



UIC SUSTAINABILITY DEPARTMENT
ECOV4R pilot assessment
Cotswold Line, United Kingdom

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INTERNATIONAL UNION
OF RAILWAYS

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1. Introduction

The Ecosystem Valuation for Railways (ECOV4R) Framework document aims to support the assessment of ecosystem services affected by and/or provided by railway infrastructure. To illustrate the practical use of the ECOV4R Framework, two pilot assessments from two project partners have been undertaken to demonstrate how ecosystem services assessments can be applied to decision-making at project level. The pilot assessment technical reports are intended to be read together with the Framework to help showcase the steps of ECOV4R. The intended audience for these pilot assessment reports is similar to those listed in Section 1.1.3 of the ECOV4R Framework, but the assessments are specifically aimed at guiding and supporting audiences intending to put the Framework into practice.

This document presents a prospective application of the ECOV4R Framework to the Cotswold Line, managed by Network Rail in the UK. Developed in collaboration with Network Rail and UIC, the assessment demonstrates how the ECOV4R Framework can guide land management beyond the rail corridor to improve asset resilience and enhance ecosystem service provision. It provides background information for the pilot project and demonstrates how each step of the ECOV4R Framework can be achieved, as well as providing recommended next steps for the pilot project as a result of the ecosystem services assessment. This pilot assessment is useful for readers looking to apply the ECOV4R Framework, as it demonstrates both a practical application of the Framework in identifying and valuing nature-based solutions implemented in land adjacent to the railway and the benefits of the Framework when it comes to building the resilience of rail assets.



2. Project background and context

The pilot focuses on the Cotswold Line which runs between Oxford and Worcester and passes through the River Evenlode floodplain in southern England (see Figure 2 for its location). The Evenlode floodplain is a flood risk zone (Figure 3), so flooding and embankment washout risks on the line are high (see Figure 1 for photos of previous flood events in the Evenlode catchment). These cause railway service disruptions and associated costs for Network Rail, the owner and infrastructure manager of most of the railway network and infrastructure in the UK. The Cotswold Line within the Evenlode catchment in England is therefore a focus for Network Rail in its efforts to deliver cost effective climate resilience.

Natural Flood Management (NFM) is a nature-based solution that aims to reduce the risk of flooding to communities and infrastructure by restoring or replicating the natural functions of rivers, floodplains and other habitats in the wider catchment. NFM interventions work by storing additional water in the catchment and slowing the rate that it runs into and along rivers. Examples of NFM include cross-slope woodland, floodplain reconnection and attenuation ponds.

AtkinsRéalis had previously completed a feasibility study¹ for Network Rail to identify opportunities in the wider catchments where NFM could be implemented instead of engineered flood defences (e.g. concrete embankments) to build the long-term resilience of the rail assets to climate change and flood risk. The study considered the entire Evenlode catchment which covers 43,000 hectares (ha) with the main river length of 115 km. The catchment is mostly rural, consisting of 18,000 ha of arable land, 17,000 ha of grassland, 2,000 ha of woodland, 4,000 ha of wetlands and a hedge length of 3,000 km. There are also 5,000 ha of land identified as 'priority' habitats (for example, lowland meadows, reedbeds and floodplain grazing marsh), which are features of principal importance for biodiversity conservation in England.

Figure 4 showcases the different target habitats being enhanced or created in the catchment due to the interventions. As a high-level overview, the proposed interventions include floodplain reconnection and floodplain meadow restoration, woodland planting and wet woodland creation, wetland creation and enhancement, ponds, attenuation ponds/retention bunds, and hedgerow planting.

This assessment estimates the benefits of the prospective NFM measures and habitat changes identified in the feasibility study in terms of their railway flood risk reduction and the provision of wider ecosystem services such as biodiversity and carbon sequestration. It will help Network Rail decide how best to invest in measures that will reduce flood risk and maintenance costs, whilst also meeting other performance commitments such as net zero².



¹ Undertaken by geomorphologists and sustainable river management specialists (e.g. aquatic ecologists and NFM specialists) to identify and assess interventions to meet Network Rail's goal of reducing embankment erosion and scour.

² Network Rail is targeting net zero carbon emissions by 2050. This strategy includes key initiatives such as the electrification of routes, the use of renewable energy, transitioning their fleet to zero-emission vehicles and setting targets aligned with science-based targets (Network Rail, 2025).



Figure 1: Photos of flooding in the Evenlode catchment (Source: AtkinsRéalis)



Figure 2: Location of the Evenlode catchment in the UK

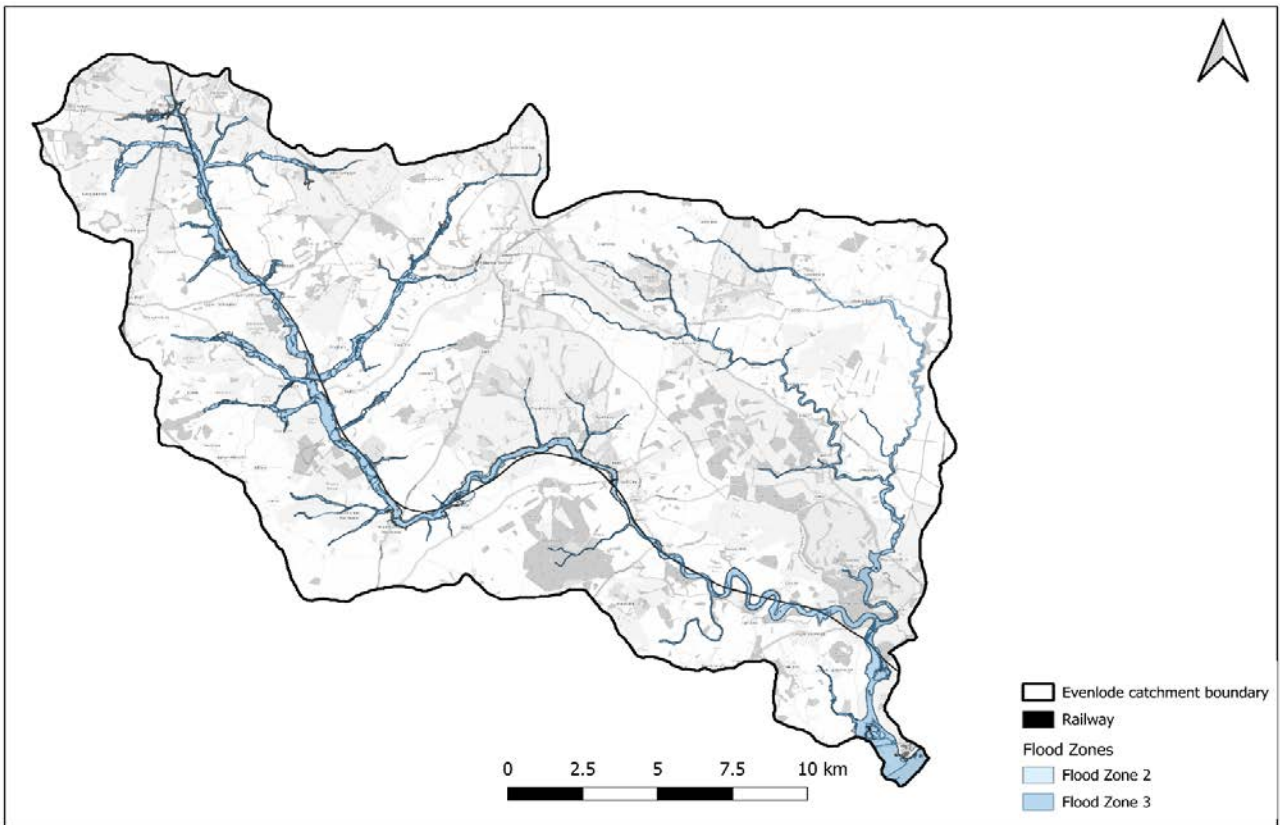


Figure 3: Flood risk map of the Evenlode catchment

TARGET HABITATS FOR EVENLODE LANDSCAPE RECOVERY

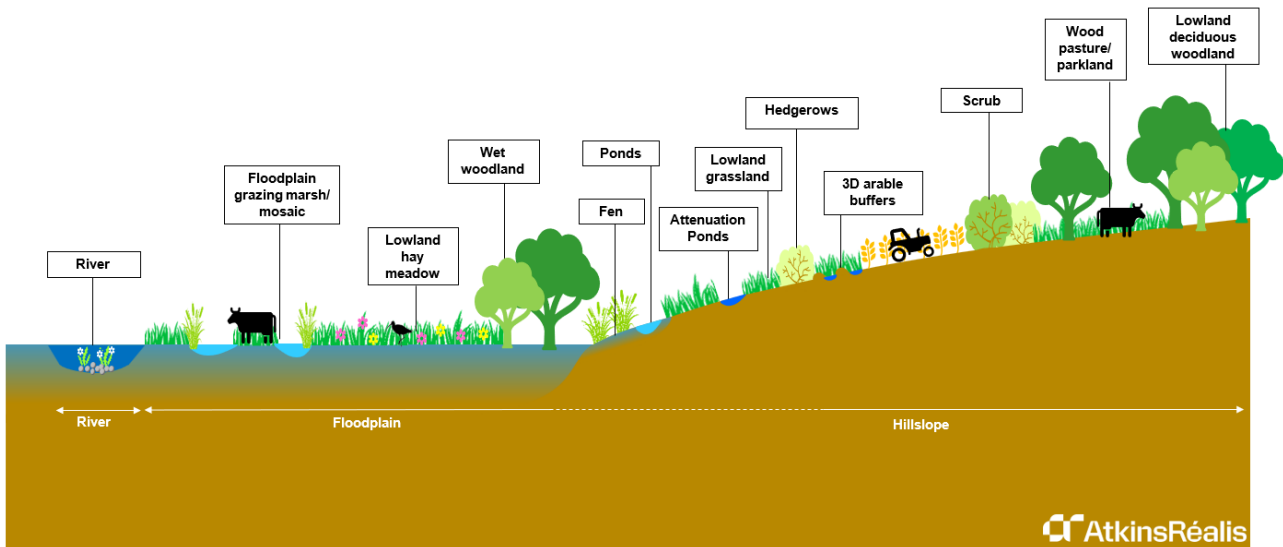


Figure 4: Target habitats/features for proposed interventions

3. ECOV4R assessment

This pilot assessment follows the steps set out in the ECOV4R Framework (as shown in Figure 5).



Figure 5: Ecosystem Service Valuation for Railways (ECOV4R) Framework

The following table presents the key parameters considered when developing the assessment. Further detail is provided in the following subsections. In terms of the key analysis parameters listed in Section 3.2.1 of the ECOV4R Framework, Table 1 below presents the key analysis parameters decided for the Network Rail pilot assessment.

Table 1: Key analysis and contextual parameters for the assessment

Key parameter	Decision for pilot assessment
Boundary of analysis	The boundary of analysis is the 3,948 ha of parcels considered for the proposed NFM interventions within the Evenlode catchment (43,000 ha) and the associated impact on the railway line (38 km).
Ownership and/or long-term management	Network Rail are planning to invest in the planned interventions across the catchment, however, the ownership of the land parcels (particularly, arable and grasslands) is with the individual landowners. Thus, it is assumed for this pilot assessment that the planned interventions will take place with permission from the landowners and that they will maintain long-term management over the habitats.
Timing of actions	As the project is currently at the design stage, it is assumed that the delivery of the proposed interventions will take place between 2026 and 2028, with all interventions in place by 2028.
Timing of impacts	Some habitats are known to take time to realise their full ecosystem service provision potential. In cases where this is known, the lag in the delivery of full benefits is determined by the ‘time to target condition’ of a habitat informed by the UK’s Biodiversity Net Gain principles (more detail on time to target conditions is explained in Section 3.4.2).
Assessment period	The assessment period is from 2028 to 2127. This assumes that implementation of proposed interventions begins in 2028. A 100-year assessment window has been used to capture the long-term benefits of the proposed interventions.
Price year for monetary values	For the purposes of this pilot assessment, the monetary values presented are in the 2024 price year. All monetary evidence and respective prices used in the calculation of ecosystem service benefits are uplifted to the 2024 price year using the most recent UK government GDP deflators.
Relevant discount rates	Following UK HM Treasury Green Book guidance, the discount rate of 3.5% is used from years 0-30, 3% from years 31-75 and 2.5% from years 76-100.

3.1. Step A: Baseline



3.1.1. Defining the baseline

The boundary of analysis includes the habitats, or land parcels, that are being enhanced or altered as part of the proposed NFM interventions. This approach deviates from the recommended 1 km buffer zone around the rail line stated in the ECOV4R Framework as the project considers targeted interventions further away from the rail line and across the Evenlode catchment that will deliver benefits to the rail line. This decision to deviate from the 1 km buffer zone to focus on the boundary of analysis was discussed and agreed with project partners. A map of the Evenlode catchment and the boundary of analysis (proposed NFM intervention parcels) is shown in Figure 6.

