Information on How to Deliver and Assess River Channel Re-Naturalisation for Nutrient Mitigation

Part 2 – Framework for River Channel Re-Naturalisation

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

This report was commissioned by Natural England to build knowledge and understanding on a range of nature-based solutions which potentially could be used to reduce nutrients. Ricardo was commissioned by Natural England to understand the mechanisms of nutrient removal for the different solutions, the factors which affect this and review the evidence on the scale of nutrient reductions that they could achieve. This report sets out a framework for the design, implementation, monitoring and maintenance and how (if it is possible) to determine any upfront scheme specific nutrient reduction for river channel re-naturalisation and floodplain reconnection schemes that will provide sufficient scientific certainty in the assessment of nutrient neutrality mitigation schemes.

Executive summary

The objective of this project is to provide support to Natural England (NE) employees and those of other relevant organisations (such as Competent Authorities) to enable them to make informed judgements on river channel re-naturalisation and floodplain reconnection proposals for nutrient mitigation. This report takes the form of a Framework, for the design, implementation, monitoring and maintenance and how to determine scheme specific nutrient reduction for river re-naturalisation schemes to achieve nutrient neutrality (NN). The project comprises three parts where:

- **Part 1** (the literature review) provides the evidence base on the effectiveness of four different NbS for nutrient mitigation including the methodology applied.
- **Part 2** (this document - The Framework) considers the design, implementation, monitoring and maintenance needs and how to determine a scheme specific nutrient reduction (where applicable). There are four framework documents, one for each of the four mitigation solutions considered in part 1.
- **Part 3** (the lookup tool – separate spreadsheet) comprises a user-friendly lookup tool with high-level practical information on a wider range of potential nutrient mitigation solutions.

This Framework specifically provides advice on achieving scientific certainty for river channel re-naturalisation to achieve NN. This Framework sets out how to determine a scheme specific nutrient efficiency reduction to determine the number of post-implementation nitrogen (N) credits which can be generated. The Framework follows the following structure to set out what information needs to be provided to evidence that the scheme is appropriate:

- Stage 1 – Design Objectives
- Stage 2 – Feasibility
- Stage 3 – Design Process
- Stage 4 – Implementation Process
- Stage 5 – Post-implementation Monitoring and Evaluation

As credits cannot be claimed upfront for N or P, this Framework outlines how to carry out baseline and post-implementation monitoring to claim credits once the scheme is functional.

Contents

1. Introduction

The overall objective of this project is to provide support to Natural England (NE) employees and those of other relevant organisations (such as Competent Authorities) to enable them to make informed judgements on Nature-based Solutions (NbS) proposals for nutrient mitigation. The overall project comprises 3 parts where:

- **Part 1** (the literature review – separate report) provides the evidence base on the effectiveness of four different NbS for nutrient mitigation;
- **Part 2** (this report known from now on as the **Framework**) considers the design, implementation, monitoring and maintenance needs and how to determine a scheme specific nutrient reduction. There are four framework documents one for each of the four mitigation solutions considered in **Part 1** (the literature review).
- **Part 3** (the lookup tool – separate excel tool) comprises a user-friendly lookup tool with high-level practical information on a wider range of potential nutrient mitigation solutions.

1.1. Framework objectives and aims

Key Aims:

Support NE staff to identify NbS for Nutrient Neutrality (NN) mitigation that are:

- Compliant with habitat regulations assessment (HRA) requirements and;
- Can achieve improvements to water quality, specifically through the reduction of nitrogen (N) and / or phosphorus (P) loading and;
- Have robust design, implementation, and monitoring and maintenance plans.

Part 2 (this document) provides the FRAMEWORK for river channel re-naturalisation and floodplain reconnection which is underpinned by evidence set out in **Part 1** and also feeds into **Part 3** (the lookup tool).

The mitigation measures in this project were determined in **Part 1** (the literature review – separate report) and comprise:

- River channel re-naturalisation and floodplain reconnection;
- Engineered logjams;
- Buffer strips; and
- Agroforestry

For each mitigation measure, there is a separate Framework document. This Framework document advises on the river channel re-naturalisation and floodplain reconnection NbS mitigation measure and what is required to achieve scientific certainty for NN. It does not consider whether it is possible and how to achieve practical certainty that the measures can be secured.

This Framework sets out how to determine a scheme specific nutrient efficacy reduction through a combination of baseline and post-implementation monitoring as not enough evidence was found in **Part 1** (the literature review) to determine precautionary efficacy estimates without monitoring. Stages 1 to 5 (explained in Figure 1:1) of the framework set out what information needs to be provided to evidence that the scheme is appropriate for the location and all factors in the design, implementation and maintenance of the scheme have been considered to ensure that there is confidence the scheme will achieve the required nutrient reductions. Checklists are provided at the end of each section to help the assessment of whether all the required information has been provided.

Although this framework focuses on river channel re-naturalisation and floodplain reconnection in the context of NN mitigation, there can be potential synergies between different mitigation solutions. Implementing a system of multiple NbS to achieve NN will provide greater nutrient reduction benefits through floodplain reconnection, reduced velocities, and increased contact time between nutrient rich flows and sediments to which they can bind. Capitalising on the synergies between NbS to achieve NN will allow for reduced nutrient loads from each scheme to be stacked together to achieve more nutrient credits than any one scheme would mitigate. The load reduction benefits of synergistic interactions between NbS would need to be addressed on a case-by-case basis for realistic credit generation. In addition, NbS have the potential to provide many wider benefits. These wider benefits are also considered as part of the feasibility process which may support other biodiversity and societal net gain ambitions as part of the planning process.

Part 3 (the lookup tool) when used in conjunction with this Framework enables assessment of appropriateness alongside a wider range of potential mitigation measures for a given scenario.

