.**

Section 6 provides summary and conclusions**.**

Further background on PACCo and its Work Package 2, which this report supports, is provided in the remainder of Section 1.

1.3 PACCo aims and approach

The objective of PACCo is to use the lessons learned from these two similar pilot projects to create a guide for the sustainable management of coastal and estuarine areas that is transferable to other locations. The intention is that this guide will be used to assess and communicate the multiple benefits of these two projects, but also provide a framework for more adaptive management projects at sites in France, England and elsewhere.

[1] www.pacco-interreg.com/ ; www.lowerotterrestorationproject.co.uk/pacco.html; www.channelmanche.com/en/projects/approved-projects/promoting-adaptation-to-changing-coasts/

To deliver these outcomes, PACCo is divided into five separate work packages, as follows:

- **Work Package M:** This covers project management tasks (meetings, reporting etc) and will be led by the Environment Agency;
- **Work Package 1 (WP1):** This involves work that will be undertaken to monitor and evaluate the environmental risks and will be led by a French partner;
- **Work Package 2 (WP2):** This package is examining the socio-economic impacts and benefits of the projects. It is being led by the East Devon Pebblebed Heaths Conservation Trust (EDPHCT) and undertaken by ABPmer and Economics for the Environment Consultancy (eftec). There is also a separate piece of work examining the public engagement work carried out as part of WP2, undertaken by the University of Exeter;
- **Work Package 3 (WP3):** This involves developing a replicable guide for other estuarine areas and is being led by the Environment Agency; and
- **Work Package Comms:** This is the communications package that is being led by EDPHCT.

This report was prepared under Work Package 2 which is being led by EDPHCT. The aim of this package is to identify, assess and quantify the economic and social benefits that can be derived from adaptive management of estuarine sites based on the proposed restoration work in the two pilot sites. The key outputs from this Work Package will also be uploaded to the website, alongside the guide.

EDPHCT commissioned ABPmer to support the delivery of this PACCo Work Package 2. ABPmer lead delivery of this work package, with assistance from eftec, and some input from the University of Portsmouth. Working with EDPHCT, this project team has divided this package into five discrete and sequential tasks. These tasks, delivered over the two-year timeframe for this project, are as follows:

- **Task 1:** Development and **justification of a methodology** for valuing the socio-economic benefits of the managed realignments at the two pilot sites (ABPmer, 2021a);
- **Task 2:** Development of a **standardised protocol** for describing the socio-economic baselines and deriving qualitative and quantitative valuations (ABPmer, 2021b);
- **Task 3:** Preparation of a **baseline socio-economic evaluation** describing the socio-economic value of the Otter site before it is implemented. An initial version of this was delivered in January 2022; a revised version was prepared for September 2022. This has now been incorporated into this overall report;
- **Task 4:** Preparation of a detailed **socio-economic impact report** (**overall report** for the Lower Otter Restoration Project (LORP)) (by Autumn 2022), prepared by ABPmer and eftec for the Otter project only. This incorporates the baseline scenario assessed under Task 3, and the restoration/impact scenario which is being implemented in England; and

- **Task 5:** Preparation of a **final (summary) report**, which will compile and summarise the findings. It will also present a non-technical summary of the final protocol (drafted by the end of 2022).

This overall LORP report, and other related PACCo project deliverables, including the standardised protocol, link closely to the guide which will be produced as part of Work Package 3. There will be sign-posting from the Guide to ensure end-users consider the baseline and future situation of potential sites that could benefit from similar adaptation schemes, as part of their pre-works assessment and reporting.

1.4 Justifying a methodology (Task 1)

In fulfilment of Task 1, a 'Methods Review' was produced in April 2021. This provided background details of the Lower Otter and Saâne Valley projects and described the general methods that could be applied to value the socio-economic effects and benefits of these, and similar, projects.

It described the Natural Capital Accounting (NCA) approach that has been adopted to examine the key socio-economic impacts of LORP. An NCA approach involves measuring changes in the stock of natural assets and describing the benefits (ecosystem services) that arise. An NCA can be rapid and qualitative or detailed and partially quantitative. A rapid assessment has been applied to both the Lower Otter and Saâne Valley projects, and is being reported on in a separate report. This report for the Lower Otter project only demonstrates how are more detailed / rigorous, partially quantitative, approach can be applied to assess natural capital related socio economic values of estuarine restoration projects.

The NCA approach is now widely advocated as a tool for managing the environment and supporting economies that rely on natural capital (e.g. European Commission, 2021).

1.5 Standardising a protocol (Task 2)

The Task 2 'Protocols Report' built on the findings from the Task 1 study and presented further details about how the socio-economic assessment of the Otter valley site should be undertaken for PACCo.

The initial protocol document was delivered in September 2021. It provided more detail on the proposed Natural Capital Accounting approach compared to the methodology, and described the proposed step-by-step approach for assessing the socio-economic value of estuarine restoration projects, including examples about how this could be applied for LORP.

This protocol has very much been seen as a working document, and further development occurred whilst applying it for the baseline and impact assessment phases.

The final methods will be presented in the final summary report that is to be produced at Task 5.

1.6 Undertaking a socio-economic evaluation of the Otter project (Tasks 3 and 4)

Under Task 3, a baseline scenario was developed and assessed throughout 2022, with the final /revised draft of this report having been delivered in September 2022. The restoration scenario accounting has now been combined with the baseline report to create an overall socio-economic evaluation report for the Otter project, thus also fulfilling Task 4. In undertaking the assessments, the steps outlined in the protocol document were followed.

This overall socio-economic evaluation report is accompanied by a separate confidential workbook (in an excel spreadsheet format) that contains the statistics in relation to the detailed NCA which has been created. This describes the assets and services from which socio-economic values are derived, as well as the valuations themselves. This workbook has been progressively updated with information on both baseline and impact assets and related values for benefits and services. Key values have been extracted into relevant tables for the purpose of this report. As confidential data is contained in this workbook, it cannot be made available to the wider public.

1.7 Summary report (Task 5)

A brief summary report is to be drafted by the end of 2022; this will summarise the protocol, as well as the LORP NCA, and provide background on the surveys which have been undertaken. If received in time, details on the qualitative NCA which will have also been undertaken for both the LORP and the Saâne projects might also be incorporated (noting that a detailed quantitative NCA has only been pursued for LORP).

2. The Study Area(s)

2.1 Study area definition

The LORP NCA study area incorporates the scheme/restoration footprint itself, as well as fronting intertidal habitats. Image 1 below depicts a poster created by the LORP project partners to illustrate the key elements of LORP (i.e. the restoration scenario; please see Section 3.1.1 for a detailed description). Figure 2 then shows the NCA study area(s).

For the LORP NCA, the LORP scheme footprint defines the immediate ('inside') study area; this currently contains terrestrial habitats and species which will be subject to change, and activities such as cattle grazing and cricket playing take place here, which will largely cease. This 'inside' study area measures 92.5 hectares (ha). The study area extends slightly north and west of Little Marsh, to incorporate areas where saltmarsh may spread in the future as a result of sea level rise (see Section 3.1 for further detail), as well as working and restoration areas affected by LORP (e.g. Budleigh Brook). The site for the new cricket club, and adjacent woodlands (which will not be directly affected), have also been included in the study area extent.

In addition, as the fronting intertidal habitats up to the White Bridge may be affected by change, these have been included as the 'outside' study area; this measures 24.0 ha.

There will also be changes and benefits to the wider water environment of the estuary and the coastal water body beyond. Furthermore, for cultural and recreational benefits, yet wider study areas will apply. The relevant areas will vary depending on what asset/service is being considered; this is stated in the context of each asset/service as part of the NCA reporting (see Section 5).

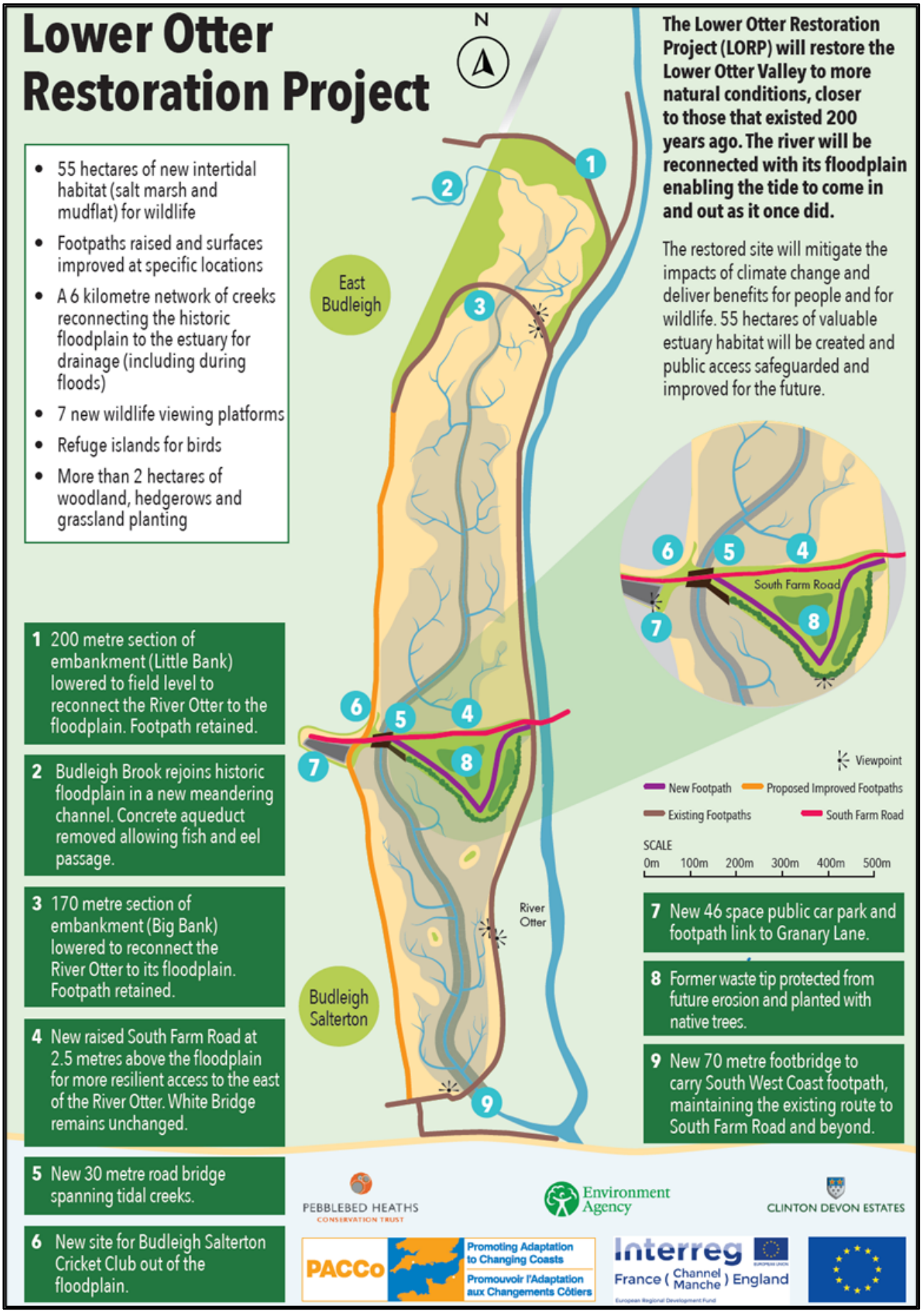
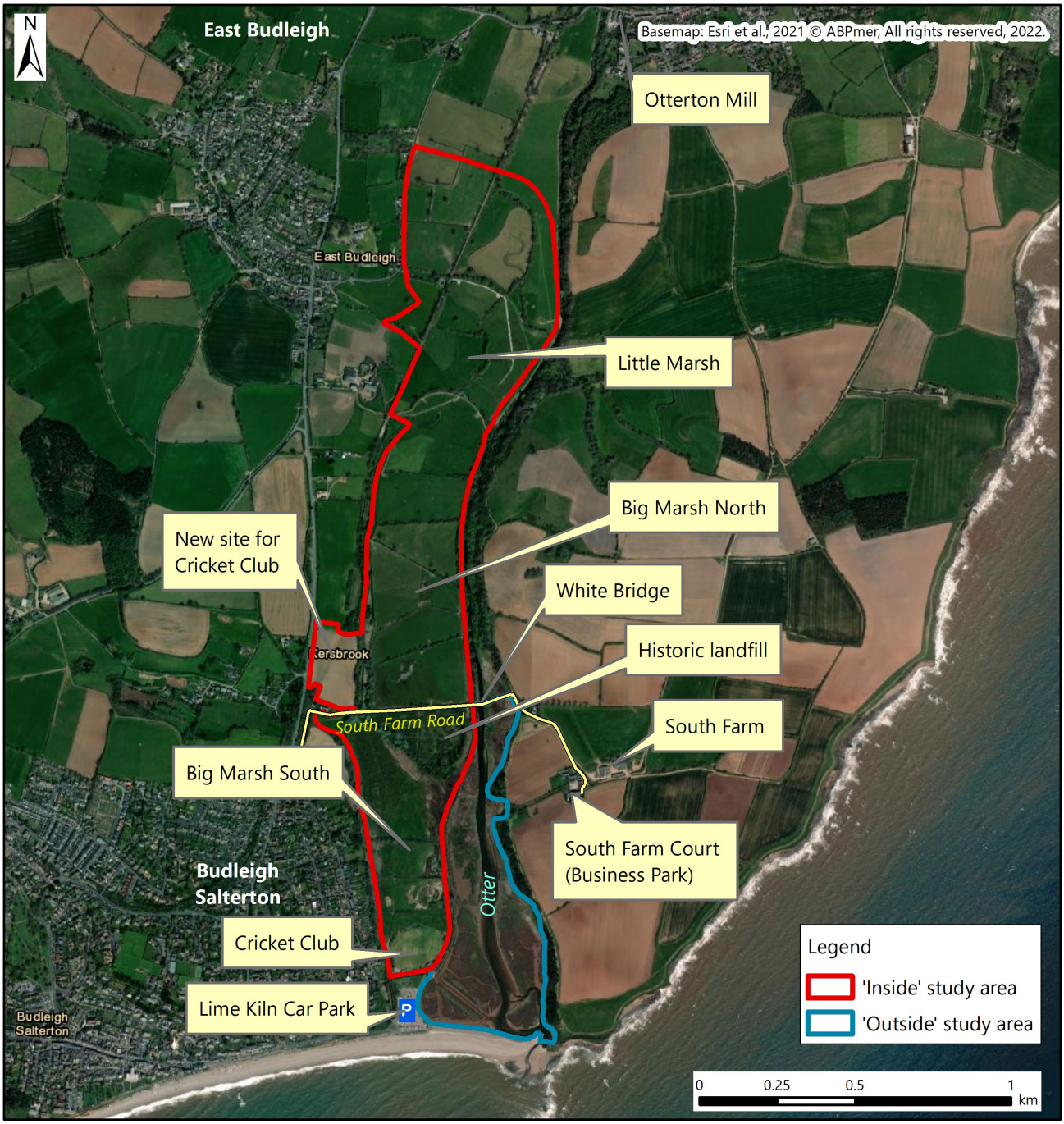


Image 1. Poster on LORP



Created by: ABPmer, 2022 (see figure for layer credits)

Figure 2. Lower Otter 'inside' and 'outside' study area boundaries, as well as other pertinent locations

Further context on the study area is provided in Section 2.2, and more detail on the baseline conditions is provided in Section 3, whereas high level baseline and restoration scenario assumptions are given in Section 2.3.

2.2 Study area context

The Lower Otter Estuary is a bar-built macro tidal estuary on the south coast of Devon, adjacent to the town of Budleigh Salterton. The estuary is an attractive landscape that is both ecologically interesting and socio-economically valuable. It supports a variety of estuarine and freshwater habitats, as well as many bird and other animal species. The

estuary, and the adjacent floodplains, are also a tourist destination that has a network of footpaths. These paths include the South West Coast Path, which runs along the central Otter embankment to White Bridge (see Section 3 for more detail).

The hydrodynamic functionality and overall ecological and biodiversity potential of the Lower Otter is, however, constrained because of substantial man-made changes in the past. The most notable man-made interventions occurred during the early part of 19th Century; from 1810 onwards. This period saw the construction of the Big and Little Bank. These embankments pushed the main river channel into a very narrow western section of the estuarine zone. This is shown in Image 2.

Source: Haycock, 2010

Image 2. View towards the coast across the Lower Otter valley, showing estuary separated from floodplain

These banks disconnected the river from its floodplain, such that only around a quarter of the previous floodplain remains downstream of Otterton (see Figure 3). The banks created three discrete areas of claimed floodplain, which are referred to as Big Marsh South, Big Marsh North and Little Marsh (see Figure 4). Throughout the estuary, there is also a range of other notable features, including: a centrally located historic landfill area, a disused railway embankment, and multiple bridges, culverts and weirs[2]. These features, in addition to Big and Little Banks, influence (and in many cases hamper) the ability of the hinterland to cope with flooding events. They also detract from the naturalness of the environment.

[2] The Budleigh Salterton cricket club is also located within Big Marsh South.

The entire LORP site lies within the East Devon Area of Outstanding Natural Beauty (AONB), and most of the site is a County Wildlife Site ('Otter Meadows'). Located along the coast at the mouth of the estuary is the 'Dorset and East Devon Coast' World Heritage Site, and the 'Otter Estuary' Site of Special Scientific Interest (SSSI) and Marine Conservation Zone (MCZ) extend from this point to the tidal limit. The fronting coast is furthermore part of the 'Jurassic Coast' World Heritage Site.

The estuary and marshes support a wide variety of breeding and wintering bird species, including waders and wildfowl, and form part of a network of important feeding sites which includes the Axe Estuary (to the east) and the Exe Estuary (to the west). Further details on assets (habitats, species, etc.) of relevance to LORP are provided in Section 3.

The LORP area is owned by Clinton Devon Estates, which owns and manages some 25,000 acres (10,117 ha) of land across three estates in Devon. The LORP site is part of the Estates' Otter Valley estate, which covers approximately 6,760 ha.

Clinton Devon Estates have progressed LORP in partnership with the Environment Agency, the government body which has responsibility for improving resilience to climate change, flood defence, increasing biodiversity and improving habitats and water quality.

The LORP site lies immediately adjacent to Budleigh Salterton; this is a small town with a population of around 6,000, though numbers increase during the summer, as it is a popular tourist destination[3]. The village of Otterton, to the north of the LORP project area, has a population of around 700.

The rear gardens of residential properties on Granary Lane, the nearest residential properties, back onto the western boundary of the LORP site, between its southern extent and South Farm Road. House prices on Granary Lane over the past 5 years have ranged from £900,000 for a 4-bed detached house, to just over £300,000 for 2 to 3-bed terraced houses, to around £250,000 for 3-bed flats[4].

South Farm Cottages lie to the north of South Farm Road on the western boundary of the site. The commercial and residential properties of South Farm Court and residential dwelling of Otter Rise lie immediately to the east of the site beyond the River Otter. Pulhayes Farm to the northwest of the site and South Farm to the east of the site are the two tenanted farms whose cattle used to graze on the study area grassland.