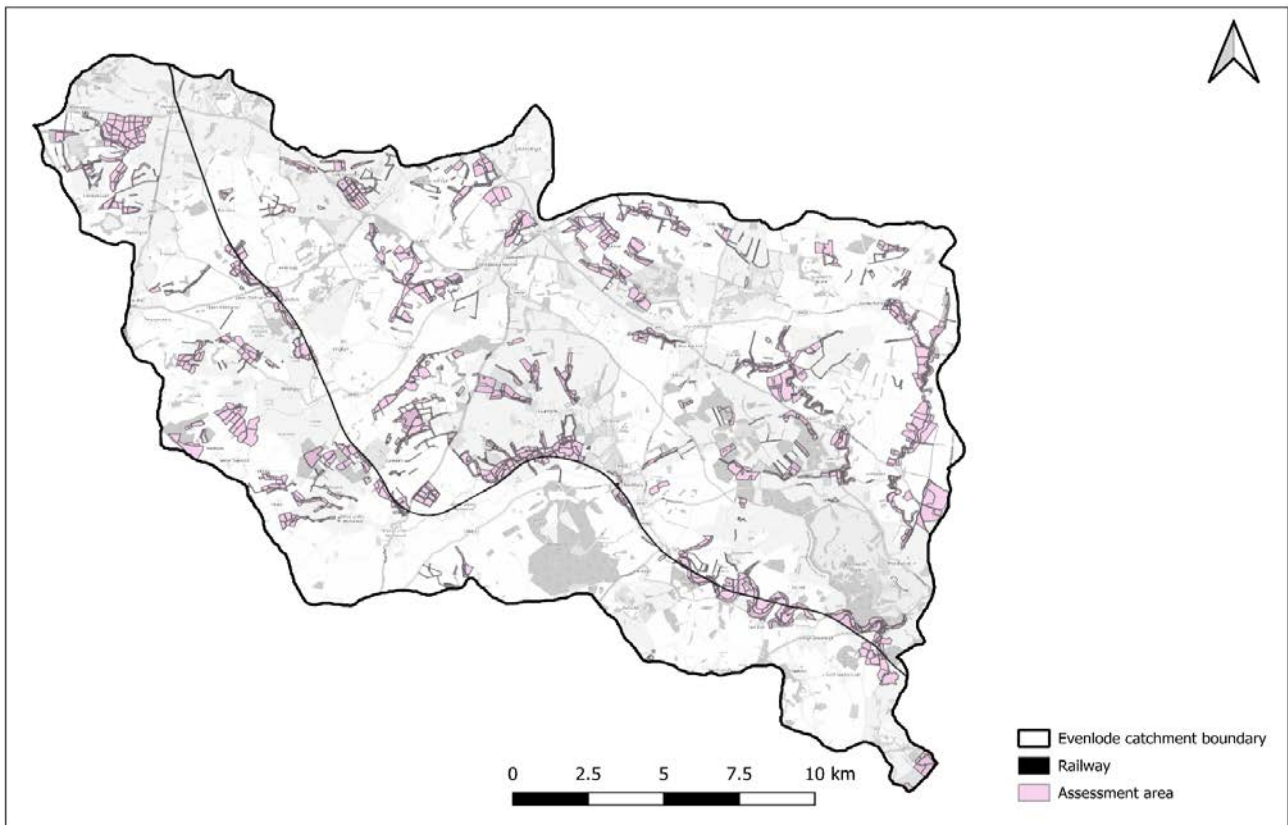


Figure 6: Map of Evenlode catchment and boundary of analysis

3.1.2. Asset register

In Section 3.2.2 of the ECOV4R Framework, it is recommended that the asset register comprises the extent, condition and location of natural capital assets. The asset register was developed by applying the methodology described in Appendix A. Figure 7 shows a high-level overview of where the land parcels considered in the project are located and their respective baseline habitat classification. Table 2 provides the list of habitats and their areas in the baseline scenario. As recommended in Section 2.3.1 of the ECOV4R Framework, the UK Habitat Classification system was mapped to the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology (GET) categories as shown in Table 2. The breakdown of the baseline assets in terms of condition is detailed in Appendix C (Table C-1).

The main habitat area in the baseline scenario is modified grassland (T6.4.4 Temperate anthropogenic grasslands) which covers approximately 50% of the assessment boundary. The next largest land cover type in the baseline is arable and horticultural land (T7.4 Cultivated croplands) covering approximately 29% of the total assessment boundary area.

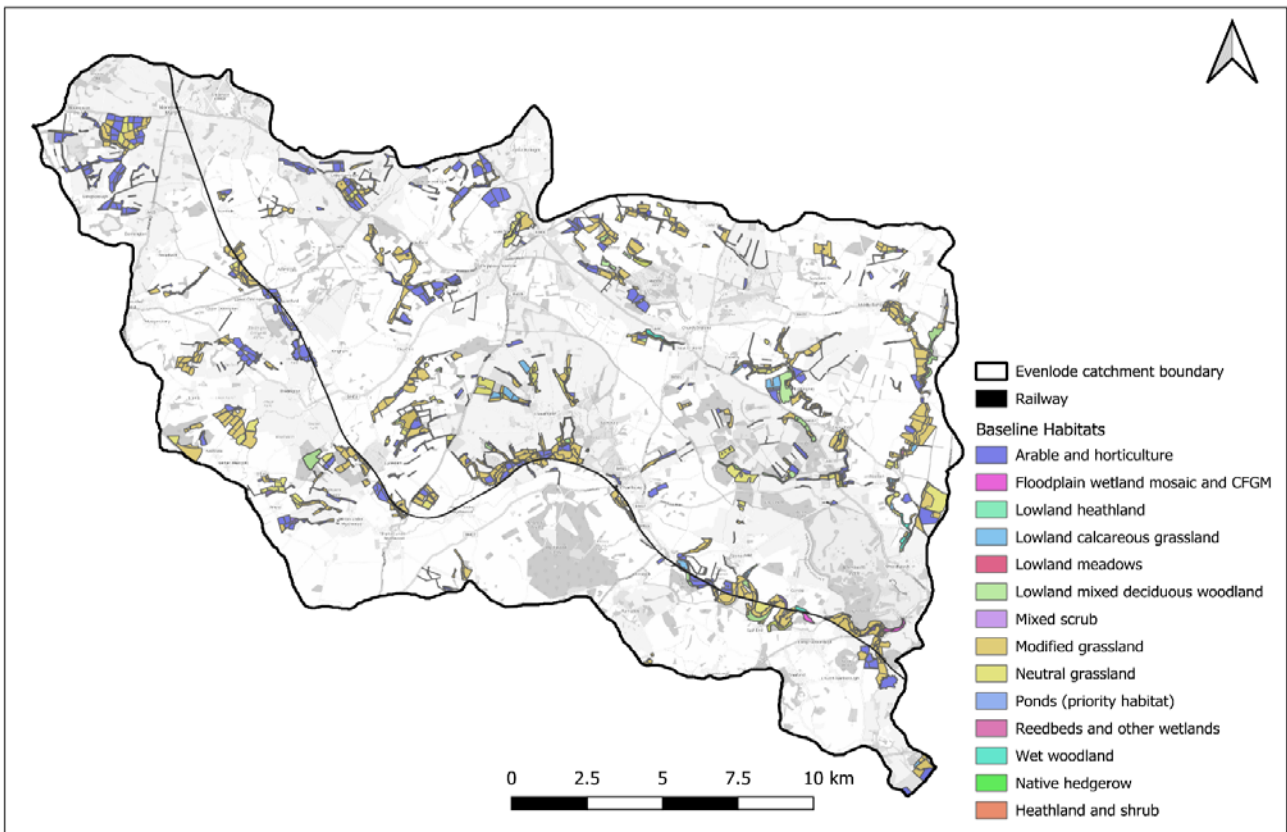


Figure 7: Map of Evenlode catchment and baseline habitats of the boundary of analysis

Table 2: Baseline asset register

UK Habitat Classification	IUCN GET Typology	Baseline area (ha)
Arable and horticulture	T7.4 – Cultivated croplands	1135.28
Floodplain wetland mosaic and coastal floodplain grazing marsh (CFGM)	T1.4.3 – Temperate–subpolar floodplain wetlands	14.26
Lowland heathland	T6.5.5 – Temperate heathlands	5.42
Lowland calcareous grassland	T6.4.2 – Temperate calcareous grasslands	70.77
Lowland meadows	T6.4.3 – Temperate mesic grasslands	2.53
Lowland mixed deciduous woodland	T1.4.1 – Temperate–subpolar broadleaf deciduous forests	268.32
Mixed scrub	T6.5.6 – Temperate shrublands	1.68
Modified grassland	T6.4.4 – Temperate anthropogenic grasslands	1959.75
Other neutral grassland	T6.4.3 – Temperate mesic grasslands	445.27
Ponds (priority habitat)	T1.5.1 – Temperate–subpolar freshwater bodies (lentic)	0.43
Reedbeds and other wetlands	T1.4.3 – Temperate–subpolar floodplain wetlands or T1.4.4 – Temperate–subpolar marshes	16.14
Wet woodland	T1.4.3 – Temperate–subpolar floodplain wetlands or T1.4.5 – Temperate swamp forests	28.31
Native hedgerow	T6.5.6 – Temperate shrublands (linear features, not directly typified in GET)	0.06
	Total	3948.21

3.1.3. Ecosystem services

Quantification and valuation of ecosystem services provided by the baseline is considered concurrently with the impact assessment. See subsequent steps, especially Step D (Section 3.4).

3.2. Step B: Impacts on natural capital assets



3.2.1. Defining the scenario

As detailed in Section 3.3.1 of the ECOV4R Framework, defining the scenario requires a rationale for the intervention, a description of what is likely to occur, and when and where the interventions will take place, as well as who it will affect. See Box 1 below for a description of the project scenario.

Box 1. Definition of the Network Rail Natural Flood Management (NFM) interventions scenario

<p>Rationale for intervention</p>	<p>The project seeks to reduce the impacts of flooding to an existing railway line (the Cotswold Line) where planned investment for proposed NFM measures will seek to enhance management, deliver environmental outcomes and wider benefits, and improve the climate resilience of the rail assets and the wider surrounding area.</p>
<p>What</p>	<p>The assessment focuses on the project’s boundary of analysis, encompassing interventions across the Evenlode catchment for NFM measures to reduce flood risk within the catchment and on the Cotswold Line. These measures include:</p> <ul style="list-style-type: none"> ■ Floodplain reconnection and floodplain meadow restoration ■ Woodland planting and wet woodland creation ■ Wetland creation and enhancement ■ Ponds, attenuation ponds/retention bunds ■ Hedgerow planting <p>These proposed interventions are nature-based solutions to enhance the resilience of rail assets and deliver wider benefits.</p>
<p>Where</p>	<p>3,948 ha of land parcels within the Evenlode catchment (43,000 ha in size) – the boundary of analysis encompasses 9% of the total catchment area.</p>
<p>When</p>	<p>2028 to 2127 (100-year appraisal period).</p>
<p>Who (beneficiaries)</p>	<ul style="list-style-type: none"> ■ Railway passengers: Passengers using the rail services on the Cotswold Line may encounter fewer disruptions to services during flood events if flood risk is reduced. Moreover, they may be able to appreciate a diverse range of habitats whilst travelling through the landscape. ■ Railway operators/managers: Railway operators and managers are likely to benefit from reduced flood risk as there is likely to be less maintenance of rail assets required. They will also benefit from fewer disruptions to train services, thus lowering the amount of compensation fees to passengers and any reactive repair works. ■ Local landowners: Local landowners will be directly impacted by the proposed interventions as they will help to facilitate the habitat enhancement or new habitat creation on their land. If productive arable land is being altered to another land cover type, landowners will lose food production value. On the other hand, there is potential for the habitat enhancement measures to have a positive impact on nearby agricultural land through supporting services such as soil and sediment retention, water purification, and pollination. ■ Local community: Villages/towns are located across the Evenlode catchment and are situated near the proposed interventions. The local communities would benefit from potential reduced flood risk in terms of flood damage to properties and assets. Changes in the landscape with a mix of habitats would also likely result in increased recreational visits and amenity value through a more visually diverse landscape. The local communities would also benefit from ecosystem services such as water purification and air filtration. The project also presents a valuable opportunity to enhance environmental education and training, whilst promoting greater public awareness of the significance of biodiversity and ecosystem services. NFM interventions may also serve as a catalyst for the development of sustainable tourism initiatives. ■ Global community: The proposed interventions are likely to have a positive impact in terms of nursery population and habitat maintenance (i.e. biodiversity), as well as improved carbon sequestration potential.

3.2.2. Quantifying the impact of the scenario

The post-intervention asset register followed the same methodology as the baseline asset register (see Appendix A). Figure 8 shows a high-level overview of the location of the post-intervention habitats. Table 3 provides the list of habitats and their areas in the post-intervention scenario. This has also been mapped to the IUCN GET categories. The breakdown of the post-intervention assets in terms of condition is detailed in Appendix C (Table C-2).

The main habitat area in the post-intervention scenario is lowland mixed deciduous woodland (T1.4.1 Temperate–subpolar broadleaf deciduous forests) covering approximately 30% of the boundary of analysis. The floodplain wetland mosaic and coastal floodplain grazing marsh³ (CFGM) (T1.4.3 Temperate–subpolar floodplain wetlands) and lowland meadows (T6.4.3 Temperate mesic grasslands) each account for 18% of the boundary of analysis.

Figure 9 provides a comparison of the baseline and post-intervention natural assets and shows the changes as a result of the proposed interventions. The main change is the full loss of arable and horticultural land and modified grassland within the boundary of analysis. The largest increases in habitat area are for lowland mixed deciduous woodland, lowland meadows and floodplain wetland mosaic and CFGM. There are also notable habitat creations for wet woodlands and lowland fens. Note that although the ‘reedbeds and other wetlands’ area is slightly reduced, this is because those features have been enhanced to a higher distinctiveness wetland habitat (e.g. lowland fen).