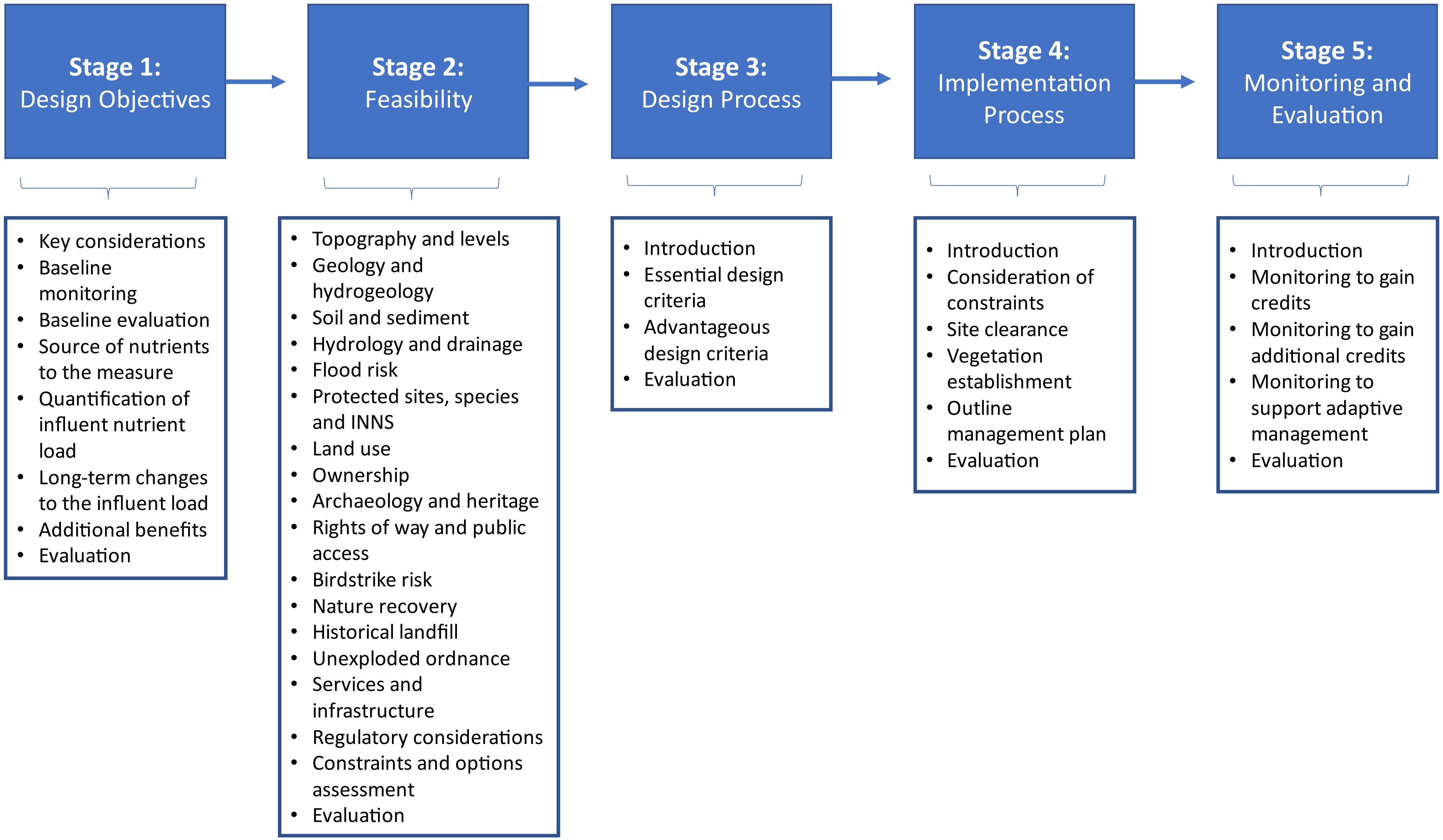

Figure 1:1 The outline structure for this framework*

*Note: the level of detail and key information categories may vary between mitigation options. A version of this figure for that can be used by screen-reading software has been included on the following page.

Stage 1: Design Objectives	Stage 2: Feasibility	Stage 3: Design Process	Stage 4: Implementation Process	Stage 5: Monitoring and Evaluation
- Key Considerations - Baseline monitoring - Baseline evaluation - Source of nutrients to measure - Quantification of influent nutrient load - Long-term changes to the influent load - Additional benefits - Evaluation	- Topography and levels - Geology and hydrogeology - Soil and sediment - Hydrology and drainage - Flood risk - Protected sites, species and INNS - Land use - Ownership - Archaeology and heritage - Rights of way and public access - Birdstrike risk - Nature recovery - Historical landfill - Unexploded ordnance - Services and infrastructure - Regulatory considerations - Constraints and options assessment - Evaluation	- Introduction - Essential design criteria - Advantageous design criteria - Evaluation	- Introduction - Consideration of constraints - Site clearance - Vegetation establishment - Outline management plan - Evaluation	- Introduction - Monitoring to gain credits - Monitoring to gain additional credits - Monitoring to support adaptive management - Evaluation

1.2. Limitations to this framework

This Framework focusses on the key considerations required for a NbS proposal to achieve suitable mitigation solutions. There are, however, limitations to its use as outlined below.

This framework relies on expert judgement related to mitigation applicability: Certainty of the efficacy of a solution beyond reasonable scientific doubt is essential even though absolute certainty is not required for a solution to be deemed suitable. Therefore, judgement over the efficacy needs to be based on a combination of the level of confidence in the data, the design, and the consistent use of precautionary input values. Judgement on a site-specific basis will be required since only a generic overview of the requirements for each mitigation scheme is provided in this Framework.

Uncertainty in quantity of nutrient mitigation for a given solution: This applies to solutions whereby percentage removal efficiencies cannot be applied to estimate nutrient load reductions before implementation. Some mitigation measures, such as river channel re-naturalisation and floodplain reconnection, need to be deployed and monitored since predictions cannot be made in advance regarding the quantity of nutrient pollution reduction they will achieve. This limits their applicability as nutrient credits will only be provided once sufficient baseline and post-implementation monitoring has taken place.

Prescriptive monitoring: Given the uncertainties highlighted above, and potential variation of geological conditions and locations, any monitoring will need to be bespoke (based around specific criteria) and dependent on incoming nutrient loads. This Framework, therefore, emphasises the importance of showing the principles of a robust approach, without limiting the options of the provider.

Detailed engineering design: This Framework is limited to the use of river channel re-naturalisation and floodplain reconnection for nutrient mitigation and considering at a high level the key design, implementation, monitoring and maintenance requirements of any scheme to ensure there is confidence any scheme will provide the proposed efficacy reduction relative to baseline environmental conditions. This Framework is not intended to provide detailed engineering advice on how to implement a NbS. This will need to be sought separately although this guidance provides the list of expected outputs.

2. Determining scheme specific efficacy

This section sets out how to determine a scheme specific efficacy using the results of baseline and post-implementation monitoring and undertaking a confidence assessment looking at key design criteria and the calculation of the baseline load.