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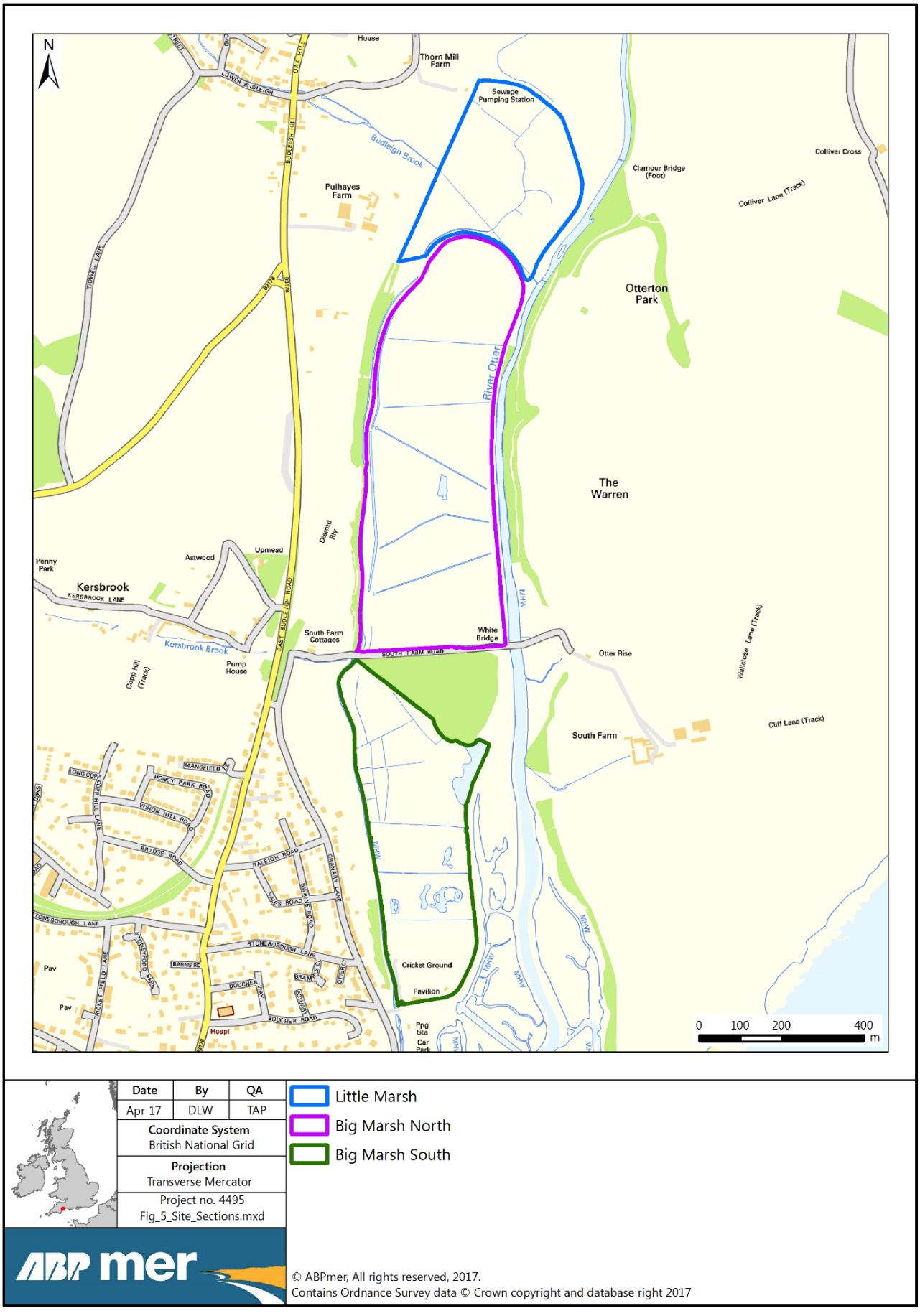
[3] Budleigh Tourist office was contacted for local tourism figures; ABPmer was informed that such statistics are not collected (pers. comm, June 2022).

[4] Source: Rightmove 'house prices' tool [last accessed September 2022]); based on records for one 4-bed house sold in May 2022; three 2 to 3 bed terraced houses sold in 2018 (none sold since), and two 2/3 bed flats (sold in 2017 and 2020).

Created by: ABPmer, 2021 (see figure for layer credits)

Figure 3. Lower Otter Estuary showing the main nearby towns and villages



Created by: ABPmer, 2021 (see figure for layer credits)

Figure 4. Lower Otter Estuary showing Little and Big Marsh areas

A wide variety of stakeholders have an interest in LORP; the key parties which have been involved in the project to date are listed in Table 1.

Table 1. LORP stakeholders (not exhaustive)

Category	Detail
Local authorities	East Devon District Council, Local Parish Councils, Devon County Council, Budleigh Salterton Town Council
Landowners	Clinton Devon Estates
Tenants	Pulhayes Farm, South Farm, South Farm Court, South Farm Cottages
Statutory agencies	Environment Agency, Natural England, Marine Management Organisation (MMO)
Other organisations	Jurassic Coast World Heritage Site, East Devon AONB, South West Water
Economy and tourism	Budleigh in Business, Budleigh Tourism Centre, Tourists (and related businesses), Heart of the South West Enterprise Partnership, South West Coast Path Association
Health and wellbeing	Seachange, Budleigh medical practices, Budleigh Salterton Cricket Club
Access	South West Coast Path Association, Devon Access Forum
Education	Local primary and secondary schools, Bicton College, regional universities
Special interest organisations	Devon Wildlife Trust, Wildfowl and Wetlands Trust, Devon Birds, Royal Society for the Protection of Birds (RSPB), National Trust, Fairlynch Museum
Local communities	Inhabitants of Budleigh Salterton and Otter valley villages; Otter Valley Association
Local enthusiasts	Broad miscellany of local existing volunteers, wildlife and water sports enthusiasts

2.3 Scenario assumptions

Two scenarios have been considered for the purpose of this NCA; a ‘baseline’ and ‘restoration’ scenario. The ‘baseline’ scenario assumes that LORP is not implemented, and that current habitats and practices persist for the time being, although changes would occur at some point in the future. Conversely, the ‘restoration’ scenario presupposes that LORP is implemented. The high level assumptions/background for the baseline and restoration scenarios are outlined below in Section 2.3.1 and 2.3.2 respectively. Further detail on cost and accounting assumptions made for the purpose of the NCA can be found in Sections 4 and 5.2. Habitat figures and tables are presented in Section 3.1.

2.3.1 Baseline

A dynamic baseline scenario has been developed for the purpose of this NCA; this assumes that LORP is not implemented, but that, instead, the situation which existed prior to construction commencing last year, continues for up to 15 years (noting that 60 years has been applied as the accounting period for this NCA, see Section 5.2).

As the shoreline management policy is 'managed realignment', and as the embankments are not in a great condition (as described in Section 3.2 below), for the non-LORP 'baseline' scenario, it is supposed that unmanaged breaching occurs at some point in the future (Year 15 has been applied for this NCA). The expectation is that the embankments would breach in several places, and not just along the southern embankments. These assumptions have been developed in collaboration with the Environment Agency and EDPHCT. It is acknowledged that, in reality, the risk of unmanaged breaching occurring before Year 15 is high; for example, in 2018, the Environment Agency invested substantial sums to repair damage at the main embankment, thus preventing an unmanaged breach. Section 3.1 details what habitats are currently present, and how these might evolve under a dynamic baseline scenario.

As a consequence of the breaching, the footpaths in the floodplain would become unusable or very frequently flooded, and South Farm Road not passable for most of the time (it would become tidal on 80% of tides). A rerouting of the South West Coast Path has been incorporated into the baseline scenario as a reactive adaptation measure. Some likely consequences of an unmanaged breach could not be taken into account, e.g. re-routing of phone and power lines, and potential impacts on groundwater abstraction, due to difficulties in costing, amongst others (see Section 5.2 for more detail).

In addition, it is also assumed that some proactive adaptation measures are undertaken in anticipation of such breaching; these chiefly relate to a major sewer and a historic landfill site which are located in the valley. In reality, these proactive measures would most likely be very difficult to achieve without significant external funding; and this would be extremely challenging to come by without the LORP and PACCo projects. Furthermore, costs of reactive adaptation may well be substantially larger than applied here, as it would be difficult to work in tidal conditions.

2.3.2 Restoration

The restoration scenario involves the implementation of LORP, as it is currently being constructed. LORP will restore the Lower Otter Valley to more natural conditions, closer to those that existed 200 years ago. The river will be reconnected with its floodplain, enabling the tide to come in and out as it once did. A myriad of construction measures are being undertaken to facilitate this.

LORP's intertidal habitats are in part being created as compensatory habitats to enable the Environment Agency to continue to manage flood risk for thousands of properties in the Exe Estuary. This management causes coastal squeeze, which gives the

Environment Agency the statutory duty to secure compensatory habitat. Delivering habitat compensation in the Otter Estuary will allow six flood risk management projects to go ahead in the Exe Estuary, with an estimated direct cost of around £23 million, and total benefits of £375 million (Environment Agency, pers. comm.).

Image 1 above shows the key elements of LORP, and Image 3 below depicts an aerial view of the site in September 2022.

At the heart of the scheme is the managed realignment of the three marsh complexes which occupy the majority of the Lower Otter valley; Big Marsh South, Big Marsh North and Little Marsh. This will be facilitated by breaching the Otter embankment in the south in spring/summer 2023. The breach will be 70 m wide and will be cut down to mudflat levels, with a deeper channel through its centre connecting it with an existing fronting creek. Meandering creeks have been excavated into the three grazing marshes, to guide the waters north, as well as across the marshes, with a new 30-m span road bridge at South Farm Road crossing the new central creek.

Along the northern extents of the scheme, sections of embankment are being lowered in the Little and Big Banks, whilst footpaths along these banks are being retained. The Budleigh Brook aqueduct has been dismantled and brook meanders are being restored along a *circa* 300 m section, where the brook joins the Little Marsh. Several kilometres of hedgerows in the upper floodplain are being improved, and new woodland and scrub areas are being planted.

Source: KOR Communications - still from 'LORP Tracking 15 Sept 22' video, available at https://www.lowerotterrestorationproject.co.uk/video.html [last accessed October 2022]

Image 3. LORP area in September 2022, view south from the Little Marsh

Section 3.1 shows what intertidal habitats would be expected to result from the LORP scheme, and how they may further develop over time.

The landfill site has been made safe, and its base reveted to protect it from erosion due to locally generated waves when the site is inundated. A small section (where the new tidal

creek has been cut) was furthermore removed. As with the baseline scenario, a major sewer pipe is being rerouted.

The Budleigh Salterton Cricket Club has relocated to a new site out of the floodplain (with improved facilities that meet modern standards), and South Farm Road has been raised by up to 2.5 m to elevate it above the floodplain (Image 4). A new 46-space car park is furthermore being constructed adjacent to the new South Farm Road, to compensate for informal parking lost along the existing South Farm Road.

Taken by: ABPmer, 2022

Image 4. South Farm Road construction works in July 2022 (looking west (left) and north (over Big Marsh North) (right))

Extensive lengths of new and improved footpaths result from LORP, and several viewpoints have been incorporated along both new and old paths. The main breach will be bridged, such that access along the main path, which carries the South West Coast Path, will be maintained.

Fronting the site, some relatively minor changes to the existing intertidal habitats are expected to result from the scheme, due to the additional tidal waters entering and leaving the site. There will be some erosion of saltmarshes and mudflats, with noticeable changes generally expected to be restricted to the area south of White Bridge, and adjacent to the breach in particular (CH2M *et al.*, 2018). This will restore the existing estuary to a more natural form.

3. Natural Capital Assets

3.1 Habitats and species

3.1.1 Overview

As a first stage in any NCA process, it is necessary to clarify the 'asset register'. This is an inventory of the natural assets in an area, and their condition. For LORP, the asset register used for the NCA includes:

- the 'inside' study area (92.5 ha), incorporating the managed realignment scheme area, as well as adjacent land affected by the restoration works and/or likely to be affected by sea level rise over the next 60 years ('adaptation zone'), and
- the 'outside' study area (24 ha); this incorporates the fronting intertidal habitats up to the White Bridge.

The current and anticipated future habitats, and their extents across these areas, are listed in Table 2. The (pre-construction) baseline habitats are illustrated in Figure 5. Going forward, post breach (either at Year 15 with the unmanaged breach for the 'baseline' scenario, or Year 2 with the 'restoration' scenario), intertidal habitats would be anticipated to develop across much of the 'inside' study area, and mature and change over the years. To reflect this, two additional time steps are shown in Table 2 for each scenario, with anticipated habitat areas derived based on expert judgment[5]. Figure 6 illustrates what habitats are expected to initially establish as a result of LORP. Please note that the new woodland areas are not shown in this figure, nor is the Budleigh Brook restoration.

For the baseline scenario, the assumption is that the embankments would breach in several places, and not just along the southern embankments. Given that (in the absence of LORP), tidal water exchange to Big Marsh North and Little Marsh would be severely restricted by the culvert under South Farm Road, it has been assumed that, post unmanaged breach, mainly brackish reedbeds would establish north of this road under the dynamic baseline scenario. This differs from the LORP 'restoration' scenario, where saltmarshes and mudflats are largely anticipated in these marshes post breach, facilitated by the new 30 m-span bridge and wide tidal creek which is to be cut, as outlined in Section 2.3.

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[5] Informed by LORP modelling and sea level rise predictions, amongst others. Initial habitat extent has been derived from CH2M *et al*. (2018, '3+' scenario). Please note that for ease of assessment, it has been assumed that all intertidal habitats are fully developed at the time of the breaching. In reality, it can take several years for intertidal habitats to reach functional equivalence with adjacent established habitats, and for saltmarshes to achieve comprehensive plant cover. Please also note that, in the NCA spreadsheet/calculations, the transitions post breach occur gradually over the years (with changes interpolated between the years shown in Table 2).

Table 2. The Lower Otter on-site natural capital asset register (current/pre-construction and anticipated future habitats)

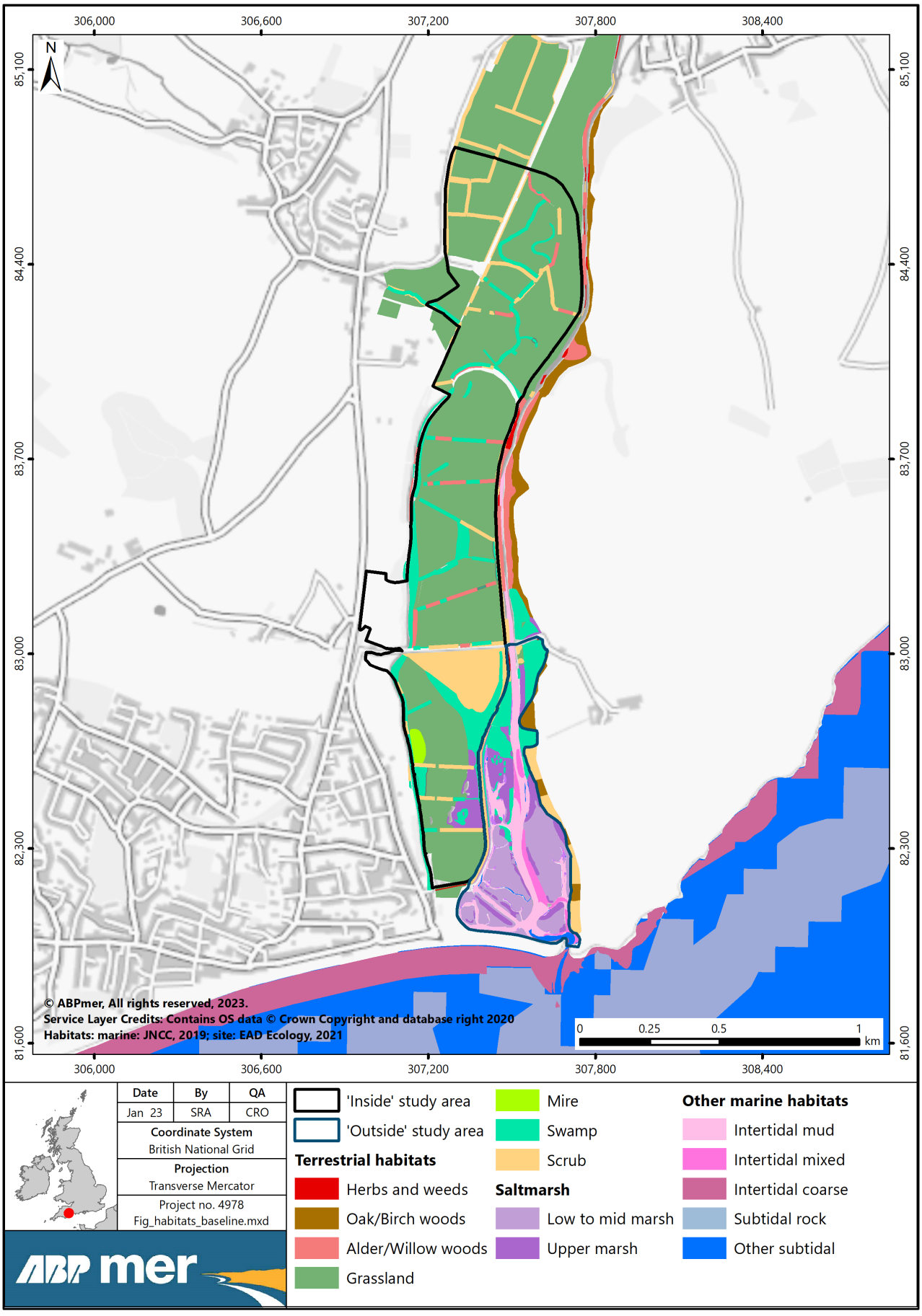
Indicator / Asset	Initial Year (both scenarios)	Baseline scenario (no LORP)		Restoration scenario (LORP)	
		Post Breach	Final Year	Post Breach	Final Year
	2022	2038	2082	2023	2082
	Extent (ha)	Extent (ha)	Extent (ha)	Extent (ha)	Extent (ha)
Within 'inside' study area	**92.5**	**92.5**	**92.5**	**92.5**	**92.5**
Grassland (grazed)	74.0	32.7	23.0	23.5	13.5
Grassland (cricket club)*	3.2	0.0	0.0	3.0	3.0
Cricket clubhouse & car park*	0.3	0.0	0.0	0.3	0.3
Saltmarsh	1.5	14.0	26.2	30.0	50.2
Swamp (/reeds)	5.2	22.0	23.0	2.2	0.0
Mire	0.6	0.0	0.0	0.0	0.0
Scrub**, #	2.8	0.0	0.0	3.4	3.4
Woodland**	1.1	0.8	0.8	3.1	3.1
Woodland (landfill site)	3.4	3.4	3.4	3.4	3.4
Roads/path##	0.4	0.4	0.1	0.6	0.6
Mudflat	0.0	19.2	16.0	23.0	15.0
Within 'outside' study area	**24.0**	**24.0**	**24.0**	**24.0**	**24.0**
Mudflat	6.5	7.7	8.0	7.7	10.0
Swamp/reeds	3.4	2.8	2.0	2.8	0.5
Subtidal	0.3	0.4	0.4	0.4	1.0
Saltmarsh	13.8	13.2	13.6	13.1	12.5

* old and new; please note that some of the grounds where the new cricket club has been built were subject to arable cropping in the past; however, for ease of assessment (and as this accounts for a small proportion of the project area), this has been included under the grazed grassland total for the pre-breach periods (and thus the related benefit accounting).