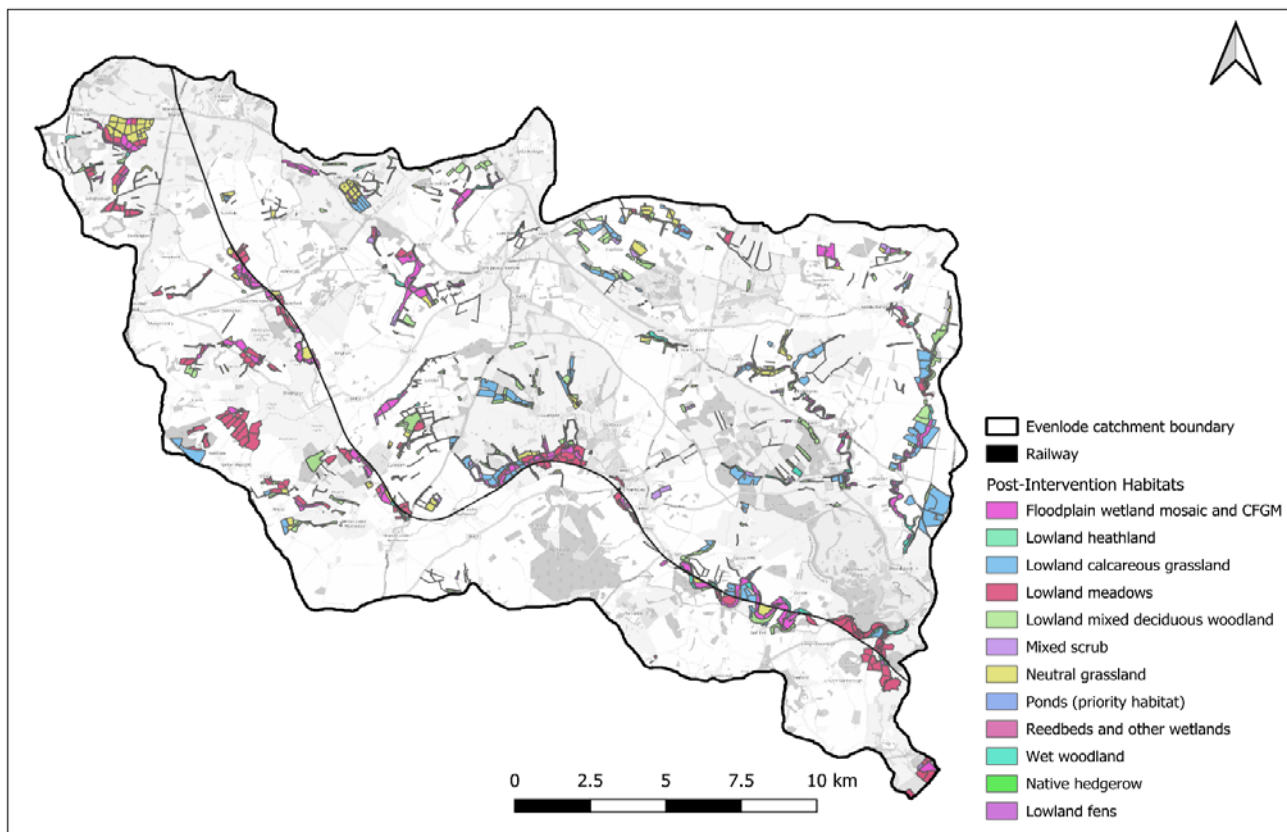


Figure 8: Map of Evenlode catchment and post-intervention habitats of the boundary of analysis

³ Coastal floodplain grazing marshes (CFGM) are low-lying, seasonally wet grasslands. They are traditionally managed through livestock grazing and play an important role in supporting biodiversity, flood storage and water quality regulation.

Table 3: Post-intervention asset register

UK Habitat Classification	IUCN GET Typology	Post-intervention Area (ha)	Comparison to baseline area
Arable and horticulture	T7.4 – Cultivated croplands	0	↓
Floodplain wetland mosaic and CFGM	T1.4.3 – Temperate–subpolar floodplain wetlands	691.98	↑
Lowland heathland	T6.5.5 – Temperate heathlands	0	↓
Lowland calcareous grassland	T6.4.2 – Temperate calcareous grasslands	564.86	↑
Lowland meadows	T6.4.3 – Temperate mesic grasslands	729.42	↑
Lowland mixed deciduous woodland	T1.4.1 – Temperate–subpolar broadleaf deciduous forests	1193.02	↑
Mixed scrub	T6.5.6 – Temperate shrublands	140.19	↑
Modified grassland	T6.4.4 – Temperate anthropogenic grasslands	0	↓
Other neutral grassland	T6.4.3 – Temperate mesic grasslands	429.83	↓
Ponds (priority habitat)	T1.5.1 – Temperate–subpolar freshwater bodies (lentic)	8.87	↑
Reedbeds and other wetlands	T1.4.3 – Temperate–subpolar floodplain wetlands or T1.4.4 – Temperate–subpolar marshes	5.13	↓
Wet woodland	T1.4.3 – Temperate–subpolar floodplain wetlands or T1.4.5 – Temperate swamp forests	163.95	↑
Native hedgerow	T6.5.6 – Temperate shrublands (linear features, not directly typified in GET)	10.10	↑
Lowland fens	T1.4.4 – Temperate–subpolar marshes (including fens)	10.84	↑
Total		3948.21	

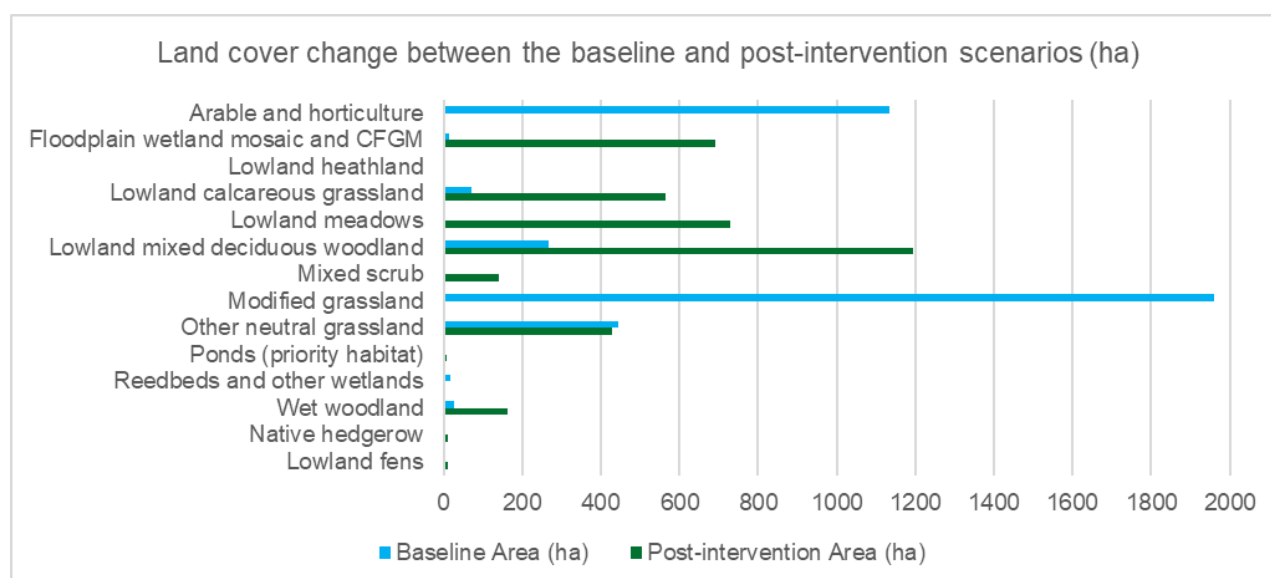


Figure 9: Comparison of the baseline and post-intervention habitats

3.3. Step C: Impacts on ecosystem services



3.3.1. Materiality assessment

As recommended in Section 3.4.2 of the ECOV4R Framework, a materiality assessment was undertaken to determine which benefits should be included in the ecosystem services assessment based on the natural capital assets within the project's assessment area. The asset-service matrix is shown in Table 4, which showcases the habitats in the asset register that are impacted either positively (habitat enhancement or creation) or negatively (loss or reduction in habitat). Impacts to the quality/condition of the natural assets are also considered.

The materiality assessment was undertaken based on expert opinion and included a quality assurance process. Additionally, as stated in Box 4 within Section 3.4.2 of the ECOV4R Framework, materiality was considered against the five potential criteria stated in the Natural Capital Protocol (Capitals Coalition, 2016). In the context of this pilot assessment, the relevant criteria are namely:

- **Operational:** Impacts on natural capital assets will impact rail operations and services, such as improved water flow regulation, and reduced flood risk may lower maintenance requirements and reduce disruption to rail services.
- **Legal and regulatory:** In England, Biodiversity Net Gain (BNG) is a legal requirement under the UK's Environment Act 2021. Developments must deliver at least a 10% increase in biodiversity value compared to the baseline. This requirement has been factored into the materiality assessment.
- **Reputational and marketing:** Network Rail's relationship with customers and stakeholders will be impacted by changes in ecosystem service provision. For example, reduced disruption to rail services through improved water flow regulation will be beneficial to customers and investors.
- **Societal:** Impacts on natural capital assets across the Evenlode catchment will generate impacts to wider society, such as landowners across the catchment and local communities.



© Cotswolds Tourism Partnership

Table 4: Materiality assessment of relevant ecosystem services to railway infrastructure projects

Ecosystem service type	Ecosystem services reference list	Arable and horticultural land	Grasslands	Heathland and shrubs	Woodlands	Wetlands and fens	Water bodies	Built linear features	Comments
Provisioning services	Biomass provisioning services (including crop/grazed biomass/livestock/wood provisioning)	✓✓	✓✓						Food production impact assessed due to loss of arable land – assessed quantitatively and monetarily.
	Genetic material services								No assessment.
	Water supply		✓	✓	✓	✓	✓		It is possible that some interventions store more water in soils, thus reducing the need for abstraction (e.g. for agricultural use) and potentially contributing to groundwater recharge. This would likely require a water resources model to assess.
Regulating services	Global climate regulation services (e.g. carbon sequestration)	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		Carbon sequestration impact through land use change and creation of habitats – assessed quantitatively and monetarily. Embodied carbon and construction emissions are excluded at this stage.
	Rainfall pattern regulation services								No assessment.
	Local climate regulation services				✓				Location and scale of created/lost habitats unlikely to influence – no assessment.
	Air filtration services	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		Air quality expected impact due to created/lost habitats – assessed quantitatively and monetarily.
	Soil quality regulation services	✓	✓						Some interventions are likely to contribute to improved soil quality (e.g. arable reversion or creating herbal leys).
	Soil and sediment retention services (e.g. landslide prevention)	✓	✓	✓	✓	✓	✓		Catchment is vulnerable to soil/embankment erosion during flood events – qualitative assessment only.
	Water purification services (e.g. water quality regulation)		✓			✓✓	✓✓		Wetlands and woodlands are known for water purification properties. Grasslands may also contribute to water quality regulation if correctly placed (e.g. riparian strips or in-field buffers) – assessed quantitatively and monetarily.
	Water flow regulation services		✓✓	✓✓	✓✓	✓✓	✓✓		Implementation of woodland and wetland creation measures, as NFM can support this service by slowing the flow of water downstream. Grasslands and heathland/shrubs will also support this service to an extent – assessed quantitatively and monetarily.

Ecosystem service type	Ecosystem services reference list	Arable and horticultural land	Grasslands	Heathland and shrubs	Woodlands	Wetlands and fens	Water bodies	Built linear features	Comments
	Flood control services				✓	✓			No assessment to prevent double-counting with water flow regulation services. This service is different to water flow regulation services as it encompasses coastal protection.
	Storm mitigation services								No assessment.
	Noise attenuation services				✓				Woodlands located near the rail line could support this service – qualitative assessment only
	Pollination services	✓	✓	✓	✓	✓			Arable land is affected, so this service is relevant. Woodlands also provide pollination services because they provide nesting and floral resources for (wild) bees. Wetlands and fens also provide pollination services because they are where certain species of hoverfly lay their eggs in standing water (i.e. ponds) – qualitative assessment only.
	Nursery population and habitat maintenance services (e.g. Biodiversity)	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		Habitat/land use change will impact the service – biodiversity assessed quantitatively and monetarily.
	Recreation-related services	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		There are public footpaths through many of the farm parcels within the assessment boundary – recreation assessed quantitatively and monetarily.
Cultural services	Visual amenity services	✓	✓	✓	✓	✓	✓		Land areas visible from the train/rail line – qualitative assessment only to prevent double-counting with recreation-related services.
	Spiritual, artistic and symbolic services								No assessment.
	Ecosystem and species appreciation								No assessment.
Legend									
	✓✓	Quantified and/or valued material impact							
	✓	Unquantified material impact							
		No material impact							
		No ecosystem service provision in boundary of analysis							

3.3.2. Qualitative assessment of impacts

The qualitative assessment has been guided the considerations listed in Section 3.4.1 of the ECOV4R Framework. As not all ecosystem services impacts can be quantified, the qualitative assessment ensures that material impacts are captured, even if they cannot be quantified or monetised.

Table 5 shows the qualitative assessment of the ecosystem services scoped in following the materiality assessment. Significance levels have been assigned based on project information, open-source data and expert judgement. The results were discussed and agreed with project partners.

Table 5: Qualitative assessment of material ecosystem services to the pilot project

Ecosystem service	Anticipated impact	Reasons/evidence for choosing the scale of the impact	Confidence rating (low, medium, high)
Air filtration services	+	Natural Flood Management (NFM) measures being implemented, such as creating woodlands, wetlands, grasslands and meadows, will have benefits to air quality by capturing air pollutants (e.g. PM10, PM2.5, SO2, NH3, NO2, O3).	Medium – moderate evidence, some uncertainty.
Biomass provisioning services (including crop/grazed biomass/livestock/wood provisioning)	--	The proposed interventions significantly reduce the extent of arable land. Therefore, there is an expected significant disbenefit due to the loss in food production. Grassland habitats (e.g. modified grasslands) may be used for grazing or hay/silage in the baseline; however, it is understood that the grasslands post-intervention would be managed for biodiversity objectives and have more limited agricultural value compared to their prior use. However, while the proposed interventions will lower agricultural productivity within the boundary of analysis, they may lead to higher productivity in arable land downstream due to better protection from flooding.	High – strong data or consensus of agreeing literature/evidence.
Global climate regulation services (e.g. carbon sequestration)	++	The proposed interventions seek to increase the extent of habitats with greater carbon sequestration capabilities. In particular, the creation of broadleaved woodland will improve and provide more habitat capable of sequestering carbon. Water bodies and wetlands in this spatial context (i.e. non-peaty soils) are assumed to have zero-carbon flux due to the high uncertainty and context-dependency in the literature. Thus, there may be some disbenefit in removing modified grassland or arable land to a pond/wetland in terms of the quantification and valuation approaches in this pilot assessment.	High – strong data or consensus of agreeing literature/evidence.
Soil and sediment retention services (e.g. landslide prevention) *	+	Parts of the catchment, particularly the railway embankments, are vulnerable to soil/embankment erosion during flood events. Improvements are expected with the creation of habitats and the implementation of NFM measures, such as woodland and wetlands which contribute to slowing the flow of water and consequently support soil retention.	Medium – moderate evidence, some uncertainty.
Water purification services (e.g. water quality regulation)	+	The creation of wetlands (e.g. floodplain wetland mosaic/floodplain grazing marsh, wet woodlands) is expected to support the water purification service.	Medium – moderate evidence, some uncertainty.