2.1. Maximum efficacy reductions

A review of studies was conducted on the efficacy re-naturalisation schemes within **Part 1** (the literature review). Owing to the lack of data on N and P removal efficacy and the short-term nature of the P removal processes regarding re-naturalisation, outlined in **Part 1** (the literature review), no value has been provided for total phosphorus (TP) or total nitrogen (TN). Baseline and post-implementation monitoring is therefore required (to calculate the credits available on a scheme-specific basis) to evidence the N and / or P removal capacity of a scheme to gain any credits.

2.2. Calculating the baseline load

A good baseline of key environmental variables is needed to robustly calculate the baseline load. This is especially important related to NN, in the context of demonstrating beyond reasonable scientific doubt that the reductions will be achieved in perpetuity in line with the Habitats Regulations requirements. Without a robust baseline it will be difficult to demonstrate the benefits that a scheme provides.

Three variables need careful consideration when calculating the scheme baseline nutrient loading as indicated in Figure 2:1. With a strong understanding of these and robust baseline monitoring, the baseline nutrient load can be calculated.

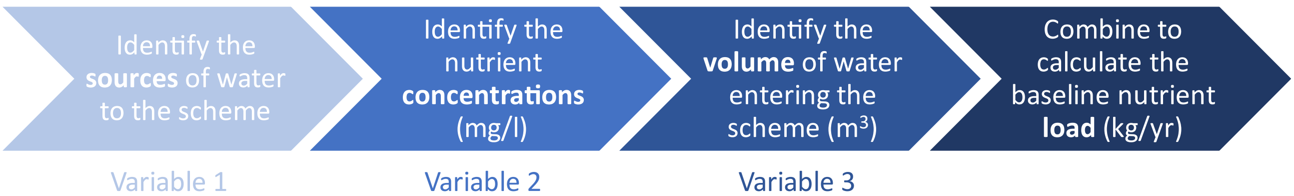

Figure 2:1 Key variables requiring consideration to when defining appropriate design objectives

To fully understand the three variables outlined above, a robust baseline assessment method is required. Baseline assessment characterises the nutrient load within the receiving environment prior to implementation of the river channel re-naturalisation scheme. This provides the loading value which the results of post-implementation monitoring can be compared to, to demonstrate credit generation. This can be done via scheme specific monitoring or using secondary datasets[1] (i.e. data that has been collected for another purpose) (see more detail in section 3.2.2). The means by which nutrient loads are characterised and the confidence the approach will have will differ between each scheme, however the broad requirements are uniform. These are as follows for generating credits:

- Quantification of the water quality and quantity that will enter the mitigation scheme. This must account for groundwater, subsurface and surface flow pathways, where required.
- *If undertaking scheme specific monitoring:* Review of evidence in **Part 1** (the literature review) indicates that a minimum of a year's baseline monitoring is necessary to confidently quantify credits that can be gained from the mitigation scheme to provide a strong understanding of nutrient cycling in the system. The length of the dataset needs to be long and frequent enough to cover the full range of likely flow and water quality conditions, which could vary spatially and temporally. The programme should aim to capture nutrient loads in the receiving environment following different magnitude rainfall / flow events. This may require a reactive sampling programme. The monitoring must account for the time lag between events that mobilise nutrients and the point at which they can be monitored in flows. The location(s) of the sampling point(s) needs to be representative of what will enter the mitigation scheme and therefore needs to be upstream and ideally close to the scheme or at least where there will be no significant additional inputs (flow or concentration) before the scheme. Whether one or multiple locations need to be monitored will depend on the type of scheme and the likely spatial variability of the flows / concentrations into the scheme. To calculate the baseline load, take a mean of the values of the flow and concentration to estimate the load of nutrients in kg / year. This approach is the minimum required.
- *If using secondary datasets (i.e. monitoring data that was collected for another purpose):* If a robust dataset already exists that can be used to quantify the baseline nutrient load entering a mitigation scheme based on the requirements detailed above, this can be used. Where secondary datasets are used, they should meet the same requirements as set out above for scheme specific monitoring on the length and frequency of the dataset, range of flow conditions and location of sampling. The use of secondary datasets will require justification to ensure that is it robust and adequately representative for determining the load into the mitigation scheme as well as documentation that details the sampling methodology, location, frequency, and duration of the sampling programme. The baseline load should be calculated in the same way as set out above for scheme specific monitoring.

[1] Whilst it is recognised that modelling to predict to flow rates and nutrient concentrations is possible, this would require a complex set of linked modelling approaches that account for sediment transportation and deposition modelling, amongst other variables, which is costly, time consuming, and requires extensive primary data.

Further details on baseline monitoring requirements can be found in section 3.2.2.

2.3. Confidence assessment

A specific scheme load reduction can only be determined through robust baseline and post-implementation monitoring for river channel re-naturalisation schemes. The confidence in the load reduction calculated is dependent on the scheme being designed robustly and the baseline load being accurate. Overestimation of the baseline load will lead to an overestimation of the likely load reduction the scheme will achieve. Table 2:1 enables a confidence assessment to be undertaken on each of the key elements which will determine whether or not the baseline load has been robustly calculated. If it has been, there will be confidence in the baseline load used to calculate the nutrient reduction post implementation.

Whilst filling out this table it should be noted that:

- The result (high, medium, or low) of each question's answer will help to determine whether or not credits can be claimed post-implementation.
- Based on the criteria specified for each question, the relevant boxes should be ticked.

The key questions need to be considered at the scheme idea stage to provide upfront clarity of the requirements and to encourage consideration at an early stage of the best practices.

The requirements in Section 3.4.2 must also be considered to enable a confidence assessment of the scheme's design. The result of each question will impact the overall confidence rating of the scheme as the results inform the answers to Table 2:1.

Table 2:1 Confidence assessment

	High	Medium	Low
Have you accounted for all sources of water / nutrients in your monitoring approach to calculating baseline loads?	Yes, all sources – river, groundwater, surface water, rainfall, point sources, etc. No – but the way it is considered is more precautionary in the context it is used	Most of the sources considered – those not considered are likely to be minor.	Only some sources considered and not considered some which could be significant source OR don't know as insufficient information has been presented.
Has the baseline load entering the scheme been accurately determined?	Yes – Any flow bypassing the scheme has been removed. The location of any monitoring points are representative of the flow and concentration entering the scheme.	The vast majority of load has been accounted for. Any flow bypassing the scheme has been removed. The location of any monitoring points means that any load inputs that are missed are minor.	No there is significant uncertainty in how it has been determined including: No consideration as to whether any flow bypasses the scheme OR If using monitoring data, there are additional significant load inputs that have not taken into account due to the location of monitoring points.
Does the baseline load calculation take account of the temporal	There is a robust estimate of temporal variability both seasonally and annually.	Not all temporal variability is accounted for, however evidence is provided that the methodology takes account of the majority of	There has been no consideration of seasonal or annual variability in flow or concentration.