** does not include individual trees; includes net gain areas for LORP scenario.

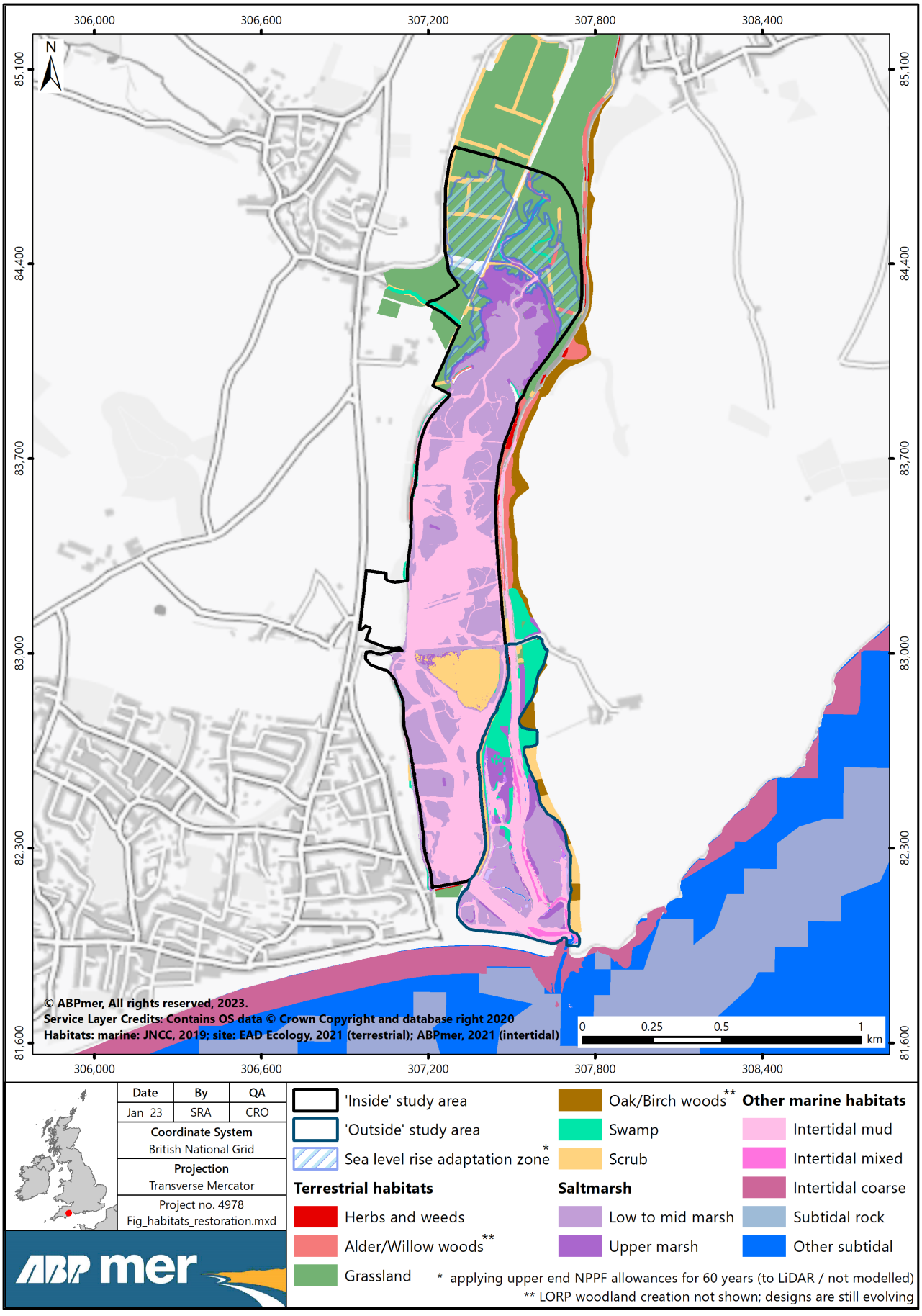
does not include substantial lengths of hedgerows (lost, retained or enhanced, noting that there is a net gain under LORP).

does not include substantial lengths of new footpaths



Created by: ABPmer, 2022 (see figure for layer credits)

Figure 5. Pre-construction baseline habitats in the Lower Otter valley



Created by: ABPmer, 2022 (see figure for layer credits)

Figure 6. Initial habitats in the Lower Otter valley for the 'restoration' scenario

These outputs show that, prior to the construction works commencing, the site comprised mainly grassland, dissected by ditches lined with scrub; small patches of woodland and swamp could also be found. The cricket club pitch and club house occupied almost 4 ha and this facility has been relocated to a new site away from the flood plain, with a new club house in progress. Most of the grassland used to be grazed by cattle, with some of it cut for silage, generally once per annum (see Section 3.2 for more detail on the baseline farming operations). Outside the project area, south of White Bridge (which carries South Farm Road across the Otter), around 24 ha of intertidal habitats can be found, comprising mudflats, saltmarshes and reedbeds/swamp, with fringing scrub and oak/birch woods.

Going forward, with LORP, saltmarshes and mudflats will dominate the Big Marsh South, North and the Little Marsh, and over time, saltmarshes are expected to spread further north as sea levels continue to rise. The new woodland and scrub planting is expected to take place in the northern reaches of the floodplain, away from areas threatened by sea level rise in the near future.

Further detail on the baseline habitats and species is presented in Sections 3.1.2 and 3.1.3 below, and restoration assumptions are outlined in Section 3.1.4.

3.1.2 Existing / pre-construction background

A brief summary background on habitats and species present pre-LORP construction (baseline) is provided below, with particular focus on those of relevance to the NCA. Unless otherwise stated, the source of the text below is the Environmental Statement (ES) (Environment Agency, 2020). Please note that the value of the many of the following species and habitats could not be valued using the natural capital approach applied for this report; please see Section 5 for more detail.

Habitats and flora

The grassland on site is classed as semi-improved neutral grassland with remnant unimproved marshy grassland and species-rich ditches. The following Habitats of Principal Importance (under Section 41 of the Natural Environment and Rural Communities Act 2006) were found on site during surveys undertaken for the Environmental Impact Assessment (EIA): deciduous woodland, lowland fen; coastal saltmarsh; floodplain meadow and grazing marsh; ponds; hedgerows and reedbeds. Please noted that the EIA study area boundary differed slightly from the ‘inside’ study area applied for this NCA.

Notable plant species recorded on site included: divided sedge (*Carex divisa),* and galingale (*Cyperus longus*). Several orchid species have also been recorded, such as the southern marsh orchid (*Dactylorhiza praetermissa*) and common spotted orchid (*Dactylorhiza fuchsii*). Please note that, for LORP, attempts are being made to translocate some of these notable plant species.

The fronting saltmarshes (see Image 5) mainly consist of mid-level marsh belonging to the sea purslane *Halimione portulacoides* community, with some common saltmarsh-grass

Puccinellia maritima dominated areas and a few upper red fescue *Festuca rubra* marsh patches (with *P. maritima*, saltmarsh rush *Juncus gerardii* and sea milkwort *Glaux maritima*) (EAD Ecology, 2021).

Taken by: ABPmer, 2022

Image 5. The fronting saltmarshes (view north-east from Lime Kiln car park)

Species (invertebrates)

Brown trout (*Salmo trutta*) and sea trout (*Salmo trutta trutta*) are numerous and widespread in the River Otter, with occasional Atlantic salmon (*Salmo salar*), although numbers of the latter have collapsed over successive decades. The River Otter is classified as a principal sea trout river, and a recovering salmon river. The majority of high quality salmonid spawning and juvenile habitat is concentrated in the lower main river reaches and tributaries below Ottery St Mary. Bullhead (*Cottus gobio*), stone loach (*Barbatula barbatula*) and European eel (*Anguilla anguilla*) have also been regularly recorded by the Environment Agency during fish surveys at Otterton Bridge between 2003 and 2016. Sea lamprey (*Petromyzon marinus*) are known from the lower Otter downstream of Otterton Weir.

Marine species, including bass (*Dicentrarchus labrax*) and mullet (*Mugilidae*) are regularly caught in the River Otter. Flounder have been recorded from Otterton Bridge in routine freshwater fish monitoring surveys. Fish typical of lower estuarine environments, such as goby species, sand smelt and flatfish would be expected to utilise mudflat and saltmarsh

habitats. Around high tide flatfish and other estuarine tolerant species use the intertidal flats as foraging grounds.

Two dedicated PACCo fish surveys have taken place in and around the saltmarsh habitats of the Lower Otter over the last two years; one two-day survey in late September 2021, and one one-day survey in late July 2022. These confirmed that the fish populations in the Lower Otter estuary and associated saltmarshes have similar characteristics to those observed in the nearby Exe estuary. They are dominated by (grey) mullet, common goby (*Pomatoschistus microps*) and bass species; small numbers of pollock (*Pollachius pollachius*) and dab (*Limanda limanda*) were also found (Colclough and Coates, 2021; EDPHCT pers. comm.).

Species (amphibians and reptiles)

Recent records of common toad (*Bufo bufo*), common frog (*Rana temporaria*), smooth newt (*Lissotriton vulgaris*) and palmate newt (*L. helveticus*) were reported on in the ES. Great Crested Newts (*Triturus cristatus*) were considered to be likely absent from the site. During the EIA reptile survey, one grass snake (*Natrix natrix*) was recorded on site, as was a small population of slow worms (*Anguis fragilis*) (on the historic landfill site).

Species (Birds)

The ES concluded that the Otter Estuary was likely to support around 159 different bird species. In total, 60 species of waders and waterfowl were found to frequent the Otter Estuary during winter, with the majority of these species occurring intermittently and in low numbers. The largest counts tend to be for black-headed gull, wigeon and herring gull. small numbers of water rail, mute swan, shelduck, teal and dunlin are observed; these are all species listed in the Otter Estuary SSSI citation. With regard to overwintering and passage birds, no major high tide roosts were identified on or near the project site.

With regard to owls, barn owl was thought to be resident during the winter, but leave in the spring. Anecdotal evidence indicated that tawny owl had bred in a tree on site. Suitable foraging habitat for owls, including rough field margins, hedgerows and river banks was found to be present within the study area.

All breeding birds which were recorded were considered to be common and widespread in the UK. Mute swan, shelduck, little owl, three species of woodpecker, nuthatch, reed and sedge warblers, stonechat and serin are all breeding bird features of the Otter Estuary SSSI. Of these, only mute swan, shelduck, great spotted woodpecker, reed and sedge warblers and stonechat have actually been recorded recently, and generally in small numbers (noting that the Otter Estuary SSSI was designated over 30 years ago). Little owl is generally considered to be an introduced species and therefore of little intrinsic ecological value despite it being a SSSI feature.

Species (Bats)

One confirmed bat roost was present on site when the EIA surveys were undertaken. Numerous trees with the potential to support roosting bats were also present. The habitats within the study area were considered to provide foraging and/or commuting habitat for an assemblage of bat species, including some of the rarer UK bat species (barbastelle bat, noctule, Nathusius' pipistrelle, Leisler's, lesser horseshoe, greater horseshoe and serotine), as well as more common species (common pipistrelle, soprano pipistrelle).

Other protected/notable species

Hedgehog were assumed to be present on site. The presence of harvest mice was confirmed, as was that of dormice. A potential one-hole badger sett and a badger sett with two active holes were identified on site. Mammal runs, possibly made by badger, were noted in numerous places across the site. Otters and beaver are found on the Otter (including in the Lower Otter, though in lower numbers), with beaver having been reintroduced successfully. Otters are protected under the 1981 Wildlife and Countryside Act and, as of October 2022, beavers are now a protected species in England (under the Conservation of Habitats and Species Regulations 2017) (BBC, 2022).

Please note that comprehensive mitigation measures and some terrestrial habitat creation/enhancement form part of LORP (including new planting of trees, hedges and species rich grassland; rare plant relocation, etc.); details are summarised Section 3.1.4.

3.1.3 Existing / pre-construction condition

Habitat (or species) condition was not assessed during the EIA specific surveys. However, a 2016 survey of the Otter Meadows County Wildlife Site (which covers all bar the cricket field area of the site) showed that the on-site habitats were generally in a good condition. Specifically, all three component habitats (floodplain grazing marsh, reedbeds and lowland fen) were assessed as having a 'high' condition (the highest of three possible options (high, medium, low). The site was considered to be in 'favourable condition' and 'positive (optimum) management' (Devon Biodiversity Records Centre, 2016).

Fronting the site, the intertidal habitats are part of a SSSI and MCZ; Natural England undertakes condition assessments for these sites. The intertidal units of the Otter Estuary SSSI were last assessed in 2009/10 and found to be in favourable condition. On site, a small area of reedbed/swamp between the landfill and the bund forms part of the SSSI; this is in unfavourable condition, which is expected to change due to LORP (pers. comm., Environment Agency).

The agricultural land in most of the LORP area were considered to be 'poor' (Grade 4), with the exception of the land in the Little Marsh and north of it, which is classed as 'good to moderate' (Grade 3).

With regard to invasive species, the ES reported that Japanese knotweed (*Fallopia japonica*) occurred in a number of small, scattered areas within the historic landfill site; this

was treated with a herbicide. Himalayan balsam (*Impatiens glandulifera*) was also widespread, particularly along watercourses. An unconfirmed recording of giant hogweed (*Heracleum mantegazzianum*) was also made near the River Otter. Water fern (*Azolla filiculoides*) was also recorded in a ditch within the Big Marsh North area of the scheme.

3.1.4 Restoration assumptions

Habitats and species

Intertidal habitats will occupy much of the 'inside' study area going forward. It will take a few years for these habitats to develop. Monitoring at UK managed realignment sites shows that, after a seawall is breached, it typically takes four to five years for comprehensive saltmarsh coverage to be achieved at suitable elevations. Potentially, it may take longer for species diversity to become directly comparable to adjacent marshes (e.g. Brown *et al.*, 2007). Full saltmarsh cover would tend to take at least five years, if not up to 10 years, to establish (ABPmer, 2020). Likewise, invertebrate biomass and species diversity in mudflats take four to five years to build up, depending upon the location.

In the future, the intertidal habitats will accrete with sediment, especially over lower lying areas. The rate of this future habitat development will depend on the amount of sediment which is available for accretion as suspended sediment concentrations (SSC) in the estuary. These are not known for the Otter Estuary, but are believed to be relatively low. It should be emphasised though that SSC increase substantially following surge events, gale force conditions, and also heavy rainfall. Thus, sporadically, SSC would be expected to far exceed the relatively low values believed to be present during quiescent conditions, and relatively high rates of accretion can occur during such sporadic events (e.g. several centimetres over the course of a surge event). The lower-lying habitats within the managed realignment area are expected to trap sediment particularly during these periods of high availability. Therefore, as is typical for managed realignment sites, relatively stable and accretional habitats are expected to form in the short to medium term, and some of the mudflats are expected to transition to saltmarsh over time.

It is likely that, in the short to medium term at least, accretion would exceed sea level rise. However, over time, rates of sea level rise are expected to exceed average annual accretion, and saltmarshes may slowly revert to mudflats in the long term (though likely after the 60-year accounting period applied for this NCA).

These insights and expectations, as well as modelling and research work undertaken as part of LORP, have been used to inform the habitat estimates provided for the dynamic LORP scenario (and summarised in Table 2 above).

Once implemented, it is expected that LORP will provide an increased habitat resource for overwintering birds, benthic estuarine invertebrates and intertidal, estuarine and migratory fish species in the Otter catchment. There are multiple beneficial significant effects from the creation of saltmarsh and mudflat habitats on site and a more natural transition from intertidal to freshwater and terrestrial habitats. This will also have a beneficial significant effect on the Otter Estuary Marine Conservation Zone and the Otter Estuary SSSI.

The biodiversity, marine ecology and fish impact assessment undertaken for the ES identified that, without mitigation, there was a potential for LORP to impact important ecological features for nature conservation and species protected by legislation.

As previously mentioned, a myriad of mitigation measures have been implemented to lower the severity of impacts on biodiversity. These comprised design stage avoidance of adverse impacts, best practice design, pollution control measures, general good construction practices, habitat protection measures, sensitive landscaping and mitigation planting (including extensive woodland, scrub and hedgerow areas). Protected species mitigation has also been undertaken in accordance with legal requirements and seeks to enhance the integrity of populations where possible to do so.

After mitigation, residual significant effects were anticipated due to habitat loss of grassland and swamp habitat, which are the qualifying features of Otter Meadows County Wildlife Site. This was due to the change in habitat required to achieve the purpose of the LORP scheme. Although avoidance and mitigation measures have been undertaken, like for like compensation for the loss of these habitats could not be achieved.

However, the habitats being created are considered to be of equal or greater value/ sensitivity and equivalent or greater scarcity and biodiversity benefit as those lost. Reinstating natural processes will furthermore result in the change of terrestrial and freshwater habitat into intertidal habitat, with long term, more sustainable benefits for species and habitats.

The localised and short term negative impacts of construction activities upon existing biodiversity and loss of habitats were expected to be balanced against longer term LORP scheme operation, which is considered to have ‘overwhelming positive impacts’ and benefits to the estuary and wider area, due to restoration of more natural environments, processes and enhanced habitats that will attract greater numbers and more varied wildlife (LORP, 2022).

Condition

For the future habitats to fulfil their full potential, and related benefits, they would need to be healthy and in a good condition. Given that the current intertidal units of the SSSI are considered to be in a good/favourable condition, it is assumed that the new mudflat and saltmarsh habitats, once established, would also be in a good/favourable condition.

3.2 Other assets

3.2.1 Water

Baseline

With regard to surface water, the Otter Estuary (up to Clamour Bridge/the tidal limit, just south of Otterton) is classed as a transitional waterbody under the Water Environment (Water Framework Directive (WFD)) (England and Wales) Regulations 2017. It is

considered to be heavily modified (for flood defence). It lies immediately adjacent to the Lyme Bay West coastal waterbody, which is not designated artificial or heavily modified.

The River Otter is a designated Main River between the mouth and its confluence with the River Love; a river WFD waterbody starts at Otterton Weir and extends to Honiton ('Lower River Otter'). The Otter Valley groundwater WFD water body lies under the project area, and the estuary; it extends north to beyond Ottery St Mary and the A30. Groundwater is also relevant to LORP, as there are two abstraction points nearby which could potentially be affected by the scheme (the source protection zone of one of these slightly overlaps with the Little Marsh, the other one is immediately adjacent, but does not directly overlap with the LORP site). However, the modelling carried out prior to the implementation of the scheme indicated that water quality would most likely not be adversely affected, otherwise the scheme would not have been able to go ahead.

There are three small watercourses on the LORP site:

1. Bicton Brook is a small river that springs in Bicton Park (north west of Otterton). It joins the River Otter floodplain near Otterton and remains in a separate channel broadly parallel to and approximately 200 m away from the Otter.

2. Budleigh Brook joins the River Otter near East Budleigh. Prior to LORP, it would flow into the River Otter via an aqueduct (see Image 6), which carried the flow across (above) Little Marsh.

3. The Kersbrook is a small tributary of the Otter which, prior to LORP, would discharge into the Trunk Drain south of South Farm Road.

The Trunk Drain begins close to Pulhayes Farm and discharges to the sea via a penstock-controlled culvert and outfall in Budleigh Salterton beach.

Source: ABPmer, February 2014

Image 6. Budleigh Brook aqueduct in Little Marsh prior to its demolition

The entire 'inside' study area lies within a tidal/fluvial floodplain according to Environment Agency flood plain mapping, with the floodplain slightly extending into Budleigh Salterton;

only four properties along the southern extent of Granary Lane lie within the same functional floodplain as that of the LORP area (see Section 3.2.2 for embankments and flooding history; and also Figure 7 in Section 3.2.2, which depicts the local floodplains, alongside flood defence structures).

LORP scenario

As noted previously, the Budleigh Brook aqueduct is being dismantled and the section where the brook joins the Little Marsh restored to a more natural, meandering, watercourse. Short reaches of the Bicton Brook and Kersbrook on the former floodplain will furthermore be replaced by tidal creeks. Groundwater impacts have been assessed, a groundwater monitoring strategy has been produced, and further ground investigations have been undertaken, finding that additional mitigation measures in the northeast area of the LORP are not required.

Condition

During the EIA, groundwater samples were taken from 16 monitoring points from on-site boreholes (at dual levels), window sample holes and trial pits. Additionally, surface water samples were taken from six locations. Following laboratory testing, the results were compared against WFD threshold values. It was found that all of the chloride results exceeded the guideline value; it was determined that this was indicative of saline conditions. Where exceedances for inorganic parameters occurred, these were all associated with either surface water or shallow groundwater samples taken close to the tidal reach of the river and represented the influence of saline estuarine waters within, or overspill from, the River Otter. There was one outlier sample which had evidence of Polycyclic Aromatic Hydrocarbon (PAH) and trace metal contamination. This was considered to be an isolated occurrence and not related to the landfill.