Ecosystem service	Anticipated impact	Reasons/evidence for choosing the scale of the impact	Confidence rating (low, medium, high)
Water flow regulation	++	Implementation of woodland and wetland creation measures as NFM measures can support this service by slowing the flow of water downstream.	High – strong data or consensus of agreeing literature/evidence.
Noise attenuation services	+	Minor improvements are expected for noise attenuation owing to the creation of woodlands near the rail line. However, as most of the woodlands created are located further from the rail line, this benefit is not significant. It is considered that noise attenuation could be beneficial not only to people but also to nature, hence, an overall benefit is assigned.	Low – limited data, high uncertainty.
Pollination services	+	The post-intervention scenario across the catchment will develop important habitats for pollination, including woodlands, wetlands, meadows and grassland areas. Pollination would be beneficial to the remaining arable land within the catchment in the post-intervention scenario.	Low – limited data, high uncertainty.
Nursery population and habitat maintenance services (e.g. biodiversity)	++	The target habitats in the post-intervention scenario are more diverse than the arable land they replace in the baseline. With a more diversified landscape, ranging from floodplain wetland mosaics, meadows, wetlands and woodlands, a wider range of species within these areas can be supported in these habitats.	High – strong data or consensus support.
Recreation-related services	+	There are public footpaths through many of the farm parcels within the catchment. With improvements to the overall landscape thanks to more wetland, woodland and meadow habitats, the number of visitors using these footpaths is likely to increase as visitors can enjoy the landscape.	Low – limited data, high uncertainty.
Visual amenity services	+	The habitats implemented as part of the interventions would provide a visually appealing landscape with different textures, colours and species throughout the year. Users that could benefit are railway users, local neighbours and farmers.	Low – limited data, high uncertainty.

Legend

++	Significant benefit
+	Benefit
0	No benefit
-	Disbenefit
--	Significant disbenefit

While there is good evidence of the impact of certain habitats on noise attenuation, pollination, recreation and visual amenity, the magnitude of any impact is highly contextual and depends on the spatial configuration and/or quality of implementation. As we have limited data on these factors, we have assigned a low confidence rating.

The term 'nursery population and habitat maintenance services' is referred to as 'biodiversity' throughout this report for clarity and ease of communication.

3.4. Step D: Benefits valuation – quantify and value



3.4.1. Assessment approach

The purpose of this step is to quantify and (where possible and appropriate) place an economic value on the changes in ecosystem services delivered by natural assets likely to be caused by the proposed NFM interventions.

The primary guidance for undertaking natural capital and ecosystem services assessments in the UK includes:

- HM Treasury Green Book Guidance (2024) on the valuation of non-market benefits, which directly references the use of a natural capital approach to assess national economic impacts such as positive and negative impacts on the environment.
- The Department for Environment, Food and Rural Affairs (Defra) 'Enabling a Natural Capital Approach' (ENCA) Appraisal Guidance (Defra, 2025a), which is quoted as best practice for undertaking an NCA within the HM Treasury Green Book guidance.
- The Environment Agency's Flood and Coastal Erosion Risk Management (FCERM) Appraisal Technical Guidance (ATG) (Environment Agency, 2024) which recommends the use of ENCA as the framework for assessing natural capital where appropriate and proportionate to do so in the development and appraisal of flood risk mitigation schemes.

3.4.2. Quantitative and monetary assessment of impacts

In the following subsections, the approaches taken to quantify and value the impacts of each ecosystem service are explained. Following the guidance in Section 3.5.3 of the ECOV4R Framework, a land cover value transfer approach was used in most cases, except for the water flow regulation service where separate modelling was carried out. This approach makes use of readily available economic valuation evidence in the UK and is a practical and cost-effective approach to inform decision-making. Some ecosystem service impacts were not quantified explicitly in biophysical terms but indirectly through the change in area of different habitats. This is due to the valuation approach for these ecosystem services being based on a monetary value per hectare approach.

All ecosystem service benefits have first been calculated in annual terms and then projected across a 100-year appraisal period using UK recommended discount rates. All monetary evidence and respective prices used in the calculation of ecosystem service benefits are presented below in their original price year but were inflated to a 2024 price year using the most recent government GDP deflators (HM Treasury, 2025). Quantitative and monetary results for all ecosystem services are provided in Section 3.5.1.

3.4.2.1. Biomass provisioning services

Food production is directly supported by ecosystems, the benefit of which can be readily quantified through market prices. In some instances, food is directly harvested and consumed in the same form and thus the benefit received, and service provided, are one and the same. More often, ecosystems support the growth of products which are then processed into secondary, consumable products.

Food production can be quantified using yield data from the John Nix Pocketbook values (Redman, 2020, 2021, 2022, 2023, 2024). An average over 5 years was taken to provide a more representative metric. The hectares of land devoted to the production of different agricultural products for the baseline and post-intervention were multiplied by the average annual yield to get the total food production for the boundary of analysis. The yield per hectare of land values and the corresponding habitat they were multiplied by are presented in Table 6. This data source is recommended for use in ENCA.

The John Nix Pocketbook also provides gross margin values for the area of land used to produce the categories quantified above. These values are in 2024 prices and presented in Table 6. These unit values were multiplied by the corresponding habitat in the baseline and post-intervention scenarios to estimate the total annual value of biomass provisioning services.

Table 6: Quantitative and monetary unit values for the provision of food production

Description	Corresponding habitat	Yield per hectare per year	Gross margin value per hectare (£/ha/year, 2024 prices)
Wheat	Arable and horticulture	8.56 tonnes/ha/year	1,126.68
Dairy cow	50% of pasture area (e.g. modified grassland)	16,800 litres/ha/year	2,497.30
Beef	50% of pasture area (e.g. modified grassland)	502.90 kg/ha/year	204.37
Lowland sheep	Semi-natural grassland (e.g. neutral grassland)	378.80 kg/ha/year	611.53
Upland sheep	Mountain, moorland and heath	144.00 kg/ha/year	-11.22

Assumptions and limitations

Grasslands in the post-intervention scenario are likely to be managed for biodiversity objectives and will have more limited agricultural value compared to their prior use. However, for the purpose of this assessment, it is assumed that the neutral grassland areas in the post-intervention scenario will deliver the biomass provisioning service. Additionally, it is assumed that 50% of the area of modified grassland is used for dairy cows and the other 50% of modified grassland for beef. This assumption has been informed by the Environment Agency's Natural Capital Register and Accounting Tool that recommends this assumption when it is uncertain how much land area is attributed to each yield type (Environment Agency, 2023).



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Box 2. Worked example for quantifying and monetising biomass provisioning services

This box demonstrates a worked example for the quantitative and monetary assessments of the biomass provisioning service using the recommended value transfer approach. See Section 3.4.2.1 for further detail on the method and evidence used.

Note that for the purposes of this illustrative example, only habitats within the asset register that are relevant to biomass provisioning and can be quantified and monetised are presented in the tables and calculations below. All other habitats not included are not directly relevant to this service and thus do not have a corresponding quantitative and monetary value to be used in the value transfer approach.

Quantitative biophysical assessment

For the quantification of the biomass provisioning potential within the baseline boundary of analysis, the habitats on the asset register were mapped to the corresponding yield category. The unit value for the annual yield per hectare value was then multiplied by the habitat's area. This results in the total yield for each habitat area and corresponding yield type. See Table 7 for the quantitative results for the baseline scenario. The same process was repeated for the post-intervention scenario as shown in Table 8.

Table 7: Baseline quantitative biomass provisioning calculations

Habitat	Corresponding yield category	Area of habitat (ha)	Yield/ha/year	Total yield per year
Arable and horticulture	Wheat	1,135.28	8.56 tonnes/ha/year	9,718.03 tonnes/year
Lowland heathland	Mountain, moorland and heath	5.42	144 kg/ha/year	780.23 kg/year
Modified grassland*	50% dairy cow	979.88	16,800 litres/ha/year	16,461,900 litres/year
Modified grassland*	50% beef	979.88	502.9 kg/ha/year	492,779.14 kg/year
Neutral grassland	Lowland sheep	445.27	378.8 kg/ha/year	168,668.10 kg/year

* Based on existing guidance on the use of these values, areas of pasture (i.e. modified grassland) can be attributed to 50% dairy cow and 50% beef, thus the total area of modified grassland has been divided in two in the table.

Table 8: Post-intervention quantitative biomass provisioning calculations

Habitat	Corresponding yield category	Area of habitat (ha)	Yield/ha/year	Yield per year
Neutral grassland	Lowland sheep	429.83	378.8 kg/ha/year	162,818.39 kg/year

Quantitative monetary assessment

For the monetary valuation of the biomass provisioning potential within the baseline boundary of analysis, the same mapping of habitats to the corresponding yield category is used. The unit value for the annual gross margin per hectare value was then multiplied by the habitat's area. This results in the total gross margin value for habitat area and corresponding yield type. See Table 9 for the monetary valuation results for the baseline scenario. The same process was repeated for the post-intervention scenario as shown in Table 10.

Table 9: Baseline monetary biomass provisioning calculations (annual value)

Habitat	Corresponding yield category	Area of habitat (ha)	Gross margin value/ha/year (2024 prices)	Total value per year (2024 prices)
Arable and horticulture	Wheat	1,135.28	1,126.68	1,279,101.49
Lowland heathland	Mountain, moorland and heath**	5.42	-11.22	-60.79
Modified grassland*	50% dairy cow	979.88	2,497.30	2,447,041.84
Modified grassland*	50% beef	979.88	204.37	200,257.05
Neutral grassland	Lowland sheep	445.27	611.53	272,295.67
			Total	4,198,635.27

* Based on existing guidance on the use of these values, areas of pasture (i.e. modified grassland) can be attributed to 50% dairy cow and 50% beef, thus the total area of modified grassland has been divided in two in the table.

** The yield category is aligned to upland heath/moorland sheep system, but the economics are likely to be similar (i.e. not economically viable without subsidy, hence a negative value)

Table 10: Post-intervention monetary biomass provisioning calculations (annual value)

Habitat	Corresponding yield category	Area of habitat (ha)	Gross margin value/ha/year (2024 prices)	Total value per year (2024 prices)
Neutral grassland	Lowland sheep	429.83	611.53	262,851.98
			Total	262,851.98
			Net change	-3,935,783.28

This means that there is a loss of £3.9 million in biomass provisioning value due to the reduced arable land and modified and neutral grasslands for the use of food production.

3.4.2.2. Air filtration services

Vegetation has an important role in removing atmospheric pollutants, which has benefits in terms of ecosystem service and health and wellbeing. These benefits can be monetised as a function of avoided health costs. Jones et al. (2017) ran a dynamic transport model of air pollution across the UK with and without vegetation in order to quantify the scale of air pollution removal by UK vegetation. For various habitat types, the model outputs an estimate of the annual mass of various pollutants deposited on the respective land cover, the subsequent volume of pollutant removed from the atmosphere and an indicative average, annual value for air pollution removal based on the avoided health costs associated. The 2030 removal rate has been used. This data source is recommended for use in ENCA.

For the quantitative assessment, the tonnes of pollutant capture per hectare was multiplied by the habitats in the asset register in both the baseline and post-intervention scenarios.

The monetary values are derived from Defra's 'Air quality appraisal damage cost guidance' (2023) which estimates the costs from respiratory and cardiovascular hospital admissions, life years lost and deaths that are avoided due to air pollutant removal by different habitats. The value per hectare of each habitat is relative to a bare-soil counterfactual. These values (Table 11) were multiplied by the area of each habitat to estimate the total annual value of air filtration services in the baseline and post-intervention scenarios.

For this service, the present value benefits over the 100-year appraisal period have been staggered based on the time to target condition for enhanced and created habitats in the post-intervention scenario. See Appendix B for the stagger factors used for each habitat.

Table 11: Air pollutant removal values applied to habitat parcels

Habitat type	Pollutant capture in 2030 as dry deposition (tonnes/ha/year) ⁴	Air pollutant removal value based on 2030 absorption capacity (£/ha/year, 2022 prices)	Air pollutant removal value based on 2030 absorption capacity (£/ha/year, 2024 prices)
Woodland	-0.081	325.8	362.2
Semi-natural grassland	-0.044	30.1	33.5
Modified grassland	-0.054	29.2	32.5
Heathland and shrub	-0.045	20.7	23.1
Enclosed farmland	-0.054	29.2	32.5
Lakes/ponds (priority habitat)	-0.034	18.6	20.7
Wetland & floodplain	-0.034	18.6	20.7

Assumptions and limitations

The monetary value is likely an over-estimate for the following reasons. Firstly, the source study projects a declining value over time for most air pollutant removals but does not provide predictions beyond 2030. Secondly, the values are averages for England: the Evenlode catchment is a rural location with no major industry that would be the source of most air pollutants and may have a lower-than-average population density.