	High	Medium	Low
variability including seasonality?	Monitoring data is for over a year, at a frequency which captures seasonality and different magnitude rainfall / flow events.	the seasonal and annual variability and takes into account the worst-case situations[2].	
Have you taken account of any known anticipated future long term changes in baseline load e.g. due to climate change or existing planned development/activities?	Yes – everything relevant considered and the assessment has been undertaken in a robust way applying precautionary assumptions.	N/A	There has been no consideration of known anticipated future long-term changes OR precautionary assumptions have not been used.
Are the appropriate forms of N and / or P considered[3]?	Yes OR	N/A	No and the form considered is less precautionary in the context it is used.

[2] In this context, worst-case refers to scenarios where the conditions support low nutrient removal compared to the year-round average. It is not acceptable to look only at the data showing the best-case scenario for nutrient credit generation.

[3] To claim the percentage removal efficiency for N, TN should be monitored. To claim P credits as a result of post-implementation monitoring, TP should be monitored to account for all forms of P in the system.

	High	Medium	Low
	No – but the form considered is more precautionary in the context it is used.		
Is the baseline assessment method appropriate to the scheme type?	Yes – monitoring carried out in line with the requirements in Section 3.2.2.	N/A	No – approach used is unjustified with insufficient information. For example, an unjustified modelling approach is used, or monitoring does not meet the requirements of Section 3.2.2.
Have the key design criteria been met in Table 3:2?	Yes – all minimum design criteria have been met.	N/A	No – not all of the minimum design criteria have been met
Is there is robust maintenance plan?	Yes, there is a detailed maintenance plan covering all maintenance requirements for the lifetime of the scheme.	N/A	No – schemes should not be agreed without detailed maintenance plans.

After answering all questions in Table 2:1, the following criteria must be considered to enable a confidence assessment of the scheme:

- If **any** answer low, the scheme design and baseline monitoring method are not robust enough to be able to generate any credits through post-implementation monitoring
- If **all** answers medium and high, the scheme design and baseline monitoring method are robust enough to endeavour to claim credits through post-implementation monitoring

Considering how any scheme will deliver against the confidence assessment throughout its development and particularly at the start, will ensure it can be designed in a way to maximise or optimise the credits that may be generated post implementation versus the costs and taking account of any constraints.

It should be noted that once credits can be claimed via post implementation monitoring, adaptive monitoring will still be required to inform any maintenance to ensure that the scheme continues providing nutrient mitigation in perpetuity (or if using as a temporary measure for as long as the scheme is required). Adaptive management monitoring should focus on scheme function.

2.4. Calculating scheme specific load reductions

Owing to the lack of data collected in **Part 1** (the literature review), river channel re-naturalisation schemes cannot claim any credits upfront. As such, in order to calculate scheme specific load reductions, baseline and post-implementation monitoring must be carried out as per the guidance in Section 2.2 and Section 3.6.2.

3. Framework for river channel re-naturalisation and floodplain reconnection

3.1. Key considerations

River channel re-naturalisation and floodplain reconnection (stated from now on as re-naturalisation) related to nutrient mitigation effectiveness is highly dependent upon a range of local environmental conditions and mitigation spatial scale. This mitigation encompasses a large range of techniques as outlined in **Part 1** (the literature review). Overall, however, for NN the mitigation needs to result in ground and surface water mitigation. Encouraging natural floodplain and / or in-channel process and connectivity is required to increase flow velocity variability that ultimately can encourage nutrient exchange. Furthermore, if delivered in conjunction with marginal and in-channel vegetation opportunities, the resultant organic matter (a source of carbon) which is often a limiting factor in preventing denitrification within soils can further help to promote nutrient cycling.

Key Headline Messages:

- Re-naturalisation to achieve NN may not be suitable for deployment in all locations.
- There are key considerations that can help identify where a proposal may not be viable and/or needs more investigation to increase confidence of success noting that evidence is required to demonstrate a favourable NN outcome.
- If sufficient evidence related to the point above is not provided, further information will need to be requested and reviewed.

A checklist for these points is provided below.

Mitigation schemes may not be suitable for deployment in all locations within a given catchment and there are certain key considerations that might indicate proposed options are not viable. A summary of the key upfront considerations that should be considered in the first stages of planning for re-naturalisation schemes is provided in the checklist below.

Table 3:1 Key considerations checklist

Key considerations	Evidence to be provided	Evidence provided (Y/N)
The Local Planning Authority has confirmed that it is	A nutrient mitigation scheme needs to have practical certainty that can be secured and will provide the mitigation for	

Key considerations	Evidence to be provided	Evidence provided (Y/N)
possible to secure the mitigation.	the lifetime of the development or if being used as a temporary measure for the length of time that the mitigation is required. It may not be possible in all cases to adequately secure that the mitigation will continue to provide the reduction for the required length of time. Mitigation proposals should demonstrate engagement with the Local Planning Authority to ensure schemes can be sufficiently secured and there is certainty that they will provide the required reductions for the length of time the mitigation is required.	
That the proposed re-naturalisation will not have an adverse impact on or hinder restoration of any protected site, or species or negatively affect existing habitats, or the ability to achieve other environmental objectives due to associated morphological change.	An evidence statement will be required. If adverse impacts are identified, the scheme will need to be reviewed / changed noting that all re-naturalisation schemes will be subject to ecological survey prior to implementation.	
There is sufficient hyporheic exchange[4] present in the water course to support nutrient removal processes.	The proposal will need to clearly show that hyporheic zone availability noting zone thickness affects ability to support NN and is dependent on geology, soils, and hydrogeology (e.g. clay-bed water	

[4] The rapid exchange beneath streams where constant mixing occurs between shallow groundwater and stream water. Water, dissolved gases, solutes, contaminants, and microorganisms are exchanged. This can support nutrient removal processes.