The Environment Agency monitors and assesses WFD waterbody condition, and from this, the following insights can be gained (as derived from the Catchment Data Explorer (Environment Agency, 2022):

- The Otter (estuary) WFD waterbody is at moderate ecological potential (2019 data), with failed chemical classification due to priority hazardous substances (Mercury and Polybrominated diphenyl ethers). The reason for not achieving good potential relates to the invertebrates element. Physico-chemical quality elements (which would include nutrients) are not assessed for this waterbody;
- The Lyme Bay West coastal WFD waterbody is at moderate ecological status, for similar reasons to the Otter estuary (nutrients have again not been assessed);
- The Otter Valley groundwater WFD waterbody is considered to be in a poor overall condition, with reasons for not achieving good status being related to livestock and nutrient management, as well as water abstraction; and
- The Lower River Otter WFD waterbody has a poor ecological status, with ‘poor’ biological quality elements and ‘moderate’ physico-chemical quality elements (with a ‘poor’ rating for phosphates (due to agriculture and sewage discharge), and ‘high’ for ammonia). The waterbody furthermore fails on priority hazardous

substances (specifically Mercury and Its Compounds, Nonylphenol and Polybrominated diphenyl ethers (PBDE)). The Hydrological Regime element furthermore 'does not support good'.

The scheme area, as well as the Lower and Upper Otter Valleys lie within in the 'Mid Devon' nitrate vulnerable zone (for groundwater); this relates to the groundwater breaches for nitrogen.

At present, the Otter is not a catchment which is subject to nutrient neutrality strategic solutions (Natural England, 2022)[6]. Such areas have recently been identified in several English catchments; for example, all catchments into the Solent and Poole Harbour (Local Government, 2022). In such nutrient advice areas, new developments in some catchments cannot proceed if they increase levels of nutrients; mitigation actions are typically required before permission is granted.

Going forward, with LORP, a more natural river system is anticipated, with improved protection from flooding of the landfill, which will help to prevent pollution. As noted above, groundwater conditions will be monitored to ensure saline intrusion is not made worse by the project. It is worth noting that intertidal habitats, notably saltmarshes, are known to improvement water quality by mediation of nutrients and other water pollutants (e.g. Watson *et al.*, 2020). This benefit has been assessed for LORP in relation to phosphates (P) (see Section 5.4.4), which contribute to the poor status of the upstream riverine waterbody, as outlined above.

3.2.2 Embankments, footpaths and roads

Baseline

Embankments

The LORP site is currently protected from normal fluvial and tidal flooding by several embankments. The embankments are referred to as Little Bank and Big Bank to the north, and the River Otter embankment (carrying the South West Coast Path) towards the south.

The Little Bank, which runs from the farm access near Frogmore Road Pumping Station through to where it meets the concrete spillway, is at a minimum elevation of 3.4 m Ordnance Datum (OD). The Big Bank runs from a farm access to the south of Pulhayes Farm towards the Budleigh Brook aqueduct, where it meets the public footpath. The Big Bank has an approximate elevation of 3.3 m OD and carries a farm access track.

[6] i.e. is not an area where poor water quality due to nutrient enrichment from elevated nitrogen and phosphorus levels has been identified as a primary reasons for habitats in designated sites being in unfavorable condition.

The River Otter embankment extends from the Lime Kiln car park in the south, to the White Bridge (which carries South Farm Road) and then extends further north beside the River Otter, to where it meets Big and Little Banks. The embankment has a minimum crest level of 3.2 m OD, and a maximum of 3.8 m OD (Environment Agency, 2020).

It is understood that the Environment Agency is responsible for maintaining the eastern outfall by the Cricket Club, whereas East Devon District Council owns the culvert that links the trunk drain to the sea (pers. comm. Environment Agency).

South Farm Road, running east-west, bisects the project area, crossing the River Otter via White Bridge. This road is fairly low lying in parts, with a minimum level of 1.2 m OD.

Flooding history

Human-led changes to the river and estuary described above in Section 2.2 mean flood flows after heavy rainfall events cannot pass down the river channel to the estuary. Water spills over the Little and Big Bank embankments into the historic floodplain, which fills until it can overtop southern embankments into the estuary, or be drained via outfalls to the sea and estuary. Prolonged deep flooding of fields, Budleigh Salterton Cricket Club, public footpaths, South Farm Road and the landfill results (i.e. across the majority of the 'inside' study area). This is due to the two main outfalls being unable to cope with flood flows, as well as tidal locking. Deep fluvial flooding last occurred in October 2021 (see Image 7). It is understood that some relatively shallow flooding of up to around 1 m depth occurs every year (Cricket Club, pers. comm.), sometimes several times per winter, whereas deeper flooding up to the embankment crests (to a depth of up to around 2.5 m) occurs approximately every 2 to 5 years.

The estuary embankments are also sometimes overtopped by exceptionally high (surge) tides, such as those that occurred in February 2014 (CH2M *et al.*, 2018).

Source: Budleigh Salterton Cricket Club, 2021

Image 7. Flooding of the cricket ground and club house in October 2021

Footpaths and roads

Footpaths have been designated along all of the embankments, and at the western edge of the floodplain. All are popular, with the most well-used being the South West Coast Path, which runs along the embankment from Lime Kiln car park to White Bridge, where South Farm Road crosses the River Otter. Just under 1 km of the South West Coast Path runs along the LORP site, which is very short when compared to its overall length (1,014 km).

Numerous types of visitors access the site via these footpaths; these include:

- Dog walkers;
- Walkers without dogs;
- Runners/joggers;
- Birdwatchers;
- Wildlife photographers;
- Visitors with limited mobility;
- Users of Budleigh Salterton beach and the River Otter; and
- Recreational cyclists.

The ES reports that (pre-Covid), over 250,000 people per annum tended to use the South West Coast Path on the estuary embankment. This was according to East Devon AONB people counter data, with counters counting people, not journeys, therefore a percentage of this number will have been return trips.

Clinton Devon Estates installed counters along some of the paths in July 2021. Although some data was lost due to flooding and other incidents, the results confirm that all the paths are well used. As with the AONB data, these counters count passes rather than number of people, thus someone walking there and back would be counted twice. Daily pass numbers peaked at just under 950 for the South West Coast Path (in late August 2021); monthly passes for this path are illustrated in Image 8. Other paths were less frequented, though still seeing between 100 and 250 passes on busy days.

Whilst numbers may peak in the summer, figures are still high at other times of the year; for example, 685 passes were counted on the South West Coast Path on 24 October 2021 (a half term Sunday). Over the year from August 2021 to July 2022, just under 190,000 passes were counted on the South West Coast Path. However, as noted above, a large proportion of these counts would be same-day return and regular repeat visitors, as many visitors and residents walk back and forth along the same stretch of path on any given day. Whilst generally busiest around mid-day, the South West Coast Path is well frequented throughout all daylight hours.

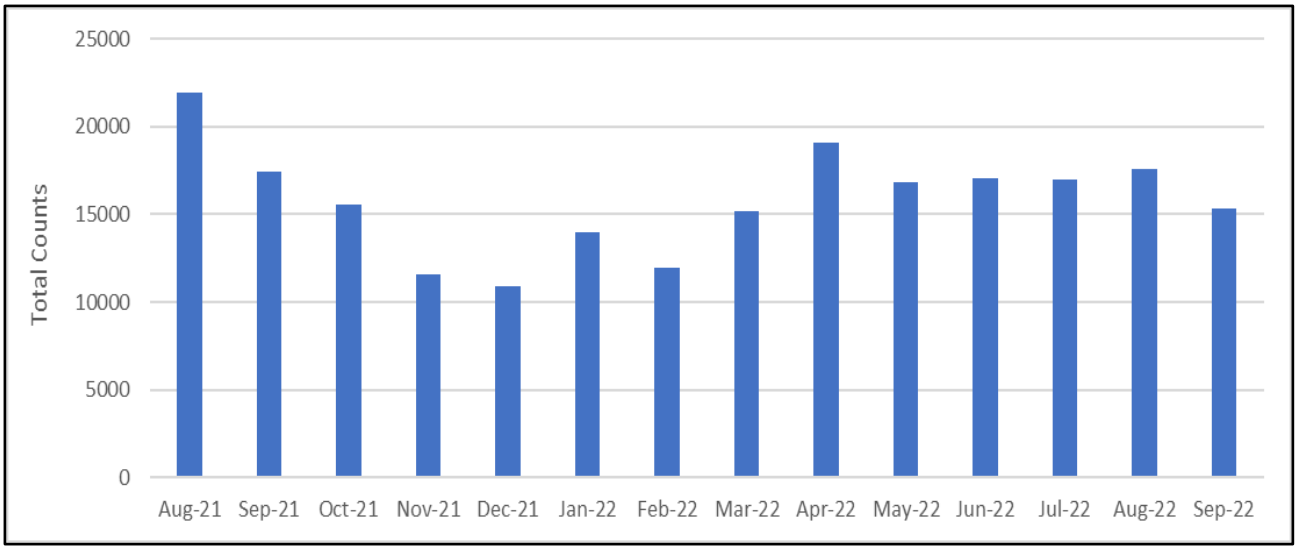


Image 8. Monthly visitor passes for the South West Coast Path, Aug 21-Sept 22

User surveys undertaken throughout July and August 2021 and 2022 revealed that the users of the South West Coast Path appreciated the Otter Valley for its wildlife and scenery, and found it both beautiful and peaceful (ABPmer, 2023).

As noted previously, the minor road 'South Farm Road' crosses the project area and provides vital access to a business park, a farm and some residential properties (see below for more detail). This currently mostly lies within the floodplain, and is regularly flooded during fluvial events (see above).

LORP scenario

For the LORP, all the embankments described above will be breached in some fashion, with the main 70 m breach planned for the River Otter embankment, and substantial sections of the Little Bank and Big Bank being lowered in the north.

New footpaths are being constructed, and existing ones improved and secured. Substantial works include the raising (by around 1 m on average) of a footpath running along the western extent of the scheme area, the construction of a new path on the landfill area, and the installation of the footbridge over the breach, to facilitate continuation of the South West Coast Path. South Farm Road is being raised out of the floodplain, effectively placing it on a new embankment.

There will furthermore be improvements for both abled and less able users' accessibility of the public footpath network, where this is affected, arising from improved surfacing and increased footpath widths (where this has been possible). Improvements to recreational and educational facilities will also result from the installation of new environmental interpretation and information boards, and several new viewing areas for public use.

With regard to flooding, as noted previously, there is generally considered to be a decreased flood risk to the properties adjacent to the Otter Estuary floodplain due to LORP.

Condition

No information is currently available on the condition of the footpaths or roads; it is understood that most of these are maintained by Devon County Council, who have undertaken comprehensive repairs along the Otter embankment crest footpaths in the past. Between 2012 and 2014, the Council spent between £100,000 and £150,000 on repairs (Devon County Council, pers. comm); for example, following damage caused by fluvial flooding in November 2012 (Image 9). Prior to LORP, South Farm Road was subject to regular flooding, as noted above.

Source: Devon County Council, 2012

Image 9. Crest level footpath damage caused by flooding in 2012

Embankment condition information has been provided by the Environment Agency (February 2022), based on 2019 to 2021 assessments; locations are displayed in Figure 7 below.

This shows that there are three Environment Agency maintained assets within, or immediately adjacent to the study areas applied for this NCA, according to the Environment Agency's 2019 'spatial flood defences' datalayer. Two of these (a short wall and equally short embankment, cumulatively measuring under 50 m) protect parts of Granary Lane, as does another short stretch of Local Authority maintained embankment. These Granary Lane defences are in a 'very good' condition.

The third apparently Environment Agency maintained embankment is a 120 m stretch adjacent to the Cricket Club. This stretch is considered to be in a 'good to fair' condition.

The remainder of the embankments within/adjacent to the study area are all privately maintained; their condition is as follows:

- Estuary embankment from Lime Kiln car park to South Farm Road: ‘fair’ condition (this asset is owned by Clinton Devon Estates, though the maintenance of the footpath which runs on the top is the responsibility of Devon County Council; see below);
- Estuary / river embankment from South Farm Rd to Big Bank: ‘fair’ condition - although a recent informal inspection noted that were some significant patches of erosion, likely a leading to ‘poor’ condition (pers. comm. Environment Agency, February 2022);
- Big Bank: ‘poor’ condition;
- Little Bank: ‘fair’ condition (noting that this embankment is erroneously shown as high ground in the Environment Agency asset datalayer; this has been corrected for Figure 7 below).

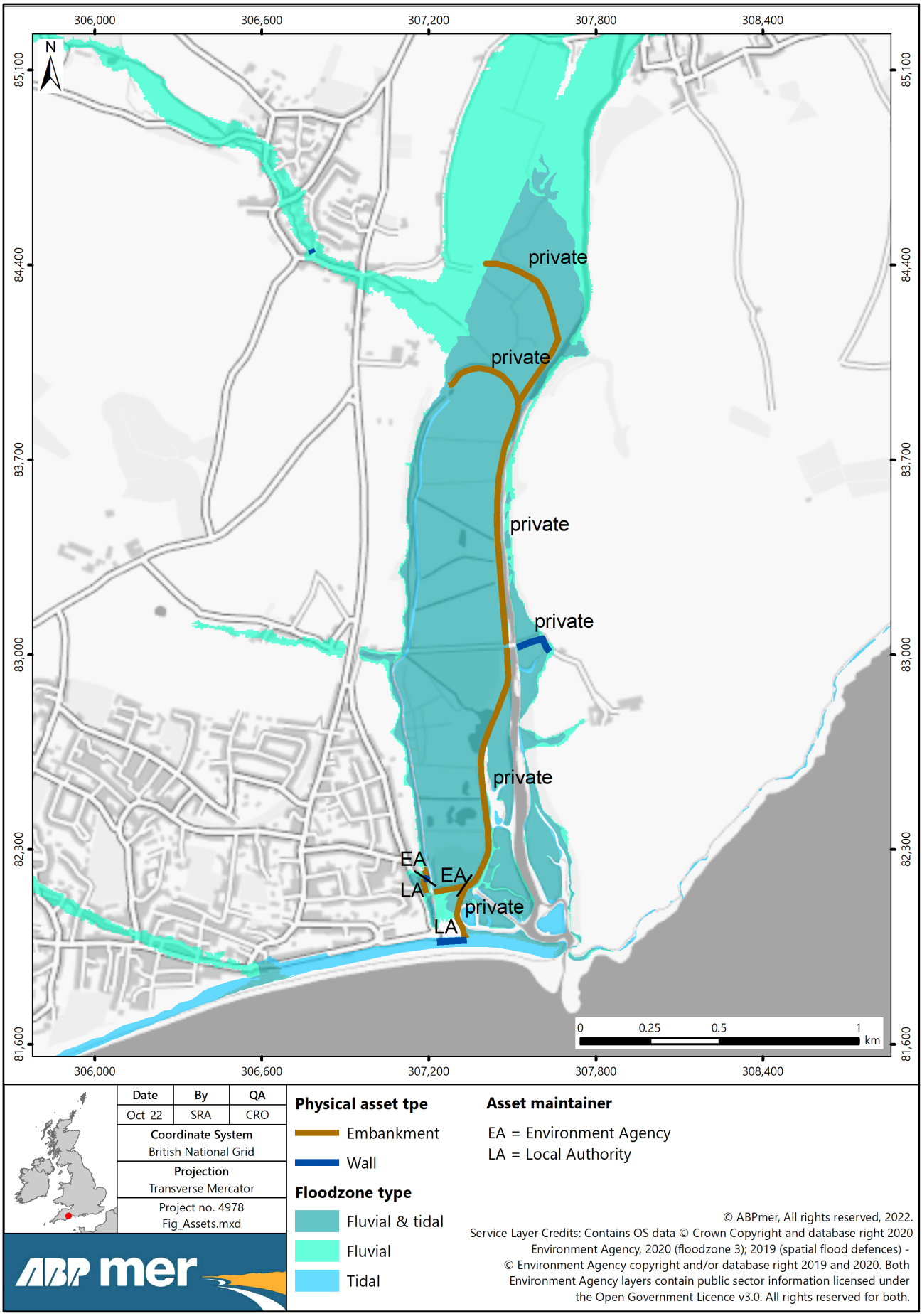
It is worth noting that the Environment Agency undertook emergency repairs of a short stretch of embankment near the main outfall in 2018, at a cost of around £300,000; apart from that, there has been almost no maintenance in the project area in recent years (pers. comm. Environment Agency, February 2022).

Based on the information presented above, substantial stretches of the embankments are at risk of failing due to being in a poor condition, and having relatively low crest levels.

The risk of failure is expected to increase with sea level rise and storms (which could potentially become more frequent due to the changing climate). This could cause further, and more prolonged and frequent, flooding of farmland, the cricket club and could also compromise access routes such as South Farm Road and the South West Coast Path. It could also cause further erosion of the old municipal tip/landfill site[7], leading to potential contamination.

Going forward, with LORP, footpath (and embankment) maintenance arrangements are still being agreed between Devon County Council and Clinton Devon Estates (LORP, 2022). New and recently constructed embankments, as well as related structures, will continue to be maintained by the respective asset owners.

[7] Regular fluvial flooding already pours over parts of the landfill, moving in a north to southerly direction (Clinton Devon Estates, pers. comm.)



Created by: ABPmer, 2022 (see figure for layer credits)

Figure 7. Flood defences and flood zones in the study areas

3.2.3 Cricket Club

Baseline

Until autumn 2022, Budleigh Salterton Cricket Club had a pitch and club house at the LORP site; these premises occupied just under 4 ha and are being moved to a new site north of Budleigh Salterton, outside of the floodplain, at present (after the 2022 season ended).

Taken by: ABPmer, 2022

Image 10. The Cricket club house and pitch (July 2022); view from Lime Kiln car park

The information below has been derived from personal communication with a senior Cricket Club volunteer (June 2022).

The club has around 450 active members, some 100 of whom are senior lifetime members who no longer actively play. However, there is a community league of around 200, only half of which are official cricket club members. Thus, there are effectively 450 active players that benefit from the club every year, even though some of them are not members of the club.

The community league plays 12 to 15 games per year, and trains at the club every week (from May to the end of August). There are 10 junior and 2 senior club teams; these play and train every week, from mid-April to the beginning of September.

The club is run entirely by volunteers; these coach the teams, staff the bar in the club house, and act as committee members and club secretary (etc.). For the purpose of the NCA, volunteer hours have been calculated; the result being that around 4,300 hour per annum are volunteered at the club.

The club has an annual revenue of approximately £ 44,000 per annum, with almost 80% of that being derived from bar revenues, and the remainder from membership fees and sponsorships.

Costs of running the club are around £38,000 per annum. Just over 30 % of this is spent on a self-employed groundsman, and just over 50 % on the annual grounds preparations and club refresh. This relates to laying of new loam, as well as cutting, weeding, fertilising, and repainting the club house. The majority of these costs are related to the regular winter flooding of the grounds and club house.

LORP scenario

For LORP, the cricket club is being moved to a new site out of the floodplain (see Figure 2). The new grounds will provide substantial improvements over the old site. The new facilities include a main cricket square, junior pitch, new club house (for which construction started in September 2022), and equipment store.

The new facility will have a new business model which involves its use as a venue for events and classes (e.g. wedding receptions, yoga classes); this will generate significant income for the club as well as providing social benefit to the area. In addition, by having a facility which is not subject to repeated flooding the club will be able to host county level cricket matches.

The new club house and facilities have largely been funded by LORP, but delivered separately by the Cricket Club. The Cricket Club initially set out to raise £250,000 for its contribution to the new facilities, and invested hundreds of volunteer hours to make it happen (pers. comm. Budleigh Salterton Cricket Club; also website). Whilst the new clubhouse, which at the time of writing is yet to be consented, is now more ambitious than initially envisaged, the above sum has been applied to the NCA calculations for this report, as it is considered a realistic cost for a like for like replacement of the past facilities in the Otter Valley.