3.4.2.3. Water purification services

Wetland habitats provide substantial benefit through their capacity to help store, detoxify and filter out pollutants associated with run-off, minimising the risk of them entering watercourses. The quantification for this service is the area of wetland habitats in the boundary of analysis. Inland wetland habitats are the only habitats in the boundary of analysis that provide measurable water purification services. These include the floodplain wetland mosaic and CFGM, reedbeds, and wetlands in the baseline and post-intervention scenarios and the created lowland fens in the post-intervention scenario.

Table 12 presents the Morris and Camino (2011) values used for valuation. These estimates are based on a value transfer function informed by evidence of wetlands across Europe and applied to UK sites. This study has been chosen as it is based on a value transfer approach using pollutant removal values by wetlands. These monetary values were multiplied by the area of wetlands (as defined above) to estimate the total annual value of water purification services in the baseline and post-intervention scenarios (see Table 17). This data source is recommended for use in ENCA.

⁴ The tonnage represents the total amount of the following pollutants: PM10, PM2.5, SO₂, NH₃ and NO₂. Source: Jones et al. (2017).

Table 12: Water purification values for inland wetlands

Inland wetland type	Water purification value (£/ha/year, 2010 prices)	Water purification value (£/ha/year, 2024 prices)
Average water quality benefits provided by inland wetlands	436.0	627.2
Average water quality benefits provided by an additional hectare of inland wetlands	292.0	420.1

Assumptions and limitations

The present value benefits over the 100-year appraisal period have not been staggered for this service as it has been assumed that once the wetland habitats are implemented, full benefits are delivered from year 1.

3.4.2.4. Global climate regulation services (carbon sequestration)

Global climate regulation services comprise the process and functions of different land uses and habitats that regulate the concentrations of greenhouse gases. In this case, of particular interest is carbon in the atmosphere which has an impact on global climate or oceans through the emission and sequestration of carbon. This provides a crucial service in mitigating the effects of anthropogenic climate change.

The volume of carbon being sequestered or emitted (a flow) can be quantified using verified average rates or 'carbon factors' for different habitats taken from meta-analyses undertaken by UK government agencies. The value of these biophysical quantities can then be monetised using prices from UK government guidance. The approach taken is in line with ENCA guidance and the Woodland Carbon Code (Forestry Commission, 2022). The carbon sequestration and emission rates per hectare of different habitat types are presented in Table 13. Any habitat types not included in the table are assumed to have zero net carbon sequestration. These values were multiplied by the area of each habitat to estimate the total annual tonnes of carbon dioxide equivalent (CO₂e) sequestered in the baseline and post-intervention scenarios.

Table 13: Annual net carbon emissions rates by habitat

Habitat	Net annual emissions (tCO ₂ e/ha/year) – low estimate	Net annual emissions (tCO ₂ e/ha/year) – medium estimate	Net annual emissions (tCO ₂ e/ha/year) – high estimate	Source
Arable land use	0.29	0.29	0.29	Natural England (Gregg et al, 2021)
Improved grassland	0.92	-0.36	-1.28	Natural England (Gregg et al, 2021)
Semi-natural grassland	-0.68	-1.55	-2.42	Natural England (Gregg et al, 2021)
Heathlands	-0.49	-1.14	-1.79	Natural England (Gregg et al, 2021)
Broadleaved woodland, light management	-5.70	-5.70	-5.70	Forest Research (Matthews et al, 2022)

Positive values represent net emissions; negative values represent net sequestration.

To value the carbon sequestered in the baseline and post-intervention scenarios, the carbon sequestration quantities (tCO₂e/year) were multiplied by the Department for Energy Security and Net Zero (DESNZ, 2023) carbon price. The emissions should be multiplied by the carbon price associated with the year of emission. To estimate value factors post-2050, an annual growth rate of 1.5% starting at the published value for 2050 was applied, following DESNZ guidance.

For this service, the present value benefits over the 100-year appraisal period have been staggered based on the time to target condition for enhanced and created habitats in the post-intervention scenario. See Appendix B for the stagger factors used for each habitat.

Assumptions and limitations

Carbon sequestration is a function of habitat type and condition; the available evidence can readily quantify the impacts of habitat change but the impact of a change in condition of the same habitat type is not consistently available. This is highly pertinent for waterbodies and wetland habitats where the net carbon flux is dynamic and reflects levels of wetness as well as prior land use. For this reason, the recommended evidence synthesis in Defra’s ENCA guidance assigns these habitats a zero net flux.

3.4.2.5. Biodiversity (nursery population and habitat maintenance services)

In England, Biodiversity Net Gain (BNG) is a legally mandated approach to development that ensures biodiversity is left in a measurably better state. To ensure consistency and transparency, developers must use Defra’s Statutory Biodiversity Metric Tool (Defra, 2025b). This tool quantifies biodiversity in ‘biodiversity units’ based on habitat type, extent, condition, distinctiveness and strategic significance. It calculates net gain by comparing baseline and post-intervention biodiversity units and it supports planning decisions by providing a standardised and auditable method for assessing biodiversity impacts.

Where an intervention is applied to the same broad habitat type as in the baseline, the interventions were ‘enhanced’ in the Statutory Biodiversity Metric Tool. For example, when the habitat type is not changed, but the condition is improved. Otherwise, if an existing habitat was removed and replaced by a different habitat type, the proposed intervention would fall under ‘habitat creation’. The biodiversity units generated are assumed to be the benefits once the habitats are fully established/enhanced.⁵

The recommended approach (Defra, 2025a) to valuing biodiversity impacts is to multiply the biodiversity units calculated for each habitat type by the average market prices for compensation of habitat removal reported by Biodiversity Units UK (2025). These are reported in Table 14 and represent actual prices paid for biodiversity units of that habitat type. However, as the number of units potentially generated here (5,000) is very large relative to the current magnitude of the nascent biodiversity unit market in the local area (~50 units traded in the past year on the official register⁶), the number of units used to calculate the value has been scaled down to 500 which reflects an assumption of how many could be reasonably sold within the next 10 years.

Table 14: Market prices for valuing biodiversity units

Habitat type	Biodiversity unit value (£ per unit, 2024 prices)
Neutral grassland	25,843
Heathland and shrub	29,907
Floodplain wetland mosaic	60,117
Freshwaters – open waters, wetlands and floodplains	69,701
Lowland meadow	35,464
Mixed deciduous woodland	56,460
Wet woodland	48,623
Hedgerow	23,736

⁵ The biodiversity units in the baseline and post-intervention scenarios have been extracted from a separate AtkinsRéalis NFM feasibility study produced for Network Rail. Please contact AtkinsRéalis or Network Rail for further information on this study.

⁶ In July of this year for Oxfordshire, with some assumptions of biodiversity units/ha uplift (an average 5.5 biodiversity units per hectare) used (Source: <https://environment.data.gov.uk/biodiversity-net-gain>).

Assumptions and limitations

Biodiversity market prices have been used as a proxy for biodiversity value, but biodiversity units can only be sold to the market when they are created or enhanced. Thus, the biodiversity units in the baseline are a proxy of biodiversity value, but the monetary value cannot be realised through the sale of biodiversity units. Therefore, the net change in biodiversity value is the key figure for this ecosystem service. Additionally, BNG is an industry-standard measure of biodiversity but only captures physical habitat change; no species-specific benefits (e.g. to protected species) have been quantified. See also above regarding the size of the market.

3.4.2.6. Recreation-related services

The recreation service refers to the contribution and opportunity provided by the environment for recreational uses. Natural ecosystems used as a place for the active and passive enjoyment of recreation, including walking, hiking, camping, cycling, boating, fishing and nature viewing. The quantification of this service is the area of habitats within the boundary of analysis that are accessible for recreation.

The preferred approach in ENCA for calculating recreational value in England is to use the Outdoor Recreation Valuation Tool (ORVal)⁷, which applies a spatially explicit visitor and travel-cost valuation function to estimate baseline and change in number of visits and monetary value. The tool is only practicable to assess individual sites and cannot readily be deployed on a large scale such as this. As such, an alternative approach is to estimate the value with reference to marginal value per hectare values reported in 'Outdoor Recreation Valuation (ORVal) Insights' (Day and Davis, 2022), a paper which summarises key findings from the application of the ORVal model at national scale. This data source is recommended for use in ENCA. These values, reported in Table 15, were multiplied by the area of each habitat to estimate the average recreational value of the habitats in the boundary of analysis in the baseline and post-intervention scenarios. These evidence values were used for a value transfer approach.

Table 15: Recreation values by habitat

Habitat type	Recreation value (£/ha/year, 2016 prices)	Recreation value (£/ha/year, 2024 prices)
Rural woodlands	392	512
Wetlands	4,697	6,132
Semi-natural grasslands	42	55
Freshwater	2,512	3,280

For this service, the present value benefits over the 100-year appraisal period have been staggered based on the time to target condition for enhanced and created habitats in the post-intervention scenario. See Appendix B for the stagger factors used for each habitat.

Assumptions and limitations

It is currently assumed that all parcels are accessible via public footpaths. However, this is likely to be an overestimate, given that some land parcels may be subject to restricted access. In future, the ORVal tool can be used to evaluate specific parcels of land which are known in order to generate physical and monetary values that are based on population density and availability of substitute greenspaces.

⁷ <https://www.leep.exeter.ac.uk/orval/>

3.4.2.7. Water flow regulation services

For the water flow regulation service, the value transfer approach recommended in ENCA uses the average flood storage volume of woodlands, grasslands and shrublands as the biophysical measure and an avoided cost of a constructed reservoir as the monetary metric (this is the avoided annual cost of replacing the flood risk protection benefits by a constructed reservoir, which is a proxy for valuing the service provided by woodlands, grassland and shrublands).

However, for this pilot assessment, the AtkinsRéalis in-house NFM Studio tool was used to calculate the potential volumetric reduction of run-off at the field scale for the Evenlode catchment as a result of a number of NFM interventions in a more granular approach using primary data. The calculations begin with a Flood Estimation Handbook (FEH) hydrograph generated for the catchment from which volumetric reductions are calculated using published hydrological equations (Daily based Morgan-Morgan-Finney (DMMF) model, Choi et al., 2017) and geospatial analysis. NFM Studio considers three main NFM intervention types:

- Infiltration – land management and land use measures across the catchment
- Temporary storage – naturalising flow pathways and bunds along the identified flow pathways
- In-channel attenuation – temporary in-channel attenuation features (e.g. leaky wood dams) to slow the flow

Changes in run-off in the catchment as a result of these interventions are applied at a field scale to identify the highest potential reduction per field and intervention, helping to prioritise the fields that will provide the greatest potential flood risk mitigation within a catchment. The total volumetric reductions are applied to the downstream hydrograph, to estimate the reduction in flood volume and peak for a given annual chance event. The 1 in 2, 1 in 20 and 1 in 100-year events were chosen to give a realistic range as NFM measures are generally more effective during lower return periods.

Table 16: Outputs from the volumetric reduction of run-off modelling

	1 in 2-year event (50% annual probability)	1 in 20-year event (5% annual probability)	1 in 100-year event (1% annual probability)
Reduction in flood volume (m3)	104,327	172,371	233,819
Reduction in flood peak (%)	4.66	1.99	1.71

Based on the reduction in flood volume in the catchment with the NFM intervention, the valuation assessment looks at how much economic damage is reduced in terms of travel disruption as a result of the change in flood volumes and associated probabilities. Rail disruption flood damages have been calculated using one of the two recommended approaches within the Multi-Coloured Manual (MCM) 2025 Handbook for Economics Appraisal (Flood Hazard Research Centre, 2021). The method has been applied to the Cotswold rail line within the Evenlode catchment. The MCM is a UK database and handbook for assessing the benefits of flood and coastal erosion risk management. However, the MCM is licensed material and not open access, thus the cancellation compensation values (in £ per service cancelled) of Train Operating Companies (TOC) as agreed in the Track Access Agreements with Network Rail cannot be presented within this report. Individual companies and Network Rail will have direct access to indicative values that are provided in the MCM and account for the differences between TOCs, which could also be utilised in this analysis. The MCM has been used here in the context of rail disruption and not in terms of properties within the catchment. This data source is recommended for use in ENCA.

Values were calculated using the average compensation costs that Network Rail pays to TOCs under Schedules 4 and 8 of the Track Access Agreements. Costs are agreed within this schedule for delays and/or cancellations depending on the type of route or operator affected and the location of the incident. The total cost of these payments is used as a proxy for the monetary value of the flood damages associated with rail disruption. The MCM provides low, medium and high values for passenger service performance delays and cancellations (per service) to account for the wide variation between operating companies and the lines impacted.⁸

⁸ Values from the MCM cannot be shared due to licensing of the product.

Given the location of the Cotswold Line and its associated usage by passengers, the low values have been used in these calculations. The low values are appropriate for rural rail lines, whereas high values would likely represent a busy, highly urbanised rail line (e.g. London) given the greater impact of economic disruption.

The remaining required assumptions relate to the number of timetabled services per day for each of the train lines. This will enable the compensation payments per service to be scaled up to a per day damage value and then total flood event related damages. To calculate the monetary impact of the rail services cancelled, the following assumptions were made:

- Number of passenger trains per hour in both directions: 4
- Number of active train hours per day: 18
- Number of weeks disturbance (i.e. closure of the line during a flood event): 2
- In the event of flooding, number of train services cancelled for the duration of disturbance: 1,008

In the flood event it is assumed that all services will be cancelled for a period of 2 weeks⁹ and therefore the indicative compensation value for performance delays and cancelled services was derived from an assumed 1,008 train services cancelled for the duration of a 2-week flood disturbance/closure. The MCM compensation value has been uplifted from a 2013 price date, using UK GDP deflators. This monetisation value represents the damages associated with a single flood event in terms of disruption to the rail line. For the sensitivity analysis, the low compensation value assumes a cancellation period of 1 week and the high compensation value assumes a cancellation period of 4 weeks.