Key considerations	Evidence to be provided	Evidence provided (Y/N)
	courses generally have limited hyporheic zones).	
There are no land constraints.	Key examples include landowner agreement to alter current planform of a water course, connection to the floodplain, and proximity to infrastructure.	
There is sufficient and robust baseline data to calculate the baseline load.	Account for what data exists. Where insufficient, further data collection may be required prior to implementing a project. This may delay development.	
The Local Planning Authority has been engaged to ensure the mitigation will serve developments impacted by NN.	Nutrient mitigation schemes must remove at least the equivalent quantity of nutrients than what will be added by new development before impact on a Habitats site waterbody takes effect. The mitigation measure will need to be upstream of the location where the development site run off and wastewater input will have its effect on the Habitats site. This means if the wastewater / run off is direct to (i.e. within) the Habitats site boundary the measures will need to be upstream of this location. If the discharge is indirect (i.e. upstream in the catchment of the Habitat site), then the mitigation measures can be up or downstream within the catchment, as long as it will provide the offsetting before the point at which the development impacts the Habitat site. Mitigation proposals should demonstrate engagement with the Local Planning Authority to ensure schemes will provide sufficient NN.	

Key considerations	Evidence to be provided	Evidence provided (Y/N)
There are no insurmountable reasons why any required permissions or consents would not be granted.	Proposal should show that the relevant competent authorities (e.g. Environment Agency) have been consulted from an early stage to ensure there are no evident or insurmountable concerns early on. This approach can also mitigate any potential risks regarding consents and permissions.	

3.2. Stage 1 – Design Objectives

3.2.1. Introduction

Re-naturalisation aims to reinstate natural processes to anthropogenically modified rivers and floodplains to allow for the formation of more natural forms and habitats. Re-naturalisation is normally achieved via planform change and increasing lateral connectivity. This helps to increase the regularity of lateral inundation where possible, and allows aquatic vegetation to recolonise naturally, whilst encouraging the return to a more natural, heterogeneous state to support ecological regeneration.

To provide confidence that a re-naturalisation scheme will deliver the allocated levels of nutrient removal, clearly defined objectives are required and must be set early in the process. For example, a primary objective may be related to N, P or indeed both pollutants with secondary objectives / ambitions related to a combination of hazard risk reduction (e.g. flood and drought), ecological (e.g., habitats for fish, aquatic inverts, mammals etc), and societal benefits (well-being etc).

Key Headline Messages:

Defining appropriate objectives to support NN requires initial understanding key factors including:

- Knowledge of the sources of water entering the scheme;
- Knowledge of the concentration of nutrients in the inflowing water;
- The overall quantity of water flowing into the mitigation scheme;
- Predicting how concentrations and flows might fluctuate over time; and
- The level of confidence there is in the understanding of these factors.

For the design objectives to be robust enough to meet the Habitat Regulations requirements, sufficient evidence and information needs to be provided for each of the above.

The following sections 3.2.2 - 3.2.7 need to be evaluated in this context.

3.2.2. Has a robust baseline monitoring method been employed to inform scheme efficacy?[5]

Key questions

- **Why is baseline monitoring required?** To fully understand the three variables outlined in figure 2:1, a robust baseline monitoring method is required to enable comparison against post-implementation monitoring results to gain credits. Choice

[5] This is essential to be able to establish potential nutrient credits gained from the NbS mitigation proposal as monitoring needs to be appropriate for the scale of mitigation and site-specific depending on the physical characteristics of the river and the floodplain activity. It is also important to understand the river's hydrogeology, particularly the extent to which it is groundwater fed. This affects the degree to which flow conditions and concentrations vary within the channel. This must be understood as it affects the quantity of monitoring that will be required to characterise the nutrient loads. For example, chalk streams which are groundwater fed are likely to have less variation in nutrient concentrations and flows.

of parameters should be clearly stated for identifying N and / or P loads. This can be done via physical monitoring or using secondary datasets.

- **What is baseline monitoring?** Baseline monitoring characterises the nutrient load within the receiving environment prior to implementation. Understanding nutrient concentrations and flow rates upstream of the river reach where the re-naturalisation is being deployed together with morphological (cross and planform) and sediment movement is essential as a minimum[6]. Implementation of continuous nutrient sensors (if available) used in conjunction with calibrated level sensors to provide ongoing monitoring of concentrations and discharge with minimal fieldwork requirements could be considered. The monitoring must account for the time lag between events that mobilise nutrients and the point at which they can be monitored in flows.
- Baseline monitoring also needs to incorporate an understanding of nutrient concentrations and flow rates downstream of the river reach where the re-naturalisation is being deployed.
- **How long is baseline monitoring required for?** Baseline monitoring should be conducted for at least year with a minimum of monthly sampling to characterise nutrient loads under all seasonal conditions which affect nutrient cycling within the environment. In addition, because the source of nutrients is mainly driven by rainfall, monitoring should also capture nutrient loads in the receiving environment following different magnitude rainfall / river flow events and different time periods / seasons to take account of any application of nutrients to agricultural land. This will require the monitoring approach to have a degree of reactiveness to accurately understand the effect of different flow conditions and impacts on nutrient transport.
- **Where should baseline monitoring take place?** The aim of baseline monitoring is to robustly characterise the nutrient dynamics within the system. To successfully do this, the locations at which upstream and downstream measurements should take place need to be identified on a project-specific basis. There are, however, guidelines which must be followed. The upstream monitoring point must be upstream of the specified reach but downstream of any features which are likely to impact nutrient loads, such as point sources of pollution and confluences of tributaries. Similarly, the downstream monitoring point must be downstream of the reach identified for re-naturalisation, but upstream of features likely to impact nutrient loads[7]. Based on these requirements, it is up to the individual to identify the best locations for monitoring to characterise the nutrient removal potential of the scheme.

[6] Fixed point photography at strategic location should be provided as a minimum to identify morphological and habitat changes. The use of Morph surveys is also highly recommended.

[7] Implementation of level sensors and / or continuous N sensors could be considered to provide a better long-term understanding of the flow, discharge, and concentrations.

- **Can secondary data be used for baseline monitoring?** It is recommended that open-source information is used first to establish if sufficient information is available. If field data already exists, a baseline dataset covering as long as possible and as big a range of rainfall / river flow conditions as possible can be considered. The locations of the monitoring points must still conform to the above requirements outlined for baseline monitoring. Secondary datasets will require documentation that details the sampling methodology, location, frequency, and duration of the sampling programme to determine if any supplementary monitoring is needed. The overarching requirements determining the suitability of a secondary dataset are the same as the requirements outlined for baseline monitoring (e.g. length of sampling, locations, etc.).
- **Have suitably precautionary values from the data been used?** The collected data must be considered wholistically, with specific reference to the most precautionary scenarios which have been characterised. It is not acceptable to look only at the data showing the best-case scenario for nutrient credit generation.
- **What should happen to the monitoring data?** This should be decided and agreed at the beginning of the monitoring programme including approaches to assess data. It is likely to be of interest to LPAs, NE and other third-party stakeholders (e.g. local catchment groups and academics). Building a supporting open-source database including the efficacy rates will be highly beneficial for future programmes.