Condition

With regard to condition, as noted above, the Cricket Club has flooded many times in the past; some form of shallow flooding occurs every winter, and deep flooding happened in October 2021 (Image 4). The damages caused by this event were around £40,000, as the flooding occurred prior to the annual pre-winter clear out. These damages related to building damage, ruined equipment and white goods, as well as lost bar stock. The club has not been insured since around 2016, due to being uninsurable on account of the repeat flooding and its location in the flood plain. This vulnerability to fluvial flooding would continue if the club stayed in its current flood prone location.

Given these condition insights, and personal communication with a senior Cricket Club member, for the baseline scenario, it has been assumed that the cricket club would be forced to cease operations after Year 5, as it would no longer be viable after this, due to repeated flooding damages.

With LORP, at the new grounds, it is anticipated that annual running costs will be much reduced, due to the club no longer being located in the Lower Otter floodplain.

3.2.4 Farming

Baseline

Two tenant farmers used to graze cattle and cut silage on the on-site grassland (away from the cricket grounds). Cattle were not on the land permanently, rather, part of a rotation of around 230 dairy cows plus their followers, with the land within the study area accounting for around 40 % of the grassland available to the farmers. One of the farmers tended to 'sub-let' the grazing rights to other local farmers.

LORP scenario

Farming/grazing will cease in Big Marsh South and Big Marsh North and will likely be significantly reduced in the Little Marsh (much of it has already been stopped due to construction works); north of these marshes, grazing continues whilst sea levels permit this during future years.

Condition

As noted above, the agricultural land in most of the LORP area is considered to be 'poor' (Grade 4), with the exception of the land in the Little Marsh and north of it, which is classed as 'good to moderate' (Grade 3).

3.2.5 Car parking

Baseline

Immediately to the south of the LORP site lies the Lime Kiln Car Park, which is owned by East Devon District Council. This car park has space for around 420 cars.

A freedom of information request (reply received August 2022) has revealed that:

- Over the 2020/21 financial year (1 April to 31 March), the revenue from this car park was £282,516 inclusive of VAT (based on 103,928 transactions), and
- For 2021/22, it was £256,762 incl. VAT (based on 111,932 transactions) (noting that pricing structure differs according to seasons).

These figures are income only and do not include any expenses / costs for running / management of the car park. The number of transactions is for cash, card and cashless, but does not include any permit holder usage, as the council has no way of recording / collecting this data.

The Council introduced tariff increases in early 2022, which they have yet to monitor the impact of. It is anticipated that, for the 2022/23 financial year, income figures for Lime Kiln will be broadly similar to the previous two years, with £270,000 having been provided as an approximate estimation of the income they expect to achieve.

LORP scenario

A new small 45-space car park is being constructed opposite South Farm cottages. This will be owned by Clinton Devon Estates, but operated by East Devon District Council. It will generate income for the management of the site, as it will be a paying car park.

Condition

No pertinent condition information could be found. Condition of this asset is not considered to be material to the NCA.

3.2.6 South Farm Court and Otterton Mill

Baseline

Eleven business units are available at the South Farm Court business park, which is owned by Clinton Devon Estates, and located east of the White Bridge, as shown in Figure 2 above. Ten businesses currently occupy these units, with one business renting two units. Several of these businesses rely on customer access (most notably a farm shop), and some trade products from the units without a store front at the business park[8].

Otterton Mill lies adjacent to the River Otter in Otterton, some 3.5 km north of the Lime Kiln car park on foot. This historic working watermill has a cafe-restaurant, as well as a bakery and gift shop.

The South Farm Court businesses are affected by conditions in the NCA study area due to the road leading to them, South Farm Road, being subject to frequent flooding at present, and also being upgraded as part of LORP. Some footpath users may also access the South Farm farm shop on foot, and many walkers follow the estuary's footpaths to Otterton, with Otterton Mill being a popular destination (pers. comm. Otterton Mill).

LORP scenario

With LORP, access to the business park, farm and residential buildings will be improved, as South Farm Road will have been raised out of the floodplain. The new footpath along South Farm Road (and on top of the old landfill) facilitates better access on foot.

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[8] e.g. Hawkins Coffee, a coffee merchant and Georgie Porgie's Puddings, a company producing hand-made puddings, including Christmas puddings (noting that the storefront for this business is in Budleigh Salterton itself, with the South Farm Court unit being utilised as both a warehouse and production site for some of the puddings (pers. comm. Georgie Porgie's Puddings)).

Condition

Condition of the above businesses *per se* is not of note for the NCA, rather it is the condition of South Farm Road and the embankment crest footpaths which have the potential to impact the above businesses, thus warranting their inclusion in this report. Condition of these assets has been discussed above.

With regard to the road, it is worth nothing that some low level flooding occurs every year, and serious flooding approximately every 2 to 5 years. When this happens, the tenants at South Farm Court are able to access the business park via a rough and steep farm track (linking to a small minor road which leads to Otterton). However, customers are not able to use this, nor are heavy vehicles. Thus, tenants can be substantially inconvenienced when the road floods, with businesses relying on deliveries often facing increased staff costs due to having to route deliveries via smaller vans and the back track, also potentially facing some lost profit where deliveries are missed (insights based on pers. comm. with four of the tenants, June-August 2022).

Should the road become inaccessible (as would be the case following an unmanaged breach, which is assumed for Year 15 under the baseline scenario), then many of the South Farm Court businesses could no longer operate out of this business park. This is why, for the purpose of the baseline NCA, it has been assumed that half of the units would be converted into holiday lets post breach (though this would of course be subject to obtaining planning permission; see next Section for further detail).

As noted above, with LORP, access to the business park, farm and residential buildings will be improved, both by car and on foot.

4. Management and Maintenance Costs

4.1 Introduction

One of the key steps in an NCA process involves describing and comparatively valuing the existing and future management and maintenance costs. These can also be termed 'liabilities' by economists. Costs for both scenarios are outlined below, in Sections 4.2 and 4.3 respectively. Please note that some of the relevant costs could not be listed here, due to them being considered confidential.

4.2 Baseline scenario

As noted previously, the baseline scenario is a dynamic one, whereby costs which currently occur have been applied, together with changing costs which are anticipated for the future.

The following three categories of management and maintenance costs have been applied for this baseline NCA:

1. Production costs; these include:
   - The Cricket club's annual £38,000 costs, as previously provided in Section 3.2.3. These were only applied for Years 1 to 5 of the baseline scenario, with the assumption being that the Club would cease operations after Year 5, when it becomes unviable due to repeated flooding damages; and
   - A one-off cost of £737,200, applied during the year following the unmanaged breach (and South Farm Road becoming inaccessible). This is for the conversion of half of the South Farm Court business units into holiday lets[9].

2. Natural capital maintenance costs; these include:
   - Assumed footpath maintenance costs of £50,000 per annum[10] (up to the breach year only; thereafter, the crest level footpaths are assumed to no longer be functioning);

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9 Calculated by ABPmer. Costs are for converting five units to five 2-bedroom houses. Derived by assuming each unit has 1,900 square feet of space. Then applied conversion cost of £77.6 per square foot (using the lower value quoted by Progressive Property, 2016, whilst adjusting the 2016 price for inflation using the Bank of England's inflation calculator). This would be subject to obtaining planning permission, but is considered a feasible assumption by Clinton Devon Estates.

10 Calculated by ABPmer. Derived by averaging the council's costs listed in Section 3.2.3, also noting the Environment Agency's repair costs quoted in Section 3.2.2 (as all the current footpaths are embankment crest footpaths, they rely on the embankment being in a good condition; furthermore, repair costs would tend to be relatively high where they are necessitated by embankment slumping or erosion, as illustrated in Image 9.

- Assumed one-off South West coast path reinstatement costs of £71,600[11], applied for the year following the unmanaged breaching (with annual maintenance costs of £453 per annum applied thereafter); and
- Confidential Clinton Devon Estates land management costs.

3. Other costs; these include:
   - Lost business costs for South Farm Court, calculated on the basis of conversations with some of the tenants, as £5,500 every two years (up to the breach year), noting that similar lost business costs could not be derived for Otterton Mill; and
   - Capital costs for protecting and making safe of the landfill, as well as re-routing the sewer (it was assumed that these actions would pro-actively be undertaken as part of the baseline scenario at Year 5, as discussed previously in Section 2.3.1).

Costs for the sewer are confidential, and actual LORP costs related to the landfill had not been made available to ABPmer and eftec at the time of writing. Instead, costs were derived from available literature (e.g. Duffy, 2005; Environment Agency, 2015). Due to the sewer costs being confidential, the derived landfill costs are not displayed here either (as the former may otherwise be attained from data in this report). As noted previously, in reality, these proactive measures would most likely be very difficult to achieve without significant external funding; and this would be extremely challenging to come by without the LORP and PACCo projects.

Further adaptation costs could have been associated with the unmanaged breaching scenario, but both potential costs and risks of other elements were difficult to determine, and have thus not been included (see Section 5.2.2 for more detail). It is however considered very likely that costs of reactive adaptation would be larger than applied here, as it would be difficult to work in tidal conditions for example.

Over the 60 year accounting period, discounted present value (PV) costs of just under £7 million have been applied to the baseline scenario.

[11] Calculated by ABPmer, by assuming the coast path is re-routed along Granary Lane and a 500 m path is reinstated along South Farm Road through the construction of a *circa* 250 m long boardwalk, as well as around 250 m of 'normal' path. Costs derived by applying values quoted by Paths for All, 2019. It is acknowledged that constructing a boardwalk in an intertidal environment (post unmanaged breach) may be difficult to achieve and more costly than has been assumed. Thus, these figures are likely to constitute an underestimate.

4.3 LORP restoration scenario

The LORP scenario is also a dynamic one, and three categories of management and maintenance costs have also been applied for this NCA scenario:

1. Production costs; these include:
   - For the Cricket club's:
     - Annual maintenance costs of £20,000 (anticipated; derived from pers. comm. with the cricket club), almost halved from pre-LORP, due to no longer needing to recover the grounds and club house from winter flooding); and
     - A one-off cost of £250,000, which represented the Cricket Club's contribution to the new grounds and clubhouse (as per pers. comm.); as noted previously, costs may now be higher due to increased ambitions, however this sum has been applied as it appears to represent a realistic like for like cost for replacing the previous clubhouse.

2. Natural capital maintenance costs; these include:
   - Assumed post-breach footpath maintenance costs of £3,915 per annum (for 4.5 km of paths; this was based on footpath maintenance costs quoted by the South West Coast Path (2022));
   - Anticipated scheme monitoring costs of £10,000 for the first 5 years, and £5,000 for years 6 to 10 (as per pers. comm. with EDPHCT);
   - Anticipated ranger costs of £35,000 per annum (as per pers. comm. with EDPHCT).

3. Other costs; these related to the one-off scheme delivery costs, which have all been classed as confidential:
   - Sewer diversion: confidential (see baseline scenario text above);
   - Landfill capping/closure and revetment: confidential (see baseline scenario text above);
   - Environment Agency: confidential; and
   - Clinton Devon: confidential.

Over the 60 year accounting period, discounted PV costs of just over £26 million have been applied to the LORP scenario. It is important to note that not all of these costs are solely aimed at the creation of natural capital (e.g. road raising).

Please note that incomes anticipated from both the baseline and LORP scenarios are outlined in Section 5.4.8 below.

5. Assessment and Valuation

5.1 Introduction

An assessment of ecosystem services and valuation methods was conducted by Economics for the Environment Consultancy (eftec), with assistance from ABPmer. This assessment was done to identify which benefits are likely to be provided by the study areas' natural capital assets, and which methods could be used for valuing and including them in the account.

As previously discussed, dynamic 'baseline' and 'restoration' scenarios have been developed for the purpose of this assessment. For the 'baseline' scenario, it is assumed that LORP is not implemented, but that, instead, the situation which existed prior to construction commencing last year, continues for the time being. This would include the processes of sea level rise and coastal erosion/damage to defences, with only minimal essential/unavoidable expenditures in response to flooding. For the 'restoration' scenario, the implementation of LORP is applied.

5.2 Assumptions

Many assumptions have been made in order to undertake this NCA; those which are key to the NCA are summarised below. Section 5.2.1 provides details on the accounting period and discounting, whereas Sections 5.2.2 and 5.2.3 discuss assumptions for the baseline and restoration scenarios respectively.

5.2.1 Accounting period and discounting

The accounting period used for this natural capital assessment is 60 years, based on the Green Book guidance (HM Treasury, 2020). Costs and benefits are discounted over time, also following advice set out in the Green Book.

5.2.2 Baseline scenario

As the shoreline management policy for the site is 'managed realignment', for the non-LORP 'baseline' scenario, it is assumed that unmanaged breaches are allowed to occur at Year 15, and that some proactive adaptation measures are undertaken in anticipation of such breaching. The following assumptions have been made for the purpose of this study (see Section 4.1 for cost assumptions and caveats):

- Prior to the unmanaged breaching, proactive adaptation actions are taken by (1) realigning the sewer (at Year 5); and (2) capping and making the historic landfill safe, including membrane and rip rap armouring (also Year 5);
- The cricket club shuts down after Year 5, as it is assumed that it can by then no longer recover from repeat winter flooding;
- 'Unmanaged' breaching occurs at Year 15; this has the following consequences:
    - Grazing will cease over most of the grassland areas;

- The footpaths on the embankments and in the floodplain become unusable; although one year post breach, the South West footpath is reinstated (via Granary Lane and South Farm Road), with a new boardwalk constructed over the wettest areas;
- South Farm Road becomes unusable most of the time (it would be under water for around 80% of high tides); 50% of South Farm Court businesses move out and those units are converted to holiday lets (with the latter and remaining units accessed via the farm track / road to Otterton); and
- Intertidal habitat gains are smaller when compared to the restoration scenario, as saline flows into the marshes north of South Farm Road are constrained; Big Marsh North and much of Little Marsh would be expected to mostly turn into brackish reedbeds.

Further adaptation measures than those outlined above (and costed in Section 4.2) could have been associated with the unmanaged breaching scenario, but both potential costs and risks of other elements were difficult to determine. For example, reactive construction for footpaths in a tidal environment may well be more costly than assumed above, and further services (such as power and phone lines) would likely also have to be re-routed / made tidal inundation proof. There may also be impacts on groundwater abstraction and freshwater drainage, etc.

5.2.3 LORP restoration scenario

A dynamic baseline has also been applied to the restoration scenario, whereby expert judgement has been utilised to gauge future habitat evolution, both in light of site evolution / colonisation and adaptation to accelerated sea level rise. This has been informed by developments observed at existing managed realignment sites; as noted in Section 3.1.4. A detailed description of the key design elements of LORP is provided in Section 2.3.1.

Whilst the planning, assessment and construction phases of LORP have taken many years, for the NCA, the costs of these phases were not applied over several years, as the focus of the NCA is on the **natural** capital, and benefits derived thereof. Therefore, planning and construction costs are applied to Year 1 of the NCA (2022), and restoration benefits come online as early as the year after (2023, the breach year).

Due to LORP, an uptick in visitor numbers is anticipated, particularly outside of the main tourist season, during the so-called ‘shoulder’ months. This is due to the anticipated extra interest from wildlife/birding enthusiasts (EDPHCT, pers. comm.). The surveys carried out for the project (discussed in Section 3.2) included a question on whether or not users expected to visit the Otter valley more frequently due to the scheme occurring. Just over 9% of respondents stated that they would. Based on this, as well as insights from other similar schemes, an uptick of 10 % has been assumed for this NCA, which is reflected in higher recreation, physical health and car parking incomes in the monetisation of the NCA (for car parking, only differentials were applied for the LORP scenario; see Section 5.4.8 for further detail).

5.3 Results / the balance sheet

5.3.1 Overview

A natural capital balance sheet has been prepared for the two scenarios; this shows asset values and liabilities. For both scenarios, values are the benefits to land users (e.g. farmers) and benefits to wider society (public goods) provided by the natural capital assets over time. Liabilities include the costs of maintaining natural capital assets, and the costs of producing the benefits; the detailed figures have been redacted in the tables due to the confidentiality of some of the input costs. Incomes which have been included are those which can be associated with the NCA assets or related actions.

Tables 3 and 4 present the resulting natural capital balance sheet for the Lower Otter NCA; Table 3 gives the values for the two scenarios, and Table 4 shows the change between the scenarios. Detail on how the values for the monetised benefits were derived is provided in Section 5.4 (with an income breakdown given in Section 5.4.8), and non-monetised benefits are discussed in Section 5.5.

Table 3 shows that, over 60 years, the net asset present value[12] (PV) for the baseline scenario is currently estimated at £18.3 million, and the gross natural capital PV60[13] at £23.5 million; with the vast majority of this being related to benefits to wider society.

The restoration scenario has a higher gross natural capital PV60 of almost £35 million, but a lower net PV60 of £12.5 million; this is due to the relatively large construction costs of the scheme (not all of which would be directly associated with the creation of natural capital). The net difference between the two scenarios is £5.8 million, as detailed in Table 4.

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[12] Net present value is the difference between the current value of asset inflows and the current value of asset outflows over a period of time (60 years in this case).

[13] I.e. the present value of the monetised ecosystem services benefits from the natural assets, before costs and incomes are taken into account.

Table 3. NCA balance sheet summary – baseline and LORP scenarios (blacked out text = redacted cost detail)

Value	Valuation metric		Baseline (PV60 £ thousand)			LORP (PV60 £ thousand)		
			Business	Wider society	Total	Business	Wider society	Total
Asset values (monetised) (see Section 5.5 for non-monetised benefits)								
Animals reared for nutrition	Gross margin		2,933		2,933	1,281		1,281
Wild animals for nutrition -	Bass fisheries supported	Value inside	3		3	12		12
		Value outside	4		4	4		4
Carbon	CO_{2e} sequestered by habitats	Value inside		2,421	2,421		5,060	5,060
		Value outside		63	63		70	70
	Value CO_{2e} emitted by livestock			(1,449)	(1,449)		(658)	(658)
	Value one-off woodland/scrub losses			(73)	(73)		(332)	(332)
Mediation of wastes (nutrients)	P removals	Value inside		2,980	2,980		3,636	3,636
		Value outside		1,678	1,678		1,515	1,515
Air pollution regulation	Value of $PM_{2.5}$ removal by woodland			3	3		13	13
Recreation	Recreation welfare value			10,188	10,188		14,358	14,358
Physical health	Cricket club social value			934	934		4,444	4,444
	Value of avoided medical costs			3,783	3,783		5,324	5,324
Total asset value	Mix of ecosystem services values		**2,940**	**20,528**	**23,469**	**1,297**	**33,516**	**34,813**
Income – total flows	(Cricket club, parking, land rental, etc.)		**1,584**	**-**	**1,584**	**3,908**	**-**	**3,908**
Liabilities								
Production costs	-		[redacted]		[redacted]	[redacted]		[redacted]
Natural capital maintenance costs	-		[redacted]		[redacted]	[redacted]		[redacted]
Other costs	-		[redacted]		[redacted]	[redacted]		[redacted]
Total gross asset costs	-		**6,908**	**-**	**6,908**	**26,270**	**-**	**26,270**
Total net asset value (monetised)	-		**(2,383)**	**20,656**	**18,272**	**(21,066)**	**33,516**	**12,451**

Table 4. NCA balance sheet summary – change (blacked out text = redacted cost detail)

Value	Valuation metric		Change / difference baseline – restoration (PV60 £ thousand)			Direction of change		
			Business	Wider society	Total	Business	Wider society	Total
Asset values (monetised) (see Section 5.5 for non-monetised benefits)								
Animals reared for nutrition	Gross margin		(1,652)		(1,652)	↓		↓
Wild animals for nutrition -	Bass fisheries supported	Value inside	8		8	↑		↑
		Value outside	(0.2)		(0.2)			
Carbon	CO_{2e} sequestered by habitats	Value inside		2,639	2,639		↑	↑
		Value outside		7	7			
	Value CO_{2e} emitted by livestock			791	791		↑	↑
	Value one-off woodland/scrub losses			(259)	(259)		↓	↓
Mediation of wastes (nutrients)	P removals	Value inside		656	656		↑	↑
		Value outside		(163)	(163)			
Air pollution regulation	Value of $PM_{2.5}$ removal by woodland			10	10		↑	↑
Recreation	Recreation welfare value			4,170	4,170		↑	↑
Physical health	Cricket club social value			3,509	3,509		↑	↑
	Value of avoided medical costs			1,541	1,541		↑	↑
Total asset value	Mix of ecosystem services values		**(1,644)**	**12,861**	**11,217**	↓	↑	↑
Income – total flows	(Cricket club, parking, land rental, etc.)		**2,324**	**-**	**2,324**	↑	↔	↑
Liabilities								
Production costs	-		[redacted]		[redacted]	↑		↑
Natural capital maintenance costs	-		[redacted]		[redacted]	↑		↑
Other costs	-		[redacted]		[redacted]	↑		↑
Total gross asset costs	-		**19,363**	**-**	**19,363**	↑	↔	↑
Total net asset value (monetised)	-		**(18,682)**	**12,861**	**(5,822)**	↓	↑	↓

5.3.2 Discussion

The appropriate counterfactual for the LORP 'restoration' scenario is the dynamic 'baseline' scenario, illustrating our best estimate of what would have taken place had the natural processes been allowed to breach the defences in an uncontrolled manner in the near future. Broadly, this predicts a breach around 15 years from now, without much investment to optimise habitat creation, or to mitigate losses of key habitats and assets such as the cricket club and footpaths. However, some limited exceptions for unavoidable costs have been made, including the requirements for sewer diversion and landfill works, as well as footpath diversion to maintain continuity of the South West Coast Path (noting that, as highlighted in Section 2.3.1, costs for these are likely to have been underestimated).