The average annual damages were calculated by multiplying the single flood event compensation value by the flood probability event in the baseline and post-intervention scenarios. The flood probabilities were assumed to reduce with NFM interventions based on the reduction in peak and volume in Table 16:

- The 1 in 2-year event in the baseline is a 1 in 5-year event in the post-intervention scenario.
- The 1 in 20-year event in the baseline is 1 in 22-year event in the post-intervention scenario.
- The 1 in 100-year event remains the same in both scenarios as the volume attenuated by NFM in large events is a smaller proportion compared to smaller, more frequent probability events.

For this service, the present value benefits over the 100-year appraisal period have been staggered based on the weighted average across the time to target condition for enhanced and created habitats in the post-intervention scenario. This weighted average stagger is 21 years. See Appendix B for the stagger factors used for each habitat.

Assumptions and limitations

The NFM Studio tool calculates the potential volumetric reduction and volume attenuated based on a conservative set of assumptions and primarily using open-source datasets. It is not a flood model with flow routing but a combined geospatial-hydrological tool that can be run at the landscape scale. Additionally, NFM Studio assumes all habitats are working at maximum capacity. It does not account for the time it will take for habitats to establish. The impact of climate change on flood volumes and increases in the probability of flood events has not been included within this high-level assessment, and therefore the results are likely an underestimate of the potential damages caused by flooding disruption to the rail line.

NFM Studio only modelled the 1 in 2, 1 in 20 and 1 in 100-year events. Thus, changes in probability as a result of the NFM interventions to estimate the annual flood damages have been assumed using the percentage reduction in flood peaks in each event to approximate this potential impact. The changes in probability to 1 in 5, 1 in 22 and 1 in 100-year events is potentially an overestimate and will require modelling to confirm.

For future assessments, if there was flood risk modelling data available, flood risk benefit to other receptors such as properties, businesses and roads could be investigated.

⁹ A disruption period of 2 weeks has been assumed based on historical flood disturbances and incident reports (Network Rail, 2007).

3.4.3. Present value of changes

Annual values and present values (PV) are calculated for all ecosystem services in this assessment. For this assessment, the discount rate was 3.5% from years 0-30, 3% from years 31-75, and 2.5% from years 76-100 in line with HM Treasury Green Book guidance (2024), and the appraisal period is 100 years. Please refer to Section 3.5.4 of the ECOV4R Framework for further information.

3.5. Step E: Using and interpreting results



3.5.1. Summary of results

Table 17 presents the indicative annual quantitative (biophysical) estimates of the ecosystem services scoped in for quantitative assessment in the baseline and post-intervention scenarios. Due to the reduction in agricultural land, the food production results in the greatest net loss in ecosystem services. However, as stated above, this is likely to be an overestimate if small areas of residual grassland are used for grazing or hay/silage purposes. The increase in other habitat types, such as woodlands, contributes to the higher carbon sequestration rate in the post-intervention scenario compared to the baseline. Table 18 provides a further breakdown of the range of carbon sequestration rates (see Section 3.4.2.4 for the method used to quantify this service). Moreover, the NFM interventions result in a net gain of almost 5,000 additional biodiversity units.¹⁰

Table 17: Quantitative estimates by ecosystem service (annual)

Ecosystem service	Unit of measurement	Baseline	Post-intervention	Net change
Biomass provisioning services	Wheat (tonnes/year)	9,718.03	0	-9,718.03
	Dairy cow (litres/year)	16,461,900	0	-16,461,900
	Beef (kg/year)	492,779.14	0	-492,779.14
	Lowland sheep (kg/year)	168,668.10	162,818.39	-5,849.71
	Upland sheep (kg/year)*	780.23	0	-780.23
Air filtration services	Pollutant capture (tonnes/year)	-216.79	-216.73	0.06
Water purification services	Area of wetland (ha)	16.14	15.98	-0.16
Global climate regulation services	tCO ₂ e/year (central value)	-2,905	-12,026	-9,121
Biodiversity	Biodiversity units	14,065	19,019	4,954
Recreation-related services	Area of habitat (ha)	3,948	3,948	-

* The value for upland sheep is used as a proxy for land in the Mountain/Moor/Heath category (i.e. lowland heath) which is likely to be a lower productivity system than lowland sheep (grazing on grassland).

¹⁰ The biodiversity units in the baseline and post-intervention scenarios have been extracted from an AtkinsRéalis NFM feasibility study. For further information, contact AtkinsRéalis or Network Rail.

Table 18: Quantitative estimates of carbon sequestration (annual)

Ecosystem service	Unit	Low baseline	Central baseline	High baseline	Low post-intervention	Central post-intervention	High post-intervention
Global climate regulation services	tCO ₂ e/year	70.6	-2,905.0	-5,175.2	-9,877.1	-12,025.8	-14,188.1

Positive values represent net emissions; negative values represent net sequestration.

Table 19 presents the reduction in flood volume in the Evenlode catchment as a result of the proposed NFM interventions. The NFM Studio tool generated hydrographs for the 1 in 2, 1 in 20 and 1 in 100-year probability events. These results demonstrate that the proposed NFM interventions will be beneficial both for reducing flood volume in the catchment and to the rail line. To help illustrate these reduced flood volumes, we can use Olympic size swimming pools, where one pool holds 2,500 m³ of water:

- 41.7 Olympic-sized pools for the 1 in 2-year flood event (50% annual probability)
- 68.9 Olympic-sized pools for the 1 in 20-year flood event (5% annual probability)
- 93.5 Olympic-sized pools for the 1 in 100-year flood event (1% annual probability)

Table 19: Net reduction in flood volume in the Evenlode catchment

Ecosystem service	Unit of measurement	1 in 2-year flood event	1 in 20-year flood event	1 in 100-year flood event
Water flow regulation	Reduction in flood volume (m ³)	104,327	172,371	233,819

Figure 10 presents the annual monetary values for each assessed ecosystem service. The total average net increase in annual value resulting from the project is approximately £546,000. The most significant contribution comes from global climate regulation service (carbon sequestration), which yields an additional £2.9 million annually. This estimate is based on the average carbon price applied over the appraisal period.

Other ecosystem services – air filtration, water purification, recreation and water flow regulation services – also show positive annual value changes, albeit on a smaller scale. It should be noted that the monetary value for water flow regulation equates to annual flood damages, thus the negative values represent the disbenefit of damage costs to the rail infrastructure, as flood disruption occurs in both baseline and post-intervention (at a reduced rate in the latter). Therefore, the net change means £282,000 of avoided annual flood damages and represents a positive benefit to the catchment and rail line. In contrast, the biomass provisioning service is the only service exhibiting a decline in value, with an estimated annual loss of -£3.9 million, primarily due to the reduction in agricultural land and associated food production.

The estimated flood damages avoided through NFM interventions in this pilot are relatively modest. This is partly due to low passenger volumes on the Cotswold Line (and consequently lower compensation costs required during flood disruption compared to a high-volume line, such as in London), but it also reflects the limited spatial scale of the interventions assessed. NFM schemes deliver greater value when applied on larger scales with coordinated uptake across multiple landowners. This pilot was not designed as a full-scale NFM scheme, but rather as a proof of concept to demonstrate that NFM can be effectively implemented in this location to enhance the resilience of rail assets. Importantly, the pilot also highlights the wider environmental and societal benefits of NFM when compared to traditional engineered solutions.

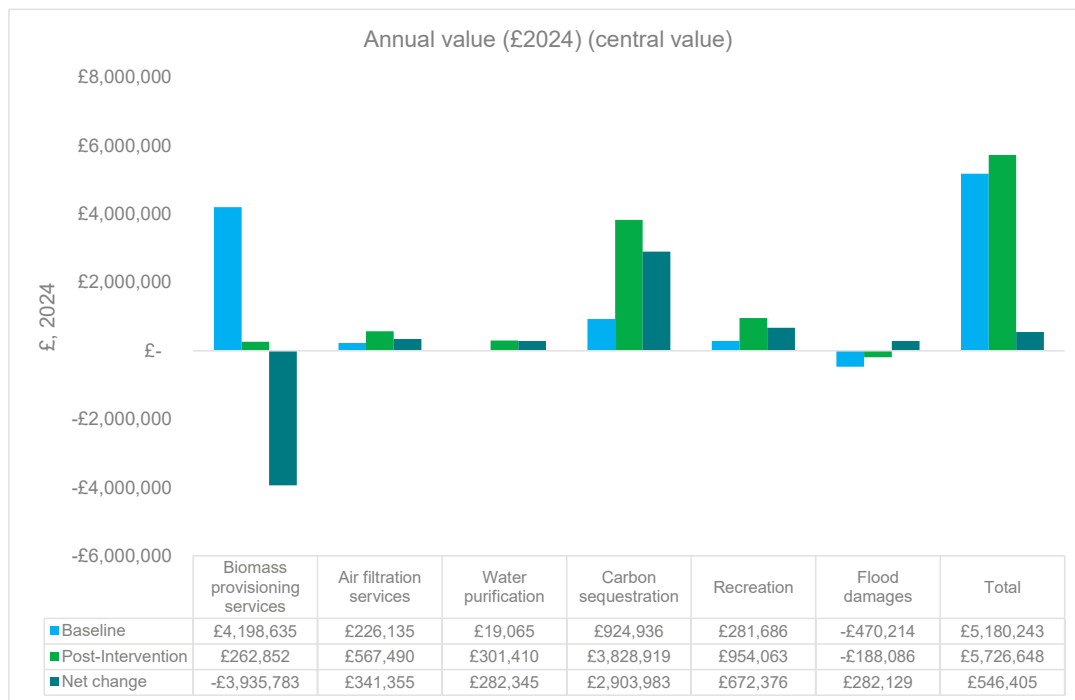


Figure 10: Annual monetary value by ecosystem service

Figure 11 illustrates the present value (PV) of each ecosystem service under both baseline and post-intervention scenarios, along with the net change. The total PV of the ecosystem service impacts attributable to the proposed interventions is approximately £483 million.

Carbon sequestration represents the largest positive contribution, with a PV of approximately £96 million. The PVs for air filtration, water purification and recreation are £4 million, £8.4 million and £10.2 million respectively. The PV for biomass provisioning reflects a loss of £117 million, consistent with the annual value reduction due to the loss of agricultural land. The results of the water flow regulation services indicate £10 million avoided in flood damages over the 100-year appraisal period which is a positive benefit. The monetary benefits for the biodiversity service have been included in this figure as the biodiversity market prices represents an upfront payment for one year only (at the time of selling credits). This means that if biodiversity credits were to be sold at the per unit prices, the payment in one year would be £47.17 million (note the caveat in Section 3.4.2.5 on the hypothetical nature of these credits and the practicality of their sale in a nascent market) .

The high monetary value attributed to biodiversity relative to other ecosystem services reflects the use of market prices of biodiversity units as the valuation metric. These prices are linked to England’s statutory BNG system where developers are required to deliver measurable biodiversity improvements, and biodiversity units can be traded to meet these obligations. While this approach provides a transparent and policy-aligned method for valuation, the market value is context-dependent and reflects regulatory requirements, habitat type, condition and strategic significance. In practice, it may not be feasible to sell the units created.



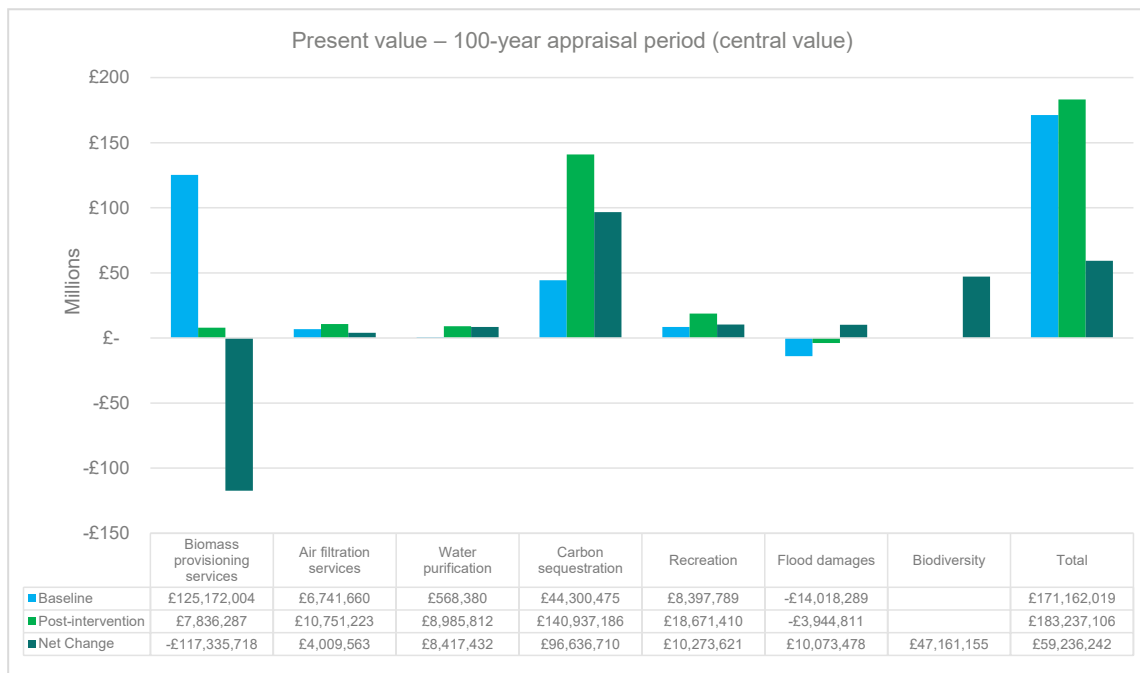


Figure 11: Present value by ecosystem service

In terms of the distributional impact of the changes across the beneficiaries, the following list summarises how the beneficiaries may ‘gain’ or ‘lose’ from the changes in ecosystem services delivered as a result of the proposed interventions:

- **Railway passengers:** Indirect gains from reduced travel disruption to train services.
- **Railway operators/managers:** Direct gains from reduced flood risk.
- **Local landowners:** Direct gains from reduced flood risk, increased carbon sequestration potential, increased biodiversity, improved water purification and air filtration services. Direct loss from reduced biomass provisioning services if the land was being used to produce food.
- **Local community:** Direct gains from reduced flood risk and recreation. Indirect gains from improved carbon sequestration, air filtration, water purification and biodiversity services. Also, potential sustainable tourism benefit for wider community. Reduced flooding may benefit insurance companies and water suppliers who face reduced costs of water filtration and purification. Improved air filtration services are also an indirect benefit for public health providers.
- **Global community:** Indirect gains from improved carbon sequestration and biodiversity services.