Key information required

- A baseline monitoring plan detailing monitoring methods, sampling locations, monitoring frequency and the duration of the monitoring programme. This may take the form of documentation supporting an existing monitoring programme using for example, the River Restoration Centre Monitoring Planner[8].
- Clear methodology explaining how the assessments have been completed. The method must provide confidence of assessment and demonstrate it has considered the hydrogeology especially in the context of ground water versus surface water catchments. Refer to open-source information first and present this with justification of the sources used. Additional field work required only when uncertainty is deemed unacceptably high.
- **Optional:** A plan detailing how data from baseline monitoring will be made available to stakeholders.
- **If using secondary data:** An evaluation evidencing that the chosen dataset is sufficiently appropriate

[8] See: Monitoring Planner | The RRC

3.2.3. Has the source of nutrients to the measure been clearly defined?

Key questions

- **Do you have a strong understanding of the number of sources of water to the water course?** Water within the channel of a river can come from a variety of sources (e.g. channel flow, groundwater, springs, agricultural runoff, and treated effluent from wastewater treatment works etc.). To robustly estimate the load of nutrients into a scheme, all sources of water, and subsequently nutrients, must be characterised and understood. This will help understand the likely spatial and temporal variation and therefore where monitoring should take place and what temporal resolution of monitoring may be appropriate.
- **Do you have a clear picture of where the nutrients will be entering the water course?** This is important to understand as it will directly determine potential project location and success (e.g. upstream or within the middle of a re-naturalised reach).
- **What is the concentration of nutrients in the river?** The concentration of nutrients in river flows will influence the location of the proposed scheme but may not greatly impact the design. Nutrient removal processes generally operate better at higher concentrations. There is likely to be a minimum concentration whereby re-naturalisation will not provide any nutrient reduction benefit, however this is highly dependent upon the scheme's design and location, therefore it is recommended that this is considered on a site-specific basis.
- **Has a detailed condition assessment of the receiving waterbody been completed?** In general terms, demonstrating consideration of areas that are not in good status and ideally poor status is likely to provide an opportunity for greatest mitigation. Assessment should also look at waterbodies upstream of a proposed mitigation scheme to establish any level of nutrient input that may be associated with these areas that will affect the baseline.

Key information required

- Maps showing nutrient point sources and where they are / will be entering the water course.
- Detailed condition assessment of water course related to the proposed mitigation.

3.2.4. Has allowance been made for long-term changes to the influent nutrient load?

Key questions

- **Has climate change impact been considered in terms of the potential impacts on influent nutrient loads?** This could have a future impact on the efficiency of a re-naturalisation scheme for achieving mitigating nutrient pollution in the future. At this stage it is recommended that key open-source data is reviewed to ascertain long term local predicted trends[9].

- **Have planned improvements been considered in terms of the potential impacts on influent nutrient loads?** Already planned improvements at a WwTW for example, could have a future impact on the efficiency of a re-naturalisation scheme at mitigating nutrient pollution due to decreased loading into the scheme. A HRA would only require an allowance for changes that are known at the time of the assessment, therefore all improvements that have been secured at this stage need to be considered.
- **Are there any known site-specific land use changes that may affect long-term nutrient impacts?** An evidence log is required to understand if any currently planned changes will result in either increasing or decreasing loads.
- **How should long-term changes in influent nutrient loads be acknowledged?** Mitigation proposals will need to incorporate known long-term increases or decreases in influent nutrient loads e.g. due to climate change or already planned land use change, and the impact this might have on the amount of nutrient mitigation a scheme will deliver in perpetuity.

Key information required

- Summary statement outlining all planned improvements within the catchment, with reference to likely impacts.
- Account for climate change that is evidenced.
- Statement of any known land use changes and potential effect (positive and negative).

3.2.5. How are credits calculated?

Key questions

- **When can credits be calculated?** Credits can be calculated after a minimum of a year of baseline monitoring to account for all seasonal variability and monitoring for a minimum of three years post-implementation, or once a quasi-equilibrium i.e. stable reduction can be evidenced.
- **How is the generation of credits calculated?** To calculate the quantity of credits that can be claimed by the mitigation scheme, a nutrient concentration and river flow trend analysis is recommended to provide a strong understanding of nutrient cycling in the system where the trend analysis will need to take account of time lags between nutrient mobilisation and the point at which the nutrients can be monitored

[9] To account for climate change, see: Product Selection - UKCP (metoffice.gov.uk). Search for the relevant area to determine the environmental impact of climate change on rainfall, and therefore influent nutrient concentrations. Use this to support research.

within the channel. To achieve this will require monitoring of a range of flow / concentration conditions with the aim of characterising nutrient trends.

The N and / or P scheme specific removal efficacy can be calculated using the trend analysis process set out in Section 2.4. This explains that the nutrient concentration and river flow trend analyses must compare the influent and effluent loads to understand the downstream load reduction because of the scheme.

Key information required

- Evidence of a sound methodology including the calculations and justifications for the method used.
- The load of TN and / or TP in kg / year which can be mitigated against by the scheme.

3.2.6. What additional benefits can be delivered through the design objectives?[10]

Key questions

- **Have wider benefits to the environment and society been considered?** River channel re-naturalisation can provide benefits over and above water quality (e.g. habitat resilience under flood and drought conditions for a range of species, enhance human health and wellbeing, recreation, air quality, carbon sequestration and local economic benefits etc). Outside of the scope of NN, these benefits are often simplistically restricted to a small subset of values such as biodiversity net gain, natural flood management and carbon sequestration. Every scheme provides the opportunity for wider benefits via the encouragement of ecosystem services.
- **Have wider benefits been considered in the context of biodiversity net gain, natural and societal capital?** Whilst mitigation should firstly focus on NN benefits and meeting the needs of the Habitat Regulations, understanding how any mitigation can support wider development requirements to support regulatory biodiversity net gain (BNG) and associated Natural Capital parameter is valuable. This understanding will help to establish how different ways of packaging multiple ecosystem goods and services can incentivise conservation-based funding support for the proposed mitigation (i.e. support stacking and bundling concepts) and avoid undervaluing nature.