The delayed breach with the 'baseline' scenario, in comparison with the LORP scenario, allows for the slightly longer maintenance of the status quo, involving some benefits (e.g. ongoing agriculture) but also costs (e.g. flooding damages and footpath maintenance). There is also an impact from discounting, notably through the unavoidable costs of sewer diversion and landfill capping, which are delayed until Year 5 in the baseline scenario, corresponding to a 15% reduction in these costs in present value (PV) terms. Longer term, the absence of investments to optimise the situation results in lower ecosystem service flows after the breach, including reduced recreational opportunities and loss of the Cricket Club, as well as reduced values from the Business Park due to unreliable access.

In the managed realignment / LORP scenario, changes occur earlier, and in a more optimised fashion, e.g. replanting of lost woodland and scrub areas, protection / diversion of footpaths, and the relocation of the Cricket Club to improved facilities not subject to flooding. In consequence, ecosystem services are generally higher, though not uniformly so, with agricultural benefits falling due to earlier cessation of grazing in the realigned area. Recreational benefits especially are much higher, due to maintained / enhanced access and experience, and the preservation of the Cricket Club. This in turn leads to higher physical health benefits than in the counterfactual. The other major sources of gain that could be monetised include carbon sequestration and nutrient (P) removals by habitats. There are also potentially significant benefits in non-monetised services, in particular biodiversity conservation, in part due to the earlier creation of key habitats in a controlled fashion, and also due to the employment of a ranger engaged in biodiversity and recreation enhancing activities (see Section 5.5 for detail on non-monetised benefits). Overall, we estimate, in PV60 terms, a total natural asset value improvement of *circa* £11.2 million.

In addition to the asset values, there are additional flows associated with monetary 'incomes' that are more or less related to natural capital, but nevertheless tied to the project (see Section 5.4.8 for a breakdown of these incomes). These include, in particular rental, incomes from the business park, Cricket Club incomes, and car parking incomes. With LORP, although rentals associated with agricultural land decline due to the earlier cessation of grazing in the inundated area, this is more than compensated for by increases in the other income streams in comparison with the baseline, with incomes overall being

around £2.3 million higher in PV60 terms. There could be increases in other incomes that have not been counted, in particular visitor spending associated with recreational use of the area, as well as increased cricket club income due to the improved facilities and location. It should be noted that these are revenues not net profits, and that there could be some double counting risk (for example between car parking fees and the benefits of recreation), but broadly we consider these revenues to be additional to the ecosystem service benefits identified above.

It is acknowledged that the managed approach to realignment incurs relatively substantial costs during the construction phase, although not all of these are related to the creation of natural capital. As noted above, some costs are unavoidable and common to both the LORP scheme and baseline, although the timing can vary. Other costs are specific to the LORP scheme.

The relatively substantial nature of the estimated managed realignment costs means that the difference in net benefits between the scheme and the counterfactual is estimated at a loss of just over £5.8 million in PV60 terms. However, it is considered that the results of this partial NCA underestimate the full value of LORP and its value relative to an unmanaged breach baseline scenario. This is for various reasons, including:

- The baseline scenario, whereby it has been assumed that an unmanaged breach would occur in 15 years' time, would result in a situation which, though far from optimised, is nevertheless somewhat similar to the project outcome with regard to the habitats resulting from it;
- It is likely that the impacts of unmanaged breaching (baseline) would be more costly than has been assumed for this NCA. For example, the costs included for constructing a new footpath are likely underestimated (as a lot of the works would need to be undertaken in the wet); and costs for the adaptation of additional services were not included;
- If any of the baseline expenditure which occurs later on in the accounting period were to be brought forward in time (e.g. by assuming earlier adaptation actions), then that could significantly increase the costs of an unmanaged breach scenario, as lower discount factors would be applied;
- The NCA's benefit estimates are broadly conservative, whereas the costs of LORP will include contingencies and optimism bias;
- Not all the LORP costs are directly related to the creation of natural capital; and
- There are several non-monetised benefits, notably related to biodiversity enhancement and mental health, which would likely be higher in the LORP scenario than in the baseline one, and could be offset against the overall PV figure.

With LORP, it is also important to note that the project's initial 55 ha of intertidal habitat creation (mudflat, saltmarsh, tidal reedbeds) act as compensatory habitat to enable the Environment Agency to continue to manage flood risk to 2,795 properties (increasing to around 5,000 by 2110) in the Exe Estuary. This management causes coastal squeeze (the loss of existing habitat in front of defences resulting from rising sea levels that drown

out the existing foreshore habitat), which gives the Environment Agency the statutory duty to secure compensatory habitat. Delivering habitat compensation in the Otter Estuary will allow six flood risk management projects to go ahead in the Exe Estuary, with an estimated direct cost of around £23 million, and total benefits of £375 million (Environment Agency, pers. comm.). Thus, substantial additional off-site benefits result from LORP being implemented, which could not be included in the NCA, but are worth highlighting.

Thus, it remains possible that the scheme could be at, or around, a break-even balance of costs and benefits (or even net positive).

5.4 Benefits valuation detail (for included benefits)

5.4.1 Animals reared for nutrition

This benefit relates to a Common International Classification of Ecosystem Services (CICES) version 5.1 'provisioning' ecosystem service: 1.1.3.1 Animals reared for nutritional purposes.

Farming values are based on a combination of evidence from the two enterprises involved in grazing cattle and cutting silage on the land (within the immediate study area, i.e. the LORP site), and evidence from the Nix pocketbook for farm management (Redman, 2021). The values are approximate, as some of the assumptions have yet to be confirmed. At present, we do not know exactly how many productive dairy cattle were present, nor for how many months in the year.

The Nix pocketbook gives 2 to 2.5 cows ha^{-1} in dairy systems. At the LORP study area, it is known that the animals were not grazed all year on the land, meaning that there were other areas involved in supporting the cattle. For the purposes of this assessment, it was necessary to isolate the contribution of the specific land within the LORP site. The evidence available (incl. communication with the farmers and land agents) suggests that an assumption of 1.5 productive cows ha^{-1} on average over the year is appropriate.

For the physical account, Nix gives 8,000 litres of milk cow^{-1} $year^{-1}$ and 47 tonnes silage ha^{-1} $year^{-1}$. For example, for the baseline scenario, this leads to the following estimates of the physical service flows during Year 1:

- 888,000 litres of milk (= 74 ha x 1.5 cows ha^{-1} x 8,000 l cow^{-1}); and
- 587.5 tonnes of silage (= 12.5 ha x 47 tonnes ha^{-1}).

For the monetary value, we assumed that the silage is consumed by the cattle over winter, within the farm enterprise, so we do not include any monetary flow for this directly. The value assumed is the Nix figure for the gross margin of dairy operations, which is £2,200 ha^{-1} $year^{-1}$. Although our assumed 1.5 cows ha^{-1} is only about 75% of the stocking rate assumed in Nix, the use of 25% of the area for silage balances this out.

The alternative approach of valuing the physical flows directly (via gate price of milk and silage), then subtracting the proportion of the costs of the farming enterprise attributable to

this area, would require data that are not available to us, and would likely not result in a great improvement in the estimate anyway, noting that the Nix estimate will smooth out year-on-year variations that would be difficult to remove from farm-level data unless we had many years of data.

This gives estimates of the monetary flows as:

- Baseline:
  - £162,800 year^{-1} pre-breach; Year 60: £50,600 (non-discounted; grassland area reduced); and
  - £2.93 million PV (discounted over 60 years).
- LORP:
  - £162,800 year^{-1} pre-breach; Year 60: £29,700 (non-discounted);
  - £1.28 million PV60.

With the 'baseline' scenario, more grassland is retained overall, due to the post (unmanaged) breaching tidal exchange being curtailed by the culvert under South Farm Road; this is reflected in higher farming incomes over the 60 year accounting period. In reality, more tidal inundation than assumed for this scenario might occur, and thus grazing not be as feasible as assumed, however, as no modelling was available for this scenario, these assumptions were applied.

5.4.2 Fisheries support

This benefit relates to the following CICES 'provisioning' ecosystem service: 1.1.6.1 Wild animals used for nutritional purposes. It can also be linked to 2.2.2.3 Lifecycle maintenance, habitat and gene pool protection - Maintaining nursery populations and habitats (Including gene pool protection), although the focus here is on the support for fisheries productivity, so we are only looking at a very narrow part of that service.

A literature review was undertaken to support the assessment of this benefit. This is provided in Appendix 1. As a result of the review, only fisheries value of seabass has been assessed, on the basis of monetary 'fish production' estimates made by Luisetti *et al.* (2011), and further developed by Holt (2019). No other studies were available for value transfer for other fish species, and thus, the true value of this benefit related to the Lower Otter's saltmarshes is likely to be much higher.

The following factors have been applied per hectare of saltmarsh, based on Holt (2019):

- £12.5 ha^{-1} (the 'central' value presented by Holt (2019), converted to 2022 values).

Applying this value to the dynamic baseline habitat values leads to a PV60 of £7,800 for the saltmarshes inside and outside the site, with the value for the saltmarshes inside coming online post breach only. For the LORP scenario, a PV60 of £16,000 is achieved.

5.4.3 Carbon sequestration/emissions

This benefit relates to the following CICES 'regulation and maintenance' ecosystem services: 2.1.1.2 mediation of wastes or toxic substances of anthropogenic origin by living processes - filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals; and 2.2.6.1 atmospheric composition and conditions - regulation of chemical composition of atmosphere and oceans.

The calculated values related to natural capital (i.e. habitats and animals) only, not infrastructure or machinery; thus, construction carbon and the carbon embodied in the new infrastructure are not included.

The sequestration factors for habitats are based on various published estimates of sequestration in woodlands, grasslands, intertidal habitats and scrublands within the immediate study area (LORP site). These are:

- Improved grasslands: 0.6 t CO_{2e} ha^{-1}, based on Soussana *et al.* (2010);
- Woodlands: 5.7 t CO_{2e} ha^{-1}, based on total UK sequestration (Office for National Statistics (ONS), 2019) and total UK woodland area (Forestry Commission 2017);
- Saltmarsh: established saltmarsh: 5.0 t CO_{2e} ha^{-1}, based on Cefas (2021). Newly created saltmarsh: 15.0 t CO_{2e} ha^{-1}, drawing on Mossman *et al.* (2022) and ABPmer (2020); this has been applied for the first 20 years post breach; thereafter, 'established' saltmarsh rates have been applied[14];
- Mudflat: established mudflats: 3.1 t CO_{2e} ha^{-1}, based on Cefas (2021). Newly restored mudflats (first 20 years): 12.2 t CO_{2e} ha^{-1}, drawing on Mossman *et al.* (2022) and ABPmer (2020);
- Reedbeds: 0.2 t CO_{2e} ha^{-1}, based on figures for figures for persistent reedbeds in Whitaker *et al.* (2015); and
- Scrublands, 1.99 t CO_{2e} ha^{-1}, based on hedgerow figures in Natural England (2021).

Emissions from cattle are based on average emissions at national level derived from Defra (2020) for cattle numbers and Jones *et al.* (2021) for emissions. These may be overestimates, since we would expect grass-fed cattle to emit less greenhouse gases than grain fed cattle. On the other hand, we have applied this estimate only to the estimated 1.5 cattle ha^{-1}, so the dry cows/heifers are not included. Average emissions 2.29 $tC0_{2e}$ head of $cattle^{-1}$ $year^{-1}$ have been assumed.

[14] It is acknowledged that, as noted above, it can take up to around 5 years for comprehensive plant cover to be established over saltmarsh elevations following managed realignment, and thus the full sequestration potential of saltmarshes to be realised. To account for this, slightly lower rates of sequestration have been applied than suggested by some authors. Furthermore, it is worth noting that, during the first few years post breach, it is the rapid accretion with sediment which largely accounts for the higher rates of sequestration, rather than the vegetation element (ABPmer, 2020).

Emissions also occur due to losses of woodland and scrub post uncontrolled breach or during LORP construction; storage values were drawn from Mossman *et al.* (2022) (281.8 tCO_{2e} ha^{-1}). For on-site woodland, there are net carbon stock losses during the 60-year accounting period for both the baseline and LORP scenarios. With LORP in particular, losses are fairly substantial, despite a net increase in woodland area (and more native species being planted). However, in the NCA, it takes longer than the 60-year accounting period for woodland to effectively re-capture the carbon released due to the cutting of trees at the start of LORP (notably over the landfill area, where a large area of monoculture trees was cleared prior to the works, and new native trees will be planted post construction). It is also worth re-iterating that individual and linear tree and shrub planting / enhancements were not taken account of in this NCA, as noted in Table 2.

The valuation uses the UK non-traded (central) carbon values from Department for Business, Energy and Industrial Strategy (DBEIS), which rise from £246 tCO_{2e}^{-1} in 2021 to £386 tCO_{2e}^{-1} in 2050; and growing at 1.5% per year in real terms after that (DBEIS, 2012) (corrected from 2020 to 2021 prices using Gross Domestic Product deflator of 1.004).

The **net** PV60 in the baseline scenario related to carbon (whereby emissions are deducted from sequestration values) is just over £1 million, with annual values fluctuating over the years due to the dynamic nature of the baseline.

For the LORP scenario, the net carbon PV60 is £4.2 million. Over 60 years, the new intertidal habitats resulting from LORP are expected to sequester just over 29,000 tCO_{2e} in total (or almost 8,000 tC). Averaged over the 60 yeas, every year, the new habitats will sequester enough carbon to offset the fossil fuel consumption of around 290 cars (2022 emissions; using values quoted by NimbleFins (2022)).

5.4.4 Mediation of wastes (nutrients)

This benefit relates to the following CICES ‘regulating’ ecosystem services: 2.2.5.2 Regulation of physical, chemical, biological conditions - "Water conditions - Regulation of the chemical condition of salt waters by living processes; 2.1.1.1 Mediation of wastes or toxic substances of anthropogenic origin by living processes - Bio-remediation by micro-organisms, algae, plants, and animals and 2.1.1.2 Mediation of wastes or toxic substances of anthropogenic origin by living processes - Filtration/sequestration/storage/ accumulation by micro-organisms, algae, plants, and animals.

A literature review was undertaken to support the assessment of this benefit. This is provided in Appendix 1. As a result of the review, it was decided to apply values quoted by Watson *et al.* (2020), who looked at excess nutrients in the Solent. These authors combined estimates of actual nutrient removals by various coastal habitats (including saltmarsh) with estimates of removal costs per kg from various measures and plans for nutrient reduction. They determined average replacement costs of reducing Nitrogen (N) and Phosphorus (P) as £295 kg^{-1} for N and £282 kg^{-1} for P as “mid-range conservative ecosystem replacement value estimates”, noting that the full range of estimates goes from

£5 kg^{-1} to £1,100 kg^{-1}. The median annual values per hectare for saltmarsh in the Solent were £111,000 ha^{-1} for N and £13,810 ha^{-1} for P.

Directly transferring these figures to the Lower Otter would however have been dubious, since the background pollutant levels and pollutant inputs are likely to be greater in the Solent. Given that the Otter does not appear to experience issues related to N enrichment, a benefit related to this has not been assessed. As noted in Section 3.2.1, the upstream water body is though currently at 'fail' for P, and applying the values from Watson *et al.* (2020) for P is thus considered justified.

However, a reduction coefficient has been employed, whereby for this NCA, 25% of the Solent removals have been used. This is because the riverine waters of the Otter are assumed to have shorter interactions with intertidal habitats when compared with the harbours and estuaries of the Solent.

The following P removal factors have thus been applied:

- Saltmarsh: £3,452 ha^{-1} $year^{-1}$;
- Mudflats: £389 ha^{-1} $year^{-1}$; and
- Reedbeds: £5,362 ha^{-1} $year^{-1}$.

The baseline PV60 related to P removal from habitats within and immediately outside the LORP site is £4.7 million, with annual values fluctuating over the years due to the dynamic nature of the baseline. For the LORP restoration scenario, the PV60 is £5.2 million; this is quite similar to the baseline scenario, as the latter assumes fairly extensive reedbeds becoming established north of South Farm Road; which have higher P removal values associated with them than saltmarshes.

5.4.5 Air pollution regulation

This benefit relates to the following CICES 'regulation and maintenance' ecosystem service; 2.1.1.2 Mediation of wastes or toxic substances of anthropogenic origin by living processes - Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals

Physical and monetary estimates for woodland in the East Devon area have been derived from the Local Air Pollutant Removal Value of Trees tool. This online tool is based on modelling by the UK Centre for Ecology and Hydrology (CEH) and eftec (2019). The tool allows users to explore the change in value resulting from new woodland planting, or removal of existing woodland, and its ability to remove fine particulate matter ($PM_{2.5}$) pollution.

The tool gives an estimate of current $PM_{2.5}$ removal per year, and a PV100 figure for total value. Values per year are not given, because they change considerably over time, in particular declining due to assumptions about lower background pollution levels in future years (because of cleaner vehicles and production processes). By going back to source calculations, a PV60 value has been estimated, which is slightly lower than the PV100

given in the online version. For example, for the Year 1 1.1 ha of woodland in the 'inside' study area, this assumes that 8.3 kg $PM_{2.5}$ is removed every year.

The baseline PV60 related to air pollution regulation is £3,300, and that for the LORP restoration scenario is £13,400.