3.5.2. Uncertainties and limitations

Figure 12 presents the sensitivity analysis of the total PV. The error bars are derived from the variability in carbon sequestration rates, as shown in Table 13. Additionally, a sensitivity analysis was undertaken on the annual flood damages. The central value of the annual flood damages uses the compensation value for a 2-week closure during a flood disturbance; the low value assumes 1 week of closure and the high value assumes 4 weeks of closure.

To account for uncertainty and to ensure a conservative approach to biodiversity valuation, a three-tiered estimate was applied. The upper bound (~£471 million) reflects a theoretical maximum if all the units generated (5,000) could be sold at current market prices. The lower bound (~£4.7 million) is a cautious estimate, where only 50 of the 5000 units could be sold (50 being the annual volume traded currently in the market in Oxfordshire). The central estimate assumes that the biodiversity units market is likely to grow, and 500 units (i.e. 10 times current market volume) could feasibly be sold. See Section 3.4.2.5 for further information.

The net change in total PV ranges from -£27 million to £531 million depending on variations in the carbon sequestration rates, annual flood damages and biodiversity. This highlights the influence of assumptions on the overall valuation and underscores the importance of robust data in ecosystem service assessments.

The positive error is derived by subtracting the high estimate of the total PV over the 100-year appraisal period with the central estimate of the total PV, and the negative error is derived by subtracting the low estimate of the PV from the central estimate of the PV.

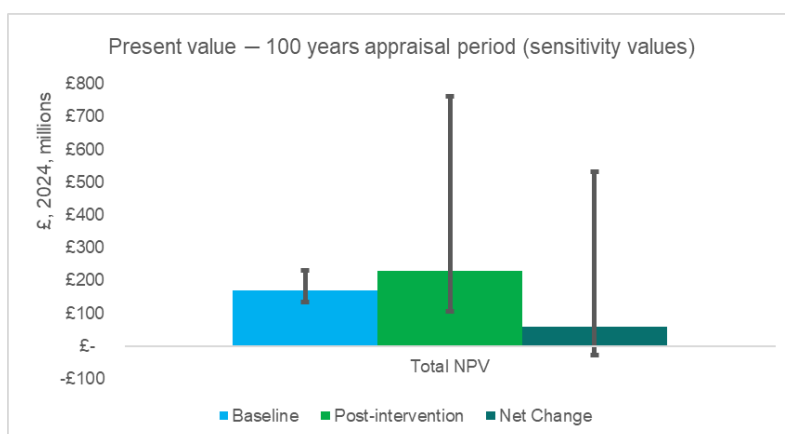


Figure 12: Total present value – sensitivity analysis

Assumptions and limitations specific to each ecosystem service methodology are included in Section 3.4.2. More general limitations of this assessment’s approach are listed below.

General assessment limitations:

There may be minor inaccuracies in the land cover data from the UKHab surveys due to changes over time. Open-source satellite imagery was used to cross-check certain areas.

Risk of establishment of habitats has not been considered. The ecosystem services provided by this project are dependent on habitat establishment and enhancement.

This study is not a full analysis of the project in general and so potential environmental and wider impacts during the construction phase have not been accounted for, such as the carbon emissions associated with soil disturbance or temporary hardstanding.

3.5.2.1. Confidence ratings of data and evidence

As stated in Section 3.6.1 of the ECOV4R Framework, it is important to understand and capture uncertainties in the underlying data and evidence used for the qualitative, quantitative and monetary assessment. One way of acknowledging these uncertainties is through a Red-Amber-Green (RAG) confidence rating system of the evidence or methods used, as presented in Table 20.

Table 20: Confidence ratings of data and evidence used

Ecosystem service	Assessment type	Anticipated impact / Net change	Confidence
Biomass provisioning services (including crop/ grazed biomass/livestock/wood provisioning)	Qualitative	↓	Green
	Quantitative (biophysical)	↓	Green
	Quantitative (monetary)	↓	Green
Air filtration services	Qualitative	↑	Yellow
	Quantitative (biophysical)	↓	Yellow
	Quantitative (monetary)	↑	Yellow

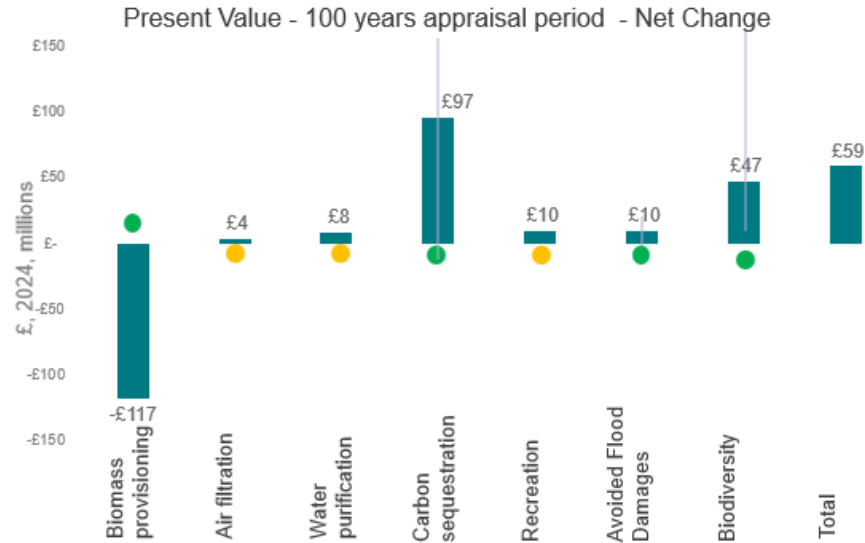
Ecosystem service	Assessment type	Anticipated impact / Net change	Confidence
Water purification services (e.g. water quality regulation)	Qualitative	↑	Amber
	Quantitative (biophysical)	↓	Amber
	Quantitative (monetary)	↑	Amber
Global climate regulation services (e.g. carbon sequestration)	Qualitative	↑	Green
	Quantitative (biophysical)	↑	Green
	Quantitative (monetary)	↑	Green
Recreation-related services	Qualitative	↑	Red
	Quantitative (biophysical)	→	Amber
	Quantitative (monetary)	↑	Amber
Water flow regulation services	Qualitative	↑	Green
	Quantitative (biophysical)	↑	Amber
	Quantitative (monetary)	↑	Green
Nursery population and habitat maintenance services (e.g. biodiversity)	Qualitative	↑	Green
	Quantitative (biophysical)	↑	Green
	Quantitative (monetary)	↑	Green
Soil and sediment retention services	Qualitative	↑	Amber
Noise attenuation services	Qualitative	↑	Red
Pollination services	Qualitative	↑	Red
Visual amenity services	Qualitative	↑	Red

Legend for confidence rating

Green	<p>Qualitative – Based on project-specific information (e.g. EIA, monitoring report, etc.) and/or strong consensus of anticipated impact.</p> <p>Quantitative – Strong or established evidence with few gaps. Based on local data sources for quantitative methods/values, using data with minimal data limitations. Recommended in guidance.</p>
Amber	<p>Qualitative – Based on national/regional data.</p> <p>Quantitative – Some evidence, but incomplete or uncertain. Based on international data sources for quantitative methods/values, using data with acceptable data limitations. Recommended in guidance.</p>
Red	<p>Qualitative – Based on professional judgement.</p> <p>Quantitative – Speculative, major gaps in evidence. Based on international data sources for quantitative methods/values, using data with significant data limitations.</p>

This infographic summarises the results of this pilot’s ecosystem services valuation assessment. The infographic provides a holistic summary of the material impacts of ecosystem services in qualitative, quantitative and monetary terms. The circles in the infographic represent the RAG confidence rating (as explained above). Where applicable, error bars have been used to report ranges in values (carbon sequestration and avoided flood damages).

Monetary Assessment



Qualitative Assessment

Ecosystem Service	Anticipated Impact	Confidence Rating
Air filtration services	↑	Amber
Biomass provisioning services (including crop/grazed biomass/livestock/wood provisioning)	↓↓	Green
Global climate regulation services (e.g., carbon sequestration)	↑↑	Green
Soil and sediment retention services (e.g., landslide prevention) *	↑	Amber
Water purification services (e.g., water quality regulation)	↑	Amber
Water flow regulation (i.e. avoided flood damages)	↑↑	Green
Noise attenuation services	↑	Red
Pollination services	↑	Red
Nursery population and habitat maintenance services (e.g. Biodiversity)	↑↑	Green
Recreation-related services	↑	Red
Visual amenity services	↑	Red

Quantitative Assessment

Ecosystem service	Unit of measurement	Net change		
Biomass provisioning services	Wheat (tonnes/year)	-9,718.03		
	Dairy cow (litres/year)	-16,461,900		
	Beef (kg/year)	-492,779.14		
	Lowland sheep (kg/year)	-5,849.71		
	Upland sheep (kg/year)	-144		
Air filtration services	Pollutant capture (tonnes/year)	0.06		
Water purification services	Area of wetland (ha)	-0.16		
Global climate regulation services	tCO ₂ e/year (central value)	-9,121		
Biodiversity	Biodiversity Units	4,954		
Recreation-related services	Area of habitat	-		
Ecosystem service	Unit of measurement	1 in 2-year flood event	1 in 20-year flood event	1 in 100-year flood event
Water flow regulation	Reduction in flood volume (m ³)	104,327	172,371	233,819



Figure 13: Infographic summarising assessment

4. Conclusions and recommendations

4.1. Conclusions

The ecosystem services assessment evidences the improvements in the services derived from the Evenlode NFM interventions, which would have positive outcomes for railway users and operators/infrastructure managers, local landowners, and the local and wider communities.

Despite the significant loss of arable land within the boundary of analysis, it is important to note that this loss is only within the boundary of analysis (encompassing 8% of the total Evenlode catchment area) and does not represent a significant loss of arable land in the Evenlode catchment overall. The proposed NFM interventions in this pilot project are intended to create new habitats and enhance existing habitats to deliver ecosystem service benefits, namely flood risk reduction to the Cotswold Line and Network Rail assets. This study is an opportunity assessment of potential NFM interventions that could be implemented in the Evenlode catchment, and it is not the case that all interventions will be applied.

The qualitative assessment identified multiple benefits, including air filtration, soil quality regulation, water purification, noise attenuation, pollination, recreation-related services and visual amenity. Notably, significant benefits were identified for carbon sequestration and biodiversity (nursery population and habitat maintenance). However, the biomass provisioning service was identified to have anticipated significant disbenefits. Not all of these ecosystem services were taken forward for the quantitative and monetary assessments due to available evidence and the outcomes of the materiality assessment.

It was estimated that the pilot project would generate approximately £59 million in net benefit over 100-years based on the monetary valuation of seven ecosystem services. Carbon sequestration is the ecosystem service with the most significant net gain (£96.6 million PV), followed by recreation (£10.2 million PV, under the assumption all parcels are accessible for recreation through public footpaths), water purification (£8.4 million PV) and air filtration (£4 million PV). As anticipated, biomass provisioning showed losses (-£117 million PV). The biodiversity service results in a gain of £47.1 million through the created and enhanced habitats in the post-intervention scenario at the time of selling the credits. The proposed NFM interventions also demonstrate flood risk reduction within the catchment and to the rail line as intended (£10 million of avoided flood damages over 100 years). This value of avoided flood damages is relatively modest, largely due to the low passenger volumes on this section of railway, the brief assumed closure period and the limited scale of interventions assessed.

The main reason for designing the proposed NFM measures is to reduce flood risk within the Evenlode catchment and to the rail line by enhancing land adjacent to the rail line and across the catchment. The ECOV4R assessment of the proposed NFM interventions demonstrates £10 million in avoided flood damages to the rail line over the 100-year appraisal period. However, more substantial ecosystem service benefits are delivered by the carbon sequestration and biodiversity services. A more traditional flood risk mitigation scheme (e.g. concrete embankments) may deliver more flood risk benefits. However, this approach is likely to miss out on the benefits of the other ecosystem services assessed (carbon sequestration, biodiversity, air filtration, water purification and recreation). Thus, there is a choice for Network Rail to balance needs with benefits. It would also likely be beneficial to bring in other partners to work with, as the benefits are distributed across other stakeholders and beneficiaries in the catchment. This pilot is not a full-scale NFM scheme, but rather a proof of concept to demonstrate that NFM can be effectively implemented in this location to deliver resilience for rail assets while also generating wider environmental and societal benefits.

Overall, the ecosystem services assessment not only highlights the net environmental gains of the NFM measures across the wider Evenlode catchment, but also demonstrates how using nature-based solutions for flood risk reduction in the wider catchment landscape can contribute to increasing the resilience of the railway infrastructure. Integrating these results and the ECOV4R Framework into railway infrastructure planning provides evidence to help Network Rail identify the key areas or interventions they would like to invest in and to engage with local landowners to implement these interventions together. Integrating these results into a cost-benefit analysis or an EIA (once the detailed design of the project and interventions are confirmed) will be useful to provide an evidence base to support the business and investment case for nature-based solutions when compared to more traditional flood risk mitigation solutions.