[10] Whilst wider benefits assessment is out of the direct scope of NN it is highly recommended that this assessment is included since planning does require assessment of biodiversity net gain and wider net zero opportunities (e.g. carbon sequestration) whilst opportunities for natural flood and drought management and resilience can support local ambitions.

Key information required

- Consideration should be given to the potential for re-naturalisation schemes to provide wider benefits to the local, and wider, community such as amenity value, pollination, job creation, food supply, local climate regulation and timber production.
- An ecosystem services assessment of the available wider benefits can be carried out to support the proposal. This should seek to link the benefits to the beneficiaries, focussing predominantly on wider values at this stage. A simple assessment based on a high-level RAG assessment would be acceptable at this stage.

3.2.7. Evaluation of design objectives

For the design objectives to be robust enough to meet the requirements of the Habitat Regulations, the key evidence and information required must be provided for each of the categories in Stage 1 – Design Objectives. If any information is missing or the information provided is not commensurate with the obligations of the Habitat Regulations, the objectives must be re-considered to meet the mandatory criterion for NN mitigation.

The series of questions within the confidence assessment outline the stages required to be able to evidence that the design objectives and baseline monitoring method for a re-naturalisation scheme are robust (Section 2.3). Table 2:1 and Table 3:2 should be completed to provide verification that likely nutrient loads entering the re-naturalised channel have been robustly estimated. As there are no efficacy values for river channel re-naturalisation schemes, the design must at least meet the minimum requirements of these tables.

To establish the strength of the design, the tables below can be used in conjunction with Table 2:1 and Table 3:2. Some cells have been left blank.

Report Section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.2.2	Baseline monitoring method		
3.2.3	Source of nutrients to the measure		
3.2.4	Allowance for long-term changes		
3.2.5	Credit calculation		

Report Section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.2.6	Additional benefits		

	Response statements
If ALL green (noting that 3.2.6 is optional)	This is a well-structured feasibility assessment that maximises the likelihood that this re-naturalisation scheme will be a sustainable natural asset within this catchment.
If SOME red	The application is missing mandatory feasibility information, as shown by the rows populating the red column. Please provide this information so that the feasibility assessment can be evaluated.

3.3. Stage 2 – Feasibility

3.3.1. Introduction

Before a re-naturalisation scheme is designed, a proposal should consider the feasibility of the scheme. The sub-sections below detail the key factors that will impact of the feasibility of a proposed solution. For most of these factors, there will be options to mitigate potential constraints on feasibility. To claim the suggested percentage removal efficiencies, a re-naturalisation proposal will need to show how constraints on feasibility have been mitigated. There are some circumstances where evidence to show feasibility is not required but is strongly recommended. These areas are highlighted in the text alongside areas where optional information should be incorporated where possible. Including optional information to support scheme feasibility will help to reduce the risk of unforeseen problems in delivering the scheme.

3.3.2. Topography and levels

Key questions

- **Will the nutrient rich water flow towards the proposed re-naturalised reach?** The topography of the site needs to be understood prior to implementing a re-naturalisation scheme. Consideration needs to be given to the topography surrounding the source of nutrient to ensure nutrient rich water will flow towards the restored reach, ideally under gravity[11].

- **Has local topography been looked at in terms of the floodplain area which is targeted for increased floodplain connectivity?** To achieve optimum success, a floodplain reconnection scheme will need to be carefully designed and dependent on a range of criteria.
- **Is there an understanding of what would constitute a natural channel (depth, width, planform and location)?** Ideally this would require a topographic survey but at this stage of feasibility, it could comprise a walk over survey and the use of LiDAR and other open-source topographic data and old map information to establish the lowest part of the floodplain and the location of any paleochannels[12].

  Note: understanding the topography is essential to good design since this relates to lateral residence time of water which affects treatment efficiency. See also sections 3.3.5 and 3.3.6.

Key information required

- Map of proposed scheme with reference to the location within the catchment and source of nutrients. Pathways should be mapped with nutrient levels. Poor design and consideration of topography could reduce the lateral residence time of water. This will compromise treatment efficiency. See also sections 3.3.5 and 3.3.6.

3.3.3. Geology and hydrogeology

Key questions

- **What is the site geology?** This is important because it provides the parent material for the soil and determines the vulnerability of any associated groundwater impacts related to water quality. Parent materials which equip subsequently derived soils with characteristics such as high P sorption capacity and permeability are favourable.
- **Are any aquifers present which may result in upward discharge in the floodplain?** Under this scenario it is likely that the concentration of nutrients would reduce in subsurface flows, hence reducing the nutrient removal efficiency of any associated floodplain soils. The opposite is also possible if subsurface flows have high N or P concentrations. Monitoring locations therefore need to consider possible locations of springs in the channel.

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[11] Using LiDAR data online maps may help to support this initial assessment together with OS contour and spot heights.

[12] To achieve this assessment may require additional expert knowledge from a river restoration specialist to understand pre-feasibility and create an outline feasibility map with constraints, opportunities, and type of in-channel options to support natural mitigation.

Key information required

- A map of the expected geology beneath and in close proximity to the proposed mitigation site. This is likely to be highly indicative at this stage and based on open-source data.
- An assessment of the potential issues that may be caused by the catchment hydrogeology.

3.3.4. Soil and sediment

Key questions

- **What is the composition?** This will affect the nutrient removal capacities of hyporheic and floodplain soils since this affects nutrient removal capacity. Sandy soils, for example, have high infiltration capacity but much lower nutrient removal potential than clay soils.
- **What is the likely soil mobilisation during construction?** Nutrients from riparian and benthic soils may be mobilised by excavation and lost to the wider environment. This is likely to be a temporary issue but should be accounted for in the design process which will require mitigation.

Key information required

- A map of the expected sediment type or types for the designated reach and an overview of associated hydraulic properties.
- An analysis of the suitability of the local soil type for a nutrient removal scheme.