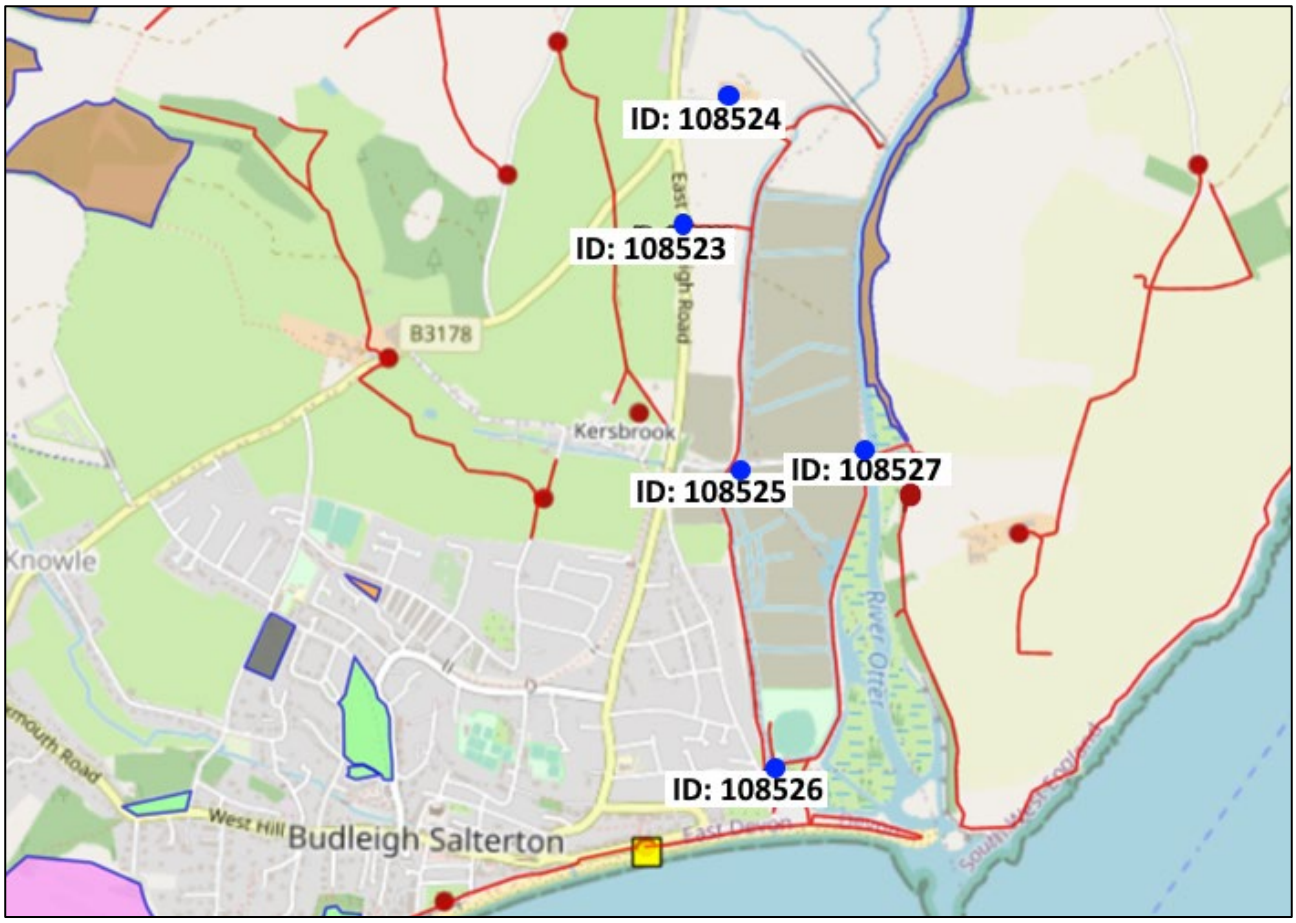
5.4.6 Recreation

This benefit relates to the following CICES 'cultural' ecosystem services; Cultural (Biotic)-Direct, *in situ* and outdoor interactions with living systems that depend on presence in the environmental setting - Physical and experiential interactions with natural environment - Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions (3.1.1.1) and Characteristics of living systems that enable aesthetic experiences (3.1.2.4)

The recreation values have been estimated using the University of Exeter's online Outdoor Recreation Valuation Tool (ORVal) tool. Some evidence on recreational use is also available from the project survey and footpath counter, however these do not (yet) give an estimate of total use throughout the year, whereas ORVal does attempt this. ORVal also has the advantage of giving estimates calculated on a consistent basis at a national scale, based on several years of data from Natural England's Monitor of Engagement with the Natural Environment (MENE) survey

There are different possible levels of estimation in ORVal, including values for the entire South West Coast path (16 million visits per year, £42 million value), for the Budleigh Salterton area (157,000 visits, £650,000), and for the access points/paths immediately in and around the project area. We have used the most conservative figures (see Image 11 below), which relate only to five access points to the path directly around the immediate study area. Higher values could be justified based on the Budleigh Salterton data, but much of this can reasonably be attributed to the beach and the path behind that, hence the more conservative approach is considered appropriate.

Under the dynamic baseline, we assumed that all access to the site is lost in the year of the breach, while works to reconnect the South West coast path are undertaken. For subsequent years, access is partially restored, although the northern part of the site / footpaths remain inaccessible. Consequently, we assumed that the trips and values relating to access points 108523 and 108524 (see Image 11) are lost, while the other access points return to pre-breach levels. Obviously these assumptions are somewhat speculative but reflect the idea that the breach would lead to long-term loss of access, despite 'do minimum' actions to reconnect the South West coast path.



Source: University of Exeter, 2018; Basemap copyright: OpenStreetMap contributors [bigger ID labels inserted by ABPmer for this report]

Image 11. ORVal access points (blue -= selected for this NCA)

The ORVal results presented above provide baseline scenario values as follows:

- Physical estimate of 106,277 visitors per year to Year 15, then 64,019 post breach (upon reinstatement of South West Coast Path);
- Monetary estimate of £499,000 year^{-1} to Year 15 and £300,000 thereafter; and
- PV60 of £10.2 million.

For the LORP scenario, a 10% increase in visitor numbers has been assumed, leading to the following results:

- Post breach, 116,905 visitors year^{-1} and monetary estimates of 549,000 year^{-1}; and
- PV60 of £14.4 million.

Please note that these values are welfare values, i.e. benefits to the recreational users, not estimates of visitor spend or impacts on the local economy. We have assumed constant flows, without attempting to account for population growth for example; doing so could result in some increase in the physical and monetary values.

5.4.7 Physical health

This benefit relates to the following CICES 'cultural' ecosystem service: Cultural (Biotic)- Direct, *in situ* and outdoor interactions with living systems that depend on presence in the environmental setting - Physical and experiential interactions with natural environment - Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions (3.1.1.1).

Benefits related to general physical health and the cricket club have been assessed.

General physical health

The physical health estimates provided in the balance sheet are based on an estimate for the proportion of recreation trips that are 'active' enough to provide a health benefit, coupled with estimates of the avoided health costs associated with this benefit. Whilst this monetisation relates to the same ecosystem service as one of those applicable to recreation (see previous section), valuing this aspect is not considered to constitute double counting. This is because recreation has been valued as per the enjoyment of individuals of their visit, whereas health has been valued based on avoided costs to society / national health services (from those people not becoming ill).

The proportion of visits that are active has been set at 51.5%, based on White *et al.* (2016). An active visit is defined as one of at least 30 minutes to the natural environment, at an effort equal to or more than 3 Metabolic Equivalents of Task. Given that the recreation visits are estimated for access to the footpath around the area, this could be an underestimate; one could argue that up to 100% of visits to this specific area would be active (in contrast to beach visits which could often be quite inactive). For example, for the baseline scenario, this gives physical flow estimate of 54,732 active visits per year at present (drawing on the ORVal visitor numbers reported above).

These active visits are translated into quality-adjusted life-years (QALYs; a generic measure of disease burden). A rate of 0.0107 QALYs $year^{-1}$ weekly $visit^{-1}$ has been assumed, based on Bending *et al.* (2008).

This involves a number of assumptions about the relationship between physical exercise and health benefits, essentially supposing that this is linear and that active visits to this particular site are representative of the general lifestyle of the visitors, since the QALY improvements relate to a consistent pattern of activity over a year. To estimate the value per visit, we allow 1/52 of the annual value. The monetary value per QALY is based on Claxton *et al.* (2015), who give £12,936 for the cost-effectiveness threshold of a QALY (2008 prices). Adjusted to 2021 prices, this gives an estimate of £3.35 per active visit.

This leads to the following monetary flow values:

- Monetary estimate:
  - Baseline: £185,200 per year (to Year 15), then lower according to lower ORVal visitor numbers; and
  - LORP: £203,700 per year post breach;

- PV60:
  - Baseline: £3.8 million; and
  - LORP: £5.3 million.

Please note that these values are welfare values, i.e. benefits to the recreational users, not estimates of visitor spend or impacts on the local economy. We have assumed constant flows, without attempting to account for population growth; doing so could result in some increase in the physical and monetary values.

Cricket Club

As noted previously, Budleigh Salterton Cricket Club (BSCC) had a pitch and club house in the LORP project area until recently; these premises occupied just under 4 ha and have been moved to a new site north of Budleigh Salterton, outside of the floodplain. The new club house and facilities are being funded by LORP and BSCC, with the landscaping and playing areas delivered by the Environment Agency contractors, and the clubhouse, car park and ancillary facilities by BSCC.

The club has/facilitates around 450 active players. It can be considered a source of value in several ways. The most obvious falls under the "recreation" heading, but participation in sport also brings health benefits, and a cricket club / pitch brings cultural and aesthetic benefits within the context of English village life. There are wider benefits in particular for children, who experience physical and psychosocial benefits including reduced risk of obesity, improved metabolic profiles, improved self-esteem and reduced risk of depression (Howie *et al.,* 2020). The role of sports clubs is especially important in the context of the observation that physical activity declines markedly during childhood in the UK, seen in most individuals of both sexes by age 6–7 years (Farooq *et al.,* 2018)

For the BSCC, there is good evidence on actual spending on club membership and associated activities: membership plus sponsorship together reach approximately £8,500 per annum; and bar revenues are around £35,000, though these are less directly associated with sporting activity. However, a focus on fees would significantly underestimate total value because individuals would be willing to pay more in order to enjoy the activity; in economic terms, they experience substantial 'surplus' over the costs paid.

In principle, it could be possible to value the benefits of active participation in sporting activity using stated preference methods, to estimate this surplus. We are not aware of any studies for cricket, but more general studies exist. For example, Orlowski and Wicker (2019) estimate willingness to pay for participation in sport in Germany. A higher frequency of participation is associated with higher monetary values: females (males) are willing to forgo between €552 and €1,281 (€491 and €1,483) per month to participate in sports or exercise at least once a month and between €577 and €1,471 (€577 and €1,662) to participate at least once a week, respectively, compared to not participating at all. Evidently, participation in sports and physical activity improves individuals' life satisfaction and is of substantial value to individuals. Nevertheless, the accuracy of these values is questionable (in technical terms, due to re-contracting issues, i.e. respondents may not in

fact be willing to pay so much on an indefinite monthly basis), and transfer to English cricket would be an additional source of inaccuracy.

An alternative approach is to look at external estimates of the overall societal benefits of sporting participation, including for example in terms of improved health, reduced crime, improved education and enhanced subjective well-being. Davies *et al.* (2019) present estimates of the social impact of sport in England, using a Social Return on Investment (SROI) framework. They estimate that in 2013/14 the social value of sports participation in England was £44.8 billion, and the total financial and non-financial inputs to sport were £23.5 billion, giving an SROI ratio of 1.91. This means that for every £1 invested in sport, £1.91 worth of social benefit was generated. Using this method offers a conservative and pragmatic approach to valuing a range of benefits from sport participation, drawing on relatively recent data from England.

For evaluating the investment in sport, we can use data on the costs incurred by BSCC. Here we have approximately £38,000 per annum, with a breakdown previously provided in Section 3.2.4. To this can be added the significant volunteer time of approximately 4,300 h per annum. Valuing this time at a conservative £10 per hour gives an additional £43,000 investment in terms of volunteer labour.

The peppercorn rent of £100 $year^{-1}$ underestimates the rental value of the land, which could be considered a form of sponsorship from Clinton Devon Estate. If instead we value the 3.8 ha baseline BSCC area at a foregone agricultural benefit of approximately £2,200 ha^{-1}, this gives about £8,400 $year^{-1}$ instead of £100. Please note that the rent will be higher going forward.

Altogether, an estimated annual investment in sport of approximately £88,700 results. Using the SROI multiplier proposed by Davies *et al.* (2019), the total social benefit is estimated at £169,417 per annum. This benefit value has been applied for both the baseline and LORP scenarios.

In the dynamic baseline, we assumed that the cricket club would be forced to stop operating in the area after Year 5; the resulting PV60 is £0.9 million. With LORP, the cricket club continues to operate for the duration of the accounting period, and PV60 is thus much higher at £4.4 million.

5.4.8 Additional incomes

On top of the natural capital benefit values explained in Sections 5.4.1 to 5.4.7, there are additional flows associated with monetary incomes that are more or less related to natural capital, but nevertheless tied to the project. Table 5 shows those which have been taken into account in the NCA, and summarises values assumed for the baseline year, as well as the PV60s resulting from the calculations.

Table 5. Additional incomes (blacked out text = redacted cost detail)

Type	Year 1	PV60		Narrative/source
	(£ thousand)			
	2022	Baseline	LORP	
Cricket club revenues	44	243	1,305	Pers. comm. cricket club (assumption being that, with LORP, revenues continue as at present; whilst income may well be increased due to the new facilities being better, this was not assessed). The 'baseline' value is lower, as this scenario assumed that the club ceases operations after Year 5.
Car parking revenues	-	-	883	Differential only applied for LORP scenario. This represents a 10% uptick (as also applied for visitors/ORVal).
Land rental incomes	[redacted]	[redacted]	[redacted]	Confidential; value is higher for the 'baseline' vs LORP scenario; this is due to more grassland remaining over the 60 year accounting period in the former scenario.
Business park incomes	[redacted]	[redacted]	[redacted]	Confidential; the 'baseline' scenario is lower, this is due to the assumed reduced income post breach (due to South Farm Road becoming largely inaccessible).
Total	[redacted]	**1,585**	**3,908**	-

As outlined above, other incomes may increase due to the project, notably visitor spending associated with recreational use of the area. However, this would to some extent constitute double counting (e.g. between car parking fees and the benefits of recreation). Furthermore, the user surveys determined that most respondents did not spend all that much, with locals often not spending any 'tourist' money after walking along the valley, and those from nearby (e.g. Exmouth) mostly paying for parking, and potentially a cup of coffee or tea. Thus, it is felt that taking account of additional parking income effectively values increased visitor spend (especially as not all visitors/users of the site pay for parking, thus the 10% uptick in visitors would likely not translate into an actual 10% increase in parking revenue).

Additional income related to the improved cricket club facilities (event and club venue, ability to host county level cricket matches) has also not been taken into account, as explained in the next Section. It should also be noted that the values shown in Table 5 are revenues and not net profits, but broadly we consider these revenues to be additional to the ecosystem service benefits identified in the preceding sections.

5.5 Benefits not quantified in monetary terms

As noted in the Protocol report (ABPmer, 2021b), an NCA balance sheet is designed to not only show quantified changes, but also material unquantified assets, ecosystem services and benefits. This is to ensure that a complete picture of the natural capital asset is given by the account, and highlights that the NCA produces partial information, where applicable.

Some benefits have not been quantified in monetary terms. This has been for a variety of reasons, including: a lack of physical data and/or lack of appropriate valuation evidence, to avoid double counting, and also because it was felt the benefit would not be material in the case of the Lower Otter NCA. Non-monetised benefits are listed in Table 6; for each benefit, a narrative and justification is provided, and their importance for the Lower Otter NCA assessed (on a low-medium-high scale, based on expert judgement).

Please note that undertaking dedicated primary research, such as willingness to pay surveys, was not within the remit of this study. However, such further work is recommended going forward / for similar studies, to help fill some of the gaps highlighted as potentially important below (e.g. related to mental health, non-use, spiritual and recreational fisheries benefits).

Table 6. Non-monetised benefits

Benefit	Narrative	Rationale for non-monetisation	Likely importance for Lower Otter NCA
Aesthetic experiences	Relevant to tourism and recreation and changes to the attractiveness of the landscape.	No relevant studies available for value transfer; also some double counting with recreation/physical health benefits.	Low to medium (also risk of double counting)
Biodiversity	The natural environment supports biodiversity, which is a source of value to people. Also, there may soon be a market for biodiversity credits, in relation to the anticipation of Biodiversity Net Gain has soon now becoming mandatory for terrestrial developments (this extends into the inter-tidal). Rare plant species (e.g. orchids) are being transplanted and thus preserved with LORP; also numerous terrestrial habitat / hedgerow / woodland / protected species enhancements are being undertaken.	There would be an element of double counting (e.g. nutrient cycling, fisheries support); also, there is a lack of data to draw clear quantitative conclusions regarding the 'amount' of biodiversity protection provided, and about the economic value associated with that. Net gain credits are a potential future income stream. Habitats created through unmanaged breaching cannot obtain net gain credits; furthermore, a proper market for such credits has yet to be established. The current net gain calculator (Biodiversity Metric 3.1) indicates a 35% (present day) net loss in biodiversity 'units' due to LORP. This purported 'loss' is related to 'difficulty of creation' and 'time to target condition' multipliers being applied in the 'site habitat creation' spreadsheet of the 3.1 version. Without having to apply these multipliers, there would be a biodiversity net gain of over 70%. When compared to the baseline / unmanaged breaching scenario, LORP has clear advantages with regard to terrestrial habitat and species mitigation, adaptation and enhancement; related biodiversity benefits are however difficult to monetise.	Medium to high (also double counting risk / partially monetised already)

Benefit	Narrative	Rationale for non-monetisation	Likely importance for Lower Otter NCA
Cricket Club additional incomes	With LORP, the new club facility will have a new business model which involves its use as a venue for events and classes; this will generate significant income for the club as well as providing socio benefit to the area. In addition, as the grounds will no longer be subject to repeated flooding, the club will be able to host county level cricket matches.	When compared to the baseline, LORP has clear benefits for the cricket club with regard to the new (flood risk free) location and improved facilities. However, the success of new/improved income streams is difficult to gauge at this point; also, club house income from these new streams is not necessarily strictly related to natural capital. Thus, this element has not been monetised.	Low to medium (also not all related to natural capital)
Disease and pest control	Invasive species (Japanese knotweed, Himalayan balsam and water fern) have been removed from the project area as part of LORP, and saline water hamper their recurrence.	No relevant studies available for value transfer.	Low / likely not material
Education and research	Relevant to education; LORP will include monitoring research and communication.	No relevant studies available for value transfer.	Low / likely not material
Existence / non-use values	Relevant in terms of the value that even those who will not or cannot visit will place on the new landscape.	No relevant studies available for value transfer; also some double counting with recreation/physical health benefits.	Low to medium (also risk of double counting)

Benefit	Narrative	Rationale for non-monetisation	Likely importance for Lower Otter NCA
Flood protection and erosion control	Saltmarshes, and to a lesser extent mudflats, attenuate wave energy (reduced wave attack). Whilst saltmarshes in particular can fulfil these functions, they do this in exposed areas with substantial fetch.	As the Otter estuary is quite sheltered, and the fetch 0.3 km at worst, this benefit is not considered to be material in the Lower Otter. Regarding erosion for housing on higher land, there does not appear to be any imminent risk due to erosion at Budleigh Salterton (notably the Granary Lane cliffs (Gallois, 2016)). It is however worth noting that LORP acts as coastal squeeze compensation for the Environment Agency's Exe Estuary flood risk management works. Without LORP, six Exe projects protecting thousands of people could not go ahead (approx. direct cost: £23 million, total benefits: £375 million (see Section 5.3.2)). It is worth noting that (unrelated to the natural capital benefits of new intertidal habitats), under the unmanaged breaching scenario, flood risk would likely be worsened in relation to fluvial risk / freshwater drainage. However, this could not be assessed.	Low / likely not material (saltmarsh wave attenuation)
Ground water for drinking	Potential ground water implications from increased saline intrusion near local bore hole.	Monitoring is taking place to determine whether or not LORP has an impact on relevant boreholes.	Low / likely not material
Mental health	Mental health benefits can arise from both physical activity and the passive enjoyment of nature. Furthermore, negative mental health impacts can result from flooding of residential properties.	There would be an element of double counting with physical health, although the passive enjoyment element could be valued separately. However, there is insufficient data/study to facilitate economic valuation of this. Also, whilst there may be some quantifiable mental health impacts in relation with the flooding of properties, this has again not been valued here, as no residential properties are directly affected by LORP, and as lost farming income and cricket club benefits have been addressed elsewhere. As noted above, potentially increased fluvial flood risk under the baseline scenario could not be assessed.	Medium to high (passive enjoyment) / not material (flooding impacts/LORP) (also double counting risk / partially monetised already)

Benefit	Narrative	Rationale for non-monetisation	Likely importance for Lower Otter NCA
Other fisheries (excl. bass)	Recreational fisheries may benefit, as may those fisheries targeting other commercial species which have not been assessed.	No relevant studies available for value transfer.	Low to medium (in addition to bass, which has been valued)
Property values	Property values could conceivably be impacted by a change in view, as well as flood risk.	It is considered that the difference between a view of agricultural grassland or estuarine habitats is not that considerable, and it is believed that none of the properties would be subject to increased risk of flooding with LORP (though some may be at increased risk with future sea level rise; however, those risks are to be mitigated through a managed adaptive approach to asset resilience in future). Thus, there would be expected to be no material difference post breach.	Low / likely not material
Seed dispersal	Increased plant diversity, abundance and seed production in wetland	No relevant studies available for value transfer.	Low / likely not material
Spiritual, symbolic and other interactions	Relevant to tourism and recreation.	No relevant studies available for value transfer; also some double counting with recreation/physical health benefits.	Low / likely not material (also risk of double counting)
Visitor spend	Increased visitor expenditure (numbers and time spent) due to the changes in habitat, as well as the implementation of the breach, may result and benefit the local economy.	This could not be fully valued due to insufficient data; there would also be a small element of double counting with ORVal (recreation benefit), which works with estimates of welfare values for visitors. For the restoration scenario, increases in car park spend have been used as a proxy for increased visitor spend, focussing on the differential only (see Section 5.4.8).	Low to medium (also: double counting risk / partially monetised already)

6. Summary and conclusions

This report describes a partial socio-economic assessment of the Lower Otter restoration project, when compared with a dynamic baseline scenario. In doing so, it has followed the steps outlined in the standardised protocol that was developed for PACCo as Task 2 of Work Package 2. It has been based on pursuing an NCA approach, which is a comparatively new concept.