4.2. Recommended actions

The following recommendations are presented in relation to the delivery of ecosystem services:

- The benefits of the ecosystem services assessed depend on the habitats becoming enhanced or created to target condition. This would require collaboration between Network Rail as the investors, and/or other potential investors, and the local landowners and land managers who would need to undertake the work to implement and maintain these target habitats.
- The pilot assessment has helped to identify the best locations for site interventions to maximise value and enables Network Rail to engage with local landowners to implement these interventions. More broadly, it demonstrates that the wider benefits to society, such as carbon sequestration and biodiversity enhancement, can potentially be as or even more valuable than the primary environmental objective of the nature-based solutions. This has important implications for decision-making, as conventional (grey) solutions to flood risk management would be unlikely to deliver these wider benefits but may have different costs and flood reduction impacts. It may also identify potential co-funding sources (e.g. biodiversity credits, carbon credits) that would enable the cost burden to be shared across multiple organisations, reducing costs for railway operators whilst still achieving the same objectives.
- The pilot highlights the importance of scale. NFM tends to deliver higher value in flood reduction benefits when applied across larger areas with coordinated uptake from multiple landowners. As many of the benefits extend beyond the railway itself, there is a clear opportunity to engage other partners and stakeholders in the catchment to maximise shared outcomes.

The following recommendations should be considered for future iterations of the ecosystem services assessment:

- The value of engaging with the railway operator when undertaking ecosystem services assessment is extremely valuable in sense-checking the approach to the ecosystem services assessment. This will be useful for internal company reporting or national government reporting requirements.
- These results can be used in cost-benefit analyses to compare the proposed NFM/nature-based solutions with alternative traditional hard-engineered flood risk mitigation (e.g. concrete embankments) if the ecosystem services assessment is undertaken again with the flood defences as an additional intervention scenario to assess and compare.
- At this stage of the project's lifecycle, this ecosystem services assessment fits into the 'optioneering' stage and contributes to 'opportunity identification'. Once specific interventions are confirmed and taken forward to the next stages of the project lifecycle, another ecosystem services assessment can be undertaken using more detailed option information (i.e. more granular land cover changes or additional environmental mitigation or enhancement measures). These results can also feed into the EIA when required and aid in the identification and potential quantification of positive and negative environmental impacts in the EIA.
- It is recommended that future iterations continue to incorporate the most up-to-date and robust ecosystem services assessment methodologies, acknowledging the dynamic nature of this field and the continual emergence of new approaches.



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Appendix A. Asset register methodology

The asset register was developed using QGIS. It combines open-source data and information provided by Network Rail to prepare the baseline and post-intervention habitat maps and asset register.

Key datasets used in the development of the asset register include:

- Land cover data sourced from the Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust (BBOWT) UK Habitat surveys from 2023
- The location and areas of planned NFM interventions provided by the North East Cotswold Farmer Cluster in collaboration with Network Rail
- Flood zone mapping sourced from the Environment Agency's Flood Map for Planning
- OpenStreetMap data layers used in the map figures
- Open-source satellite imagery and data on watercourse locations used to cross-check land cover and to supplement mapping

Once key datasets were obtained, the data was clipped to the boundary of the Evenlode catchment for context of the wider catchment and the areas surrounding the Cotswold Line. For the boundary of analysis, the land cover data was clipped to the parcels within the defined boundary of analysis. Once clipped, the asset register for the baseline and post-intervention scenarios were generated.



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Appendix B. Time to target conditions

Table 21 lists the years to the target condition of the enhanced and created habitats in the post-intervention scenario. For the calculation of present value benefits over the 100-year appraisal period for the air filtration services, global climate regulation services and recreation-related services, a stagger factor was applied to each habitat using its corresponding time to target condition. From year 0 (2028), zero benefits are claimed, then benefits are assumed to increase linearly until the time to target condition year from which full benefits are claimed.

Table 21: Time to target conditions for habitats enhanced and created for staggering present value benefits

Habitat	Condition	Time to target condition (years)
Floodplain wetland mosaic and CFGM	Good	20
Lowland calcareous grassland	Good	20
Lowland meadows	Good	15
Lowland mixed deciduous woodland	Good	30
Lowland mixed deciduous woodland	Moderate	30
Mixed scrub	Good	10
Other neutral grassland	Good	10
Ponds (priority habitat)	Good	5
Reedbeds and other wetlands	Good	5
Wet woodland	Moderate	15
Wet woodland	Fairly good	30
Lowland fens	Fairly good	25
Native hedgerow	Good	5
Native hedgerow	Moderate	5

Appendix C. Condition asset register

Following the recommendations to consider the condition of natural assets within the boundary of analysis, Table 22 and Table 23 provide a further breakdown into the baseline and post-intervention asset registers.

Table 22: Condition of baseline assets

Habitat	Condition	Area (ha)
Arable and horticulture	Condition N/A	1135.28
Floodplain wetland mosaic and coastal floodplain grazing marsh (CFGM)	Moderate	8.56
Floodplain wetland mosaic and coastal floodplain grazing marsh (CFGM)	Poor	5.7
Lowland heathland	Poor	5.42
Lowland calcareous grassland	Moderate	14.15
Lowland calcareous grassland	Poor	56.62
Lowland meadows	Good	2.53
Lowland mixed deciduous woodland	Good	80.50
Lowland mixed deciduous woodland	Moderate	26.83
Lowland mixed deciduous woodland	Poor	160.99
Mixed scrub	Poor	1.68
Modified grassland	Moderate	391.95
Modified grassland	Poor	1,567.80
Other neutral grassland	Good	89.05
Other neutral grassland	Moderate	178.12
Other neutral grassland	Poor	178.12
Ponds (priority habitat)	Poor	0.43
Reedbeds and other wetlands	Moderate	16.14
Wet woodland	Moderate	8.49
Wet woodland	Poor	19.82
Native hedgerow	Moderate	0.06

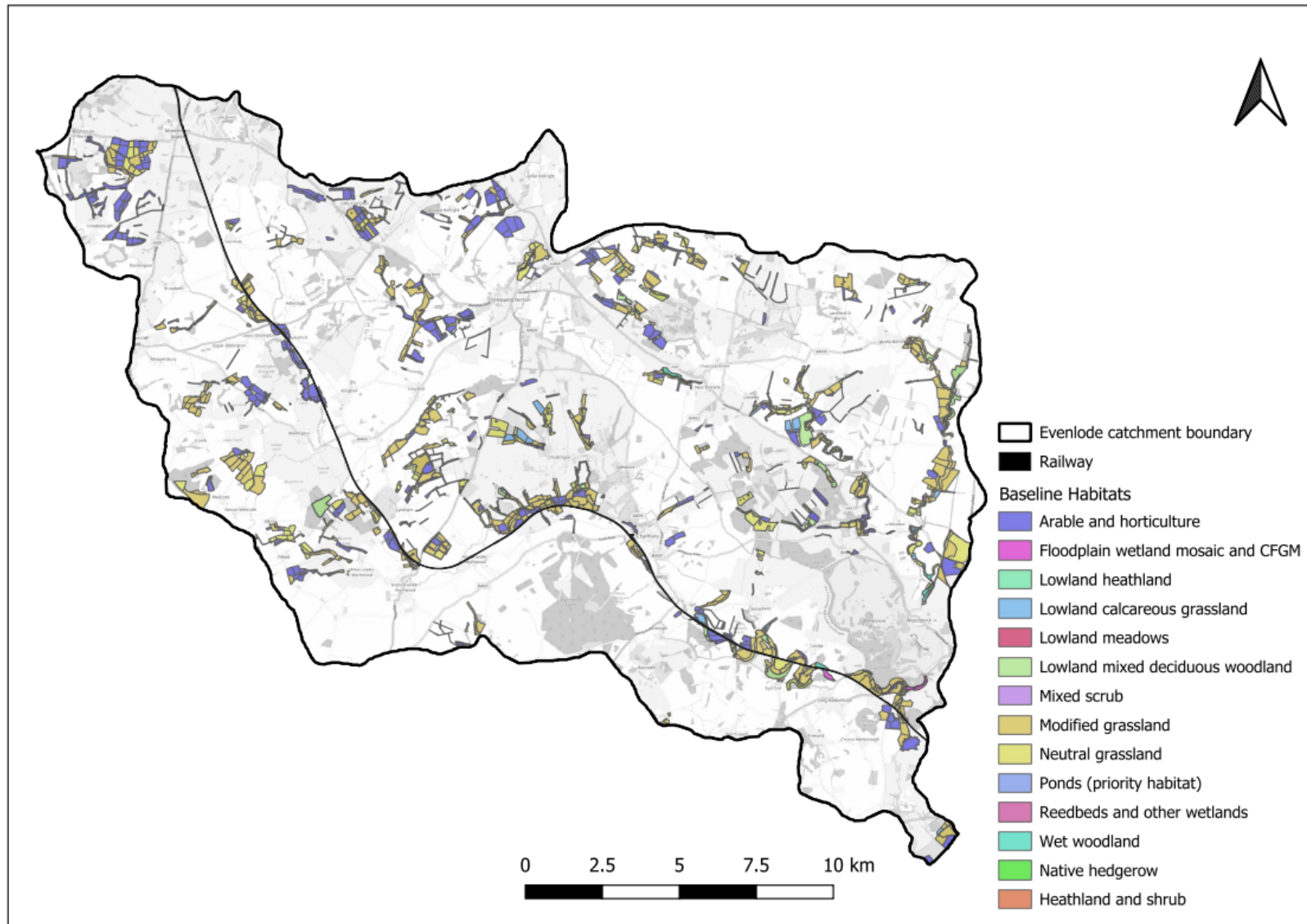
Table 23: Condition of post-intervention assets

Habitat	Condition	Area (ha)
Floodplain wetland mosaic and CFGM	Good	691.98
Lowland calcareous grassland	Good	564.86
Lowland meadows	Good	729.42
Lowland mixed deciduous woodland	Good	477.21
Lowland mixed deciduous woodland	Moderate	715.81
Mixed scrub	Good	140.19
Other neutral grassland	Good	429.83
Ponds (priority habitat)	Good	8.87
Reedbeds and other wetlands	Good	5.13
Wet woodland	Fairly good	49.19
Wet woodland	Moderate	114.77
Native hedgerow	Good	0.06
Native hedgerow	Moderate	10.04
Lowland fens	Fairly good	10.84

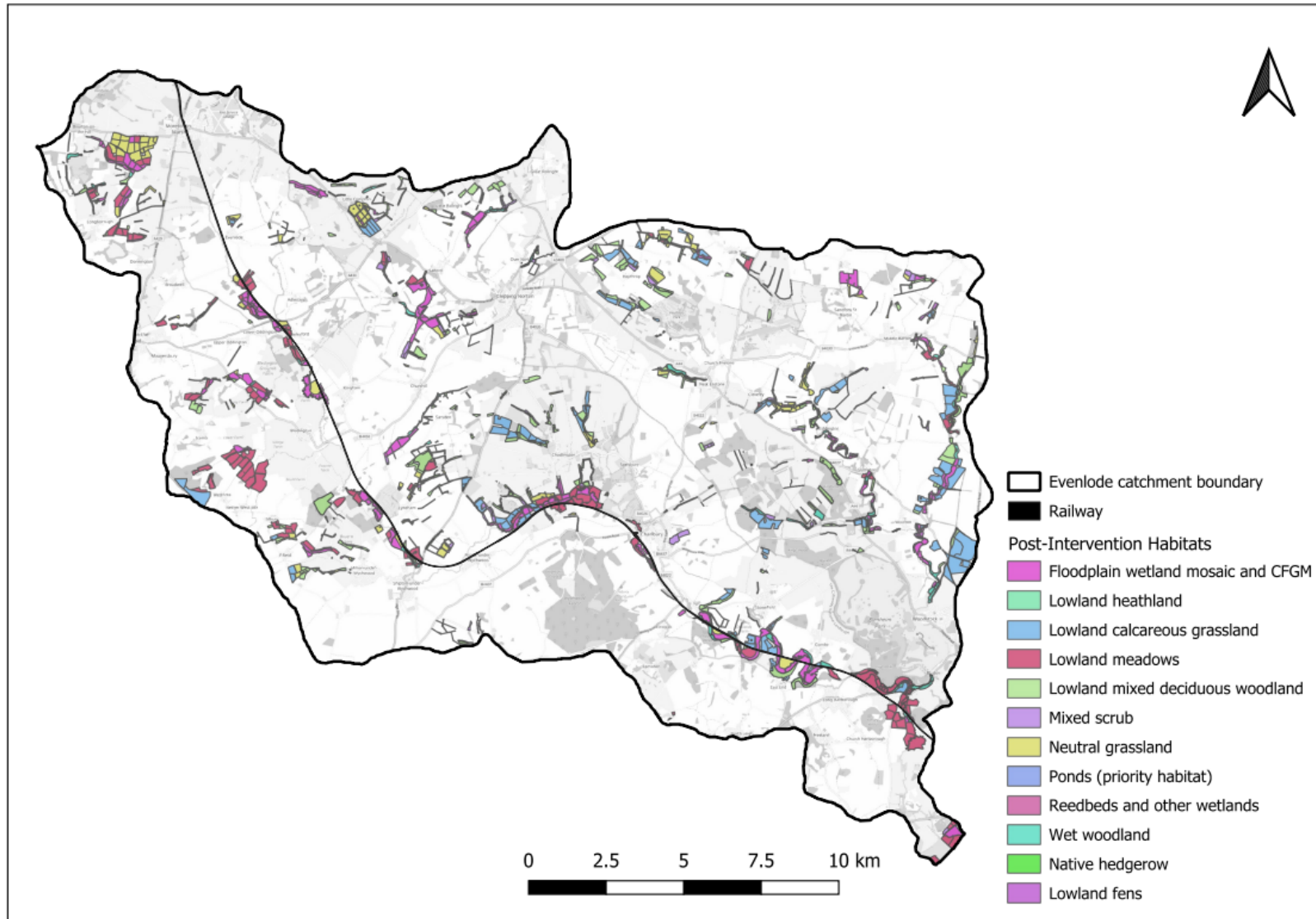


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Appendix D. Baseline map



Appendix E. Post-intervention map



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