The natural assets, as well as other applicable assets, for the study area have been described, and an assessment of the benefits and values of ecosystem services undertaken, using best available data at this point. Dynamic assumptions have been applied for two scenarios, the 'baseline' scenario, and the LORP 'restoration' scenario.

The 'baseline' scenario illustrates a best estimate of what would have taken place had the natural processes been allowed to breach the defences in an uncontrolled manner; for this scenario, this was set to occur 15 years from now. After this time, intertidal habitats are envisaged to establish over much of the Lower Otter valley, although saltmarshes are not expected to spread as far north as with LORP, due to tidal exchange being constricted by the culvert at South Farm Road (these were assumptions made for the NCA in the absence of modelling, in reality more tidal inundation may occur). This unmanaged breaching has been assumed to happen without much intervention, though some limited exceptions for unavoidable costs have been made, including the requirements for sewer diversion and historic landfill securing, as well as footpath diversion to maintain continuity of the South West Coast Path.

In the managed realignment / LORP scenario, habitat changes occur earlier, and in a more optimised fashion. In consequence, ecosystem services are generally higher, though not uniformly so, with agricultural benefits falling due to earlier cessation of grazing in the realigned area. Recreational benefits in particular are much higher for the LORP scenario, due to maintained/enhanced access and experience, and the preservation of the Cricket Club. This in turn leads to higher physical health benefits than in the counterfactual. The other major sources of gain that have been monetised include carbon sequestration and nutrient (P) removals by habitats. There are also potentially significant benefits in non-monetised services, in particular biodiversity conservation, in part due to the earlier creation of key habitats in a controlled fashion, and also due to the employment of a ranger engaged in biodiversity and recreation enhancing.

Over 60 years, the net present value (PV) derived from the natural capital for the baseline scenario is estimated at £18.3 million, and the gross natural capital PV60 at £23.5 million. The LORP/restoration scenario has a higher gross natural capital PV60 of almost £35 million. Therefore the LORP restoration scenario has a higher natural capital value. The natural capital benefits associated with the LORP / restoration scenario are substantially higher (just under 50%) than those calculated for the baseline. Of the benefits which could be monetised, the benefits related to the welfare value of recreational visits were valued

most highly, followed by physical health benefits (particularly related to the cricket club), water quality and carbon sequestration related benefits.

LORP's net natural capital PV60, after scheme costs have been deducted, was calculated as being lower than that of the 'baseline' scenario, by £5.8 million. This is related to the relatively high costs estimated for construction and delivery of the LORP scheme itself. Details of these are confidential, but it is worth highlighting that not all of the costs associated with LORP relate to the creation of natural capital *per se*; however, as these could not be dis-entangled, overall costs only have been included. In addition, the baseline scenario, whereby it has been assumed that an unmanaged breach would occur in 15 years' time, would result in a situation which, though far from optimised, is nevertheless somewhat similar to the project outcome with regard to the habitats resulting from it (and thus the benefits derived). Managed realignment however is a way of working with/helping natural processes in a controlled fashion so as to enhance benefits and reduce risks. This is clearly demonstrated in the total natural asset value improvement of *circa* £11.2 million described above.

Moreover, it should be noted that not all the benefits which could conceivably be assessed have been valued; this is for a variety of reasons, including missing data, insufficient research, the risk of double counting and benefits not considered to be material for the LORP study area. Such key benefits which have not been valued include those related to biodiversity and mental health. Not all gaps getting filled, and that not all the possible benefits getting valued is normal and accepted with NCA. Primary research is recommended going forward to help fill some of the gaps highlighted in this report.

With LORP, it is also important to point out that the project's intertidal habitats are created as compensatory habitats to enable the Environment Agency to continue to manage flood risk for thousands of properties in the Exe Estuary. This management causes coastal squeeze, which gives the Environment Agency the statutory duty to secure compensatory habitat. Delivering habitat compensation in the Otter Estuary will allow six flood risk management projects to go ahead in the Exe Estuary, with an estimated direct cost of around £23 million, and total benefits of £375 million (Environment Agency, pers. comm.). Thus, substantial additional off-site benefits result from LORP being implemented, which could not be included in the NCA, but are worth highlighting.

Furthermore, the NCA's benefit estimates are broadly conservative, whereas the costs will include contingencies and optimism bias. Also, it is likely that the impacts of unmanaged breaching would be much more costly than has been assumed for this NCA.

Thus, the results of this partial NCA are considered to underestimate the full value of LORP and its value relative to an unmanaged breach scenario. Nevertheless, the NCA is helpful in identifying the multiple and significant benefits of such projects, and the methodology developed in this study can be used and built upon as our knowledge of benefits improves.

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List of abbreviations

A	Main/Primary Road (UK)
ABPmer	ABP Marine Environmental Research Ltd
AONB	Area of Outstanding Natural Beauty
BBC	British Broadcasting Corporation
BSCC	Budleigh Salterton Cricket Club
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEH	Centre for Ecology and Hydrology
CICES	Common International Classification of Ecosystem Services
CO_{2e}	Carbon Dioxide Equivalent
CPUE	Catch Per Unit of Fishing Effort
Defra	Department for Environment, Food and Rural Affairs
DBEIS	Department for Business, Energy and Industrial Strategy
EDPHCT	East Devon Pebblebed Heaths Conservation Trust
eftec	Economics for the Environment Consultancy
EIA	Environmental Impact Assessment
ERDF	European Regional Development Fund
ES	Environmental Statement
EU	European Union
€	Euro
GVA	Gross Value Added
ha	hectares
HM	Her Majesty's
ID	Identity
LORP	Lower Otter Restoration Project
m	million (Euro)
MCZ	Marine Conservation Zone

MENE	Monitor of Engagement with the Natural Environment (survey)
MMO	Marine Management Organisation
NCA	Natural Capital Accounting
OD	Ordnance Datum
ONS	Office for National Statistics
ORVal	Outdoor Recreation Valuation (Tool)
PACCo	Promoting Adaptation to Changing Coasts
PAH	Polycyclic Aromatic Hydrocarbon
PBDE	Polybrominated diphenyl
$PM_{2.5}$	Fine Particulate Matter
£	Pound Sterling
PV	Present Value
QALYs	Quality-Adjusted Life-Years
RSPB	Royal Society for the Protection of Birds
SeaFish	UK non-departmental public body; supports the seafood sector
SROI	Social Return on Investment
SSC	Suspended Sediment Concentrations
SSSI	Site of Special Scientific Interest
tCO_{2e}	Tonnes of Carbon Dioxide Equivalent
UK	United Kingdom
VAT	Value Added Tax
WFD	Water Framework Directive
WP	Work Package

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendix 1. Review on Benefits Valuation Options – Fisheries and Waste Mediation

A.1. Fisheries support

Saltmarsh restoration could contribute to increased yields from commercial fisheries, and improved recreational fisheries, for some stocks. In the UK, the contribution to sea bass fisheries is likely most important due to the strong ecological link and the high value of the fishery, but other stocks also benefit.

Attempts to value habitat-fishery linkages have focused on production function approaches, attempting to model a relationship between coastal wetland abundance and fish population dynamics, linked with an economic model of the fishery, to allow the estimation of economic values. Early models were static models, linking changes in habitat to changing profits from existing fishing levels (e.g. Sathirathai and Barbier, 2001). Dynamic models also take account of the impact on fishing levels, and their dependence on management (in particular whether the fishery is open access, 'optimally managed', or subject to some intermediate regime) (e.g. Barbier and Strand, 1998; Barbier 2003, 2007). These models have been applied with some success in cases with large scale changes in habitat provision with a clear, strong link to fishery productivity, notably the impact of widespread mangrove losses on tropical coastal fisheries. There have been attempts to quantify the contribution of nursery habitats to some UK fisheries via production function methods (e.g. Tinch, 2004; Stevenson, 2002), but the explanatory power of the production functions is weak and difficult to apply to specific areas. For example, Tinch and Provins (2009) examine the valuation evidence for commercial and recreational fisheries in the Severn Estuary but were not able to draw firm conclusions regarding the impact of any options for a Severn Barrage.

Luisetti *et al.* (2011) made monetary estimates for the Blackwater estuary, using a series of simplifying assumptions and a fish production function estimated by Fonseca (2009), based on quantitative estimates of the abundance of juvenile bass up to two years old. The estimated annual abundance range of juvenile bass per hectare of saltmarsh was applied to a range of average survival rates, to an approximate length of 36 cm, the minimum size for legal commercial capture of wild sea bass in the UK. This gave an estimate of the contribution to the local inshore fishery in units of kg of bass per hectare of saltmarsh, converted to monetary terms using a range of local market values for wild-caught bass. The fish production value for newly created saltmarsh nurseries is assumed to be a linear multiple of the per hectare value.

This approach to assessing the fisheries support service involves many simplifying assumptions, including:

- Steady state stock structure with no variation in supply of year-0 bass to saltmarsh nurseries;

- No variation in any environmental or ecological parameters, constant quality of habitat;
- Adjustment to correct for out migration (arguably not appropriate since these fish would recruit to adult stock somewhere);
- Essentially all biomass supplied to adult stock assumed to be captured and sold as small bass
- Assumed constant price, no direct consideration of costs or changes in CPUE;
- Only commercial fishing considered, no assessment of recreational angling values; and
- No consideration of other fish species identified as present.

The approach of valuing sale value ignores the costs of fishing (it measures revenue, not profits) and in that sense could overstate the value of the service; a more accurate assessment might break the value down among different inputs, including boats, fuel, fishermen's labour and so on, with only the residual 'resource rent' ascribed to the ecosystem service. On the other hand, the landing value also ignores values supported beyond first sale, including for example jobs and sales in retail, restaurants and so on. Multipliers for estimating GVA supported are estimated by SeaFish as 3.91.

Thus, the calculations are at best gross approximations, and doubly so if transferring to other areas than the original study site in Essex. The values estimates cover a wide range in physical terms, with a mid- estimate of 1.65 kg catch ha^{-1} $year^{-1}$ (range 0.28 kg – 6.78 kg) valued at £11.55 (£1.93-£47.45) ha^{-1} $year^{-1}$ at average wholesale prices (although it is noted that prices can be very volatile).

An alternative approach presented recently by McCormick *et al.* (2021) focuses on a "residency index" calculated from estimates of the proportion of time spent in the saltmarsh habitat at different life stages.

However, the interpretation of the "residency index" is not clear, other than that it is higher for stocks that spend more time in saltmarsh, especially when juvenile. Taking the sea bass example, the input data are that it spends 28% of juvenile stage in saltmarsh, and 22% of adult stage. The residency index calculated is 0.873. Interpreting that as "87% of value comes from saltmarsh" is highly questionable. In fact, the key equation does not give residence indices that sum to 1 across habitats, so using it to give weights for splitting up value does not work, at least not directly. For the bass example, the same data can be used to calculate a "residency index" for everywhere that is not saltmarsh (where they must spend 72% of juvenile state and 78% of adult stage), giving a "residency index" of 0.997 for the "not saltmarsh" habitat.

There are additional problems with the residency index approach, including that it ignores any potential for density-dependent mortality either during or after the saltmarsh stage, and the assumption of 14 years for time spent as an adult bass (i.e. after the 6 years spent as juveniles). In fact there are almost no bass that survive to age 20: they could live to 30 or so, but they almost all get caught or eaten first. Going back to the original paper (Scott, 2000) this parameter is based on a kind of average of age at first maturity and maximum

lifespan, but allowing for natural mortality, to give the age at which the population is half the original level of adults. However, the focus on *natural* mortality means the 'theoretical' population they're looking at is nothing like the actual population, for which fishing mortality is substantial and there are very few bass older than 12 or so. In practice the assumption used by Luisetti *et al.* – that all biomass supplied is caught as young bass – is probably closer to reality. On the other hand, Luisetti *et al.* only look at the nursery function, whereas the McCormick *et al.* data show heavy use of saltmarsh by adult bass.

Furthermore, the rationale for splitting value across habitats only really holds for natural capital accounting purposes. In reality, it is quite possible that the stocks could be 100% dependent on saltmarsh (and simultaneously on other habitats), and that losing all saltmarsh would result in collapse of the fishery. However, neither this approach, nor the residency index, really helps address the question of the value of increasing the provision of saltmarsh, until we add some assumption such as a linear relationship between a per hectare value for the existing situation and future increases in provision.

Using a value per hectare transferred from Luisetti *et al.* also avoids the need to define and quantify a local fishery specifically for the Lower Otter, which might be possible in economic terms, but much harder to justify in ecological terms, noting that seabass are migratory with fidelity to inshore summer feeding grounds, but no clear evidence for offshore (deeper) overwintering and spawning areas (López *et al.*, 2015). That is, it is hard to draw a direct link between the adult fish caught in a particular area and the saltmarsh adjacent to that area.

The Suffolk Marine Pioneer report (Holt, 2019) valued fisheries support, drawing on the Luisetti *et al.* figures, and this seems the most appropriate option for valuation in the Lower Otter, despite the uncertainties. Overall, none of the methods available are considered to be sufficient to allow robust estimation of the value of saltmarsh habitat in supporting commercial (or recreational) fisheries, but use of the Luisetti *et al.* bass calculations allows inclusion of an indicative, though highly uncertain, value for this service. The central estimate from Holt (2019) has thus been applied to this NCA (see Section 5 of the main report). Corrected to 2021 prices, this gives a central estimate of £12.50 ha^{-1} per year (noting that a range of £2.10-£50.80 ha^{-1} is quoted in Holt, 2019). Though uncertain, the resulting value is conservative and likely to be an underestimate of the potential values of improving saltmarsh provision, since it focuses only on commercial seabass fishing and does not account for other fish species that also benefit from saltmarsh, nor for any increase in the value of angling for seabass.

A.2. Mediation of wastes

An important service provided by natural systems, and in particular wetlands, is the improvement of water quality by mediation of nutrients and other water pollutants. In the case of the lower Otter, this is essentially related to improving the quality of estuarine and coastal waters by cleaning nutrients introduced from upstream, from local agricultural activity, and/or introduced to coastal waters from other areas. Valuing these services requires consideration of a counterfactual (i.e. what would happen in the absence of the

service). The possible responses to increased pollutant concentrations in the hypothetical absence of the ecosystem service are many. They include the categories shown in Table A.1, but could be applied in different combinations.

Table A.1. Potential responses to pollutant concentrations (users/beneficiaries)

Possible response	Valuation approach
Reducing the inputs of pollution at source	Abatement cost
Replacing the service by alternative pollution removal methods upstream	Shadow project cost (replacement cost)
Capital investment and/or operational expenditure in treatment (e.g. water treatment plants, individual property-level treatment)	Productivity change method, replacement cost
Accept the damages	Productivity change method, avoided damage costs
Reduced use (e.g. less water-based recreation, less fishing, alternative water sources)	Avoided damage costs, averting behaviour method

In reality, the impact of lower water quality in the absence of the water purification service might involve a combination of several of these responses. The various costs and benefits are location-specific, being dependent on levels of pollutant inputs to the system and on local demands for clean water for various purposes. .Assessing the various behavioural changes and damage costs would require quite complex modelling.

A simpler approach relying on existing data is generally possible, as an approximation. Usually this means relying on estimates of the costs of alternative nutrient removal methods, because detailed evidence regarding the various damages caused is lacking for most cases. These estimates are either abatement cost (cost of cutting pollutants at source) or replacement costs (costs of removing pollutants from the environment, for example by artificial wetlands). Their use relies on the assumption that, in the absence of the ecosystem service, these alternatives would actually be implemented.

For example, La Notte *et al.* (2017) focussed on the costs of constructing artificial wetlands upstream as a replacement for natural purification services, and estimated that constructed wetland would cost 2.33 £ kg^{-1} of N. A more coastal solution of shellfish aquaculture ranges from around £12 kg^{-1} N (Pollack *et al.*, 2013) to around £225 kg^{-1} N (£128-322) (Dvarskas *et al.*, 2020). The ranges of costs are very wide.

The most recent example on the English south coast is Watson *et al.* (2020), who looked at excess nutrients (essentially N and P) in the Solent. They combined estimates of actual nutrient removals by various habitats (including saltmarsh) with estimates of removal costs per kg from various measures and plans for nutrient reduction. They find average replacement costs of reducing N and P as £295 kg^{-1} for N and £282 kg^{-1} for P as “mid-range conservative ecosystem replacement value estimates”, noting that the full range of estimates goes from £5 kg^{-1} to £1100 kg^{-1}. The median annual values per hectare for

saltmarsh in the Solent are £111,000 ha^{-1} for N and £13,810 ha^{-1} for P. Directly transferring these figures to the lower Otter is dubious, however, since the background pollutant levels and pollutant inputs are likely to be greater in the Solent. Nevertheless, these figures indicate the potential for very high values per hectare under this service.

Given that the Otter does not tend to experience issues related to N enrichment, a benefit related to this has not been assessed. However, as noted in Section 3.2.1, the upstream water body is currently at 'fail' for P, applying the values from Watson *et al.* (2020) is considered justified. However, a reduction coefficient has been applied, whereby for this NCA, 25% of the Solent removals have been used. This is because the riverine waters of the Otter are assumed to have shorter interactions with intertidal habitats when compared with the harbours and estuaries of the Solent.