3.3.5. Hydrology and drainage

Key questions

- **Will the mitigation result in more frequent but periodic floodplain inundation?** This sequencing is required to promote oxic and anoxic conditions, both of which are required to support denitrification[13]. This is dependent on the drainage and the underlying water table: if the water table is too high or too low in reference to the floodplain, the hydrological conditions of the system will either be consistently saturated or dry.
- **Will the proposed re-naturalisation mitigation allow for better connectivity with the water table?** Channel re-naturalisation and floodplain reconnection should

[13] The primary forms of N from wastewater are nitrate and ammonia. To cycle ammonia to nitrate (as is required prior to denitrification), oxic conditions are required. The primary forms of N from agriculture are nitrate and ammonium (which also requires oxic conditions to be nitrified into nitrate). Denitrification (the process of cycling nitrate into gaseous forms of N) requires anoxic conditions. Where only anoxic conditions are present, the denitrification process to remove N from the system is limited to nitrate inputs only.

result in better connectivity. This will be determined by the local topography (see section 3.3.2) and the proposed location of the mitigation. Detailed design will enable the promotion of periodic floodplain inundation to further support reconnection.

Key information required

- The expected lateral inundation should be characterised to ensure that it occurs periodically so as to not compromise the suitability of the design. Data from local gauging stations, predictions based on the flood estimation handbook[14] or the Institute of Hydrology flood estimation report for small catchments[15] will support this.
- Map (refer also to section 3.3.2) showing proposed mitigation outline design and level of floodplain connectivity.

3.3.6. Flood risk and floodplain reconnection

Key questions

- **Is there any infrastructure close to the proposed mitigation site?** Increasing lateral connectivity via floodplain reconnection and channel re-naturalisation is likely to increase flooding locally (extent and levels). If any local infrastructure has the potential to be affected a flood risk assessment (FRA)[16] would be required.
- **Have flood risk benefits been identified?** Re-naturalisation of a water course via a combination of changing the cross and planform section can slow the flow locally which can in turn support flood mitigation downstream. Reconnection to local floodplains can be beneficial but the impacts must be identified.
- **Have likely trends of lateral connectivity and periodic inundation been considered?** Regular wetting and drying of floodplains is a key factor promoting nutrient uptake. Constant inundation does not promote the necessary conditions and can therefore hinder the treatment efficiency of the scheme.

Key information required

- A map to show if both the current water course and any potential alterations of the course related to floodplain connectivity will result in increased flooding extent and levels.

[14] See: Flood Estimation Handbook and Flood Studies Report | UK Centre for Ecology & Hydrology (ceh.ac.uk)

[15] See: IH_124.pdf (nerc.ac.uk)

[16] See: Flood risk assessments if you're applying for planning permission - GOV.UK (www.gov.uk)

- A map showing current flood risk extent based on the Environment Agencies flood risk mapping will support this understanding including downstream to any key infrastructure[17].
- Demonstration that the relevant FRA has been completed with an assessment if more detailed modelling will be necessary at the detailed design phase.
- Note: if areas of risk are identified they should be flagged to determine if any localised flood mitigation strategy is necessary/can be implemented.

3.3.7. Protected sites, species, and Invasive Non-Native Species (INNS)

Key questions

- **Will the re-naturalisation scheme impact a protected site or other environmental objectives?** If the deployment location for the proposed mitigation is within, or near, a protected site, either its implementation or operation phases may impact the site. The following authorisations might be required:
    - As the owner or occupier of a SSSI, notice must be given, and NE's permission (consent) is required before a planned activity is carried out on the site. This only applies to owners of land within the SSSI itself.
    - Public bodies must give notice and get NE's agreement (assent) before carrying out a planned activity that's likely to damage a SSSI or land near the site's boundary.
    - For proposals within European sites and Ramsar sites, a competent authority must undertake a HRA for any plan or project which is not necessary for management of the site.
- **Will the re-naturalisation scheme impact protected species?** If protected species are present at or near the deployment location and could be impacted by the scheme. This will need to be discussed with NE to gain consent.
- **Are there any known INNS at the site and/or upstream?** There may be INNS at the deployment location, which would require an INNS risk assessment to show how these species will be removed and disposed of to remove the risk of spreading INNS to other locations in the catchment.
- **Will the re-naturalisation scheme impact other natural habitats or environmental objectives?** The scheme should not compromise the restoration of other natural habitats or cause a negative impact on existing natural habitats. It should also not negatively the ability to achieve other environmental objectives.

[17] See: Check the long term flood risk for an area in England - GOV.UK (www.gov.uk) and Flood Risk Maps for Rivers and Sea in England - December 2019 (arcgis.com)

Key information required

- Maps of international (SAC, SPA, Ramsar) and national (SSSI) protected sites for nature conservation.
- Maps of locally protected nature/environment sites (local nature reserves, local wildlife sites and local geological sites) and other protected areas (National Parks, AONBs) that may have requirements which need consideration when deploying a re-naturalisation scheme.
- Maps of priority habitats and areas that are currently under habitat restoration.
- Map of INNS locations using any local observations and the NBN Atlas[18] with INNS statement on pathways and impacts.

Depending on the interaction of the scheme with the above designations, a full ecological assessment may be required to provide confidence there will be no impacts on these designations due to the scheme.

3.3.8. Land use

Key questions

- **Can previous land use impact the efficacy of the proposed scheme?** If the scheme involves floodplain reconnection, the current and previous land use needs to be considered to ascertain the risk of legacy nutrients being remobilised. This is a greater issue for P than N, as N is less readily stored in soils and is most likely to occur during implementation. It may be necessary to test soil nutrient levels to determine potential legacy risk from land use. For example, if a weir is to be removed as part of the scheme, nutrients maybe stored, or more connectivity and mixing of sediment within the hyporheic zone could have a negative impact if legacy nutrients are stored in either the floodplain or a heavily modified water course.

  The Framework Approach for Responding to Wetland Mitigation Proposals specifies the following limits to prevent remobilisation of nutrients:
  - Soils with TN content < 1000 mg / kg.
  - Soils with TP < 80 mg / kg.
- **Are there interactions with other land management schemes?** If land is currently under an agri-environment scheme, payments may be lost through the deployment of river planform reconfiguration and/or reconnection to a floodplain. 'In-channel' naturalisation mitigation through, for example, narrowing a current water course would have less impact.

[18] See: NBN Atlas - UK's largest collection of biodiversity information

Key information required

- Map of current land use and explanation of any previous land uses that might cause an elevated risk of pollution during project implementation.
- Map of active agri-environment schemes where appropriate.

3.3.9. Ownership

Key questions

- **Has the landowner, and any surrounding landowner agreed to the mitigation in principle?** A project can only be delivered with the agreement of the landowner and following discussion with any other landowners where there may be a direct effect. It is likely that this type of mitigation would be received favourably. A legal agreement should be confirmed with the landowner that the land used for the re-naturalisation will remain in place in perpetuity (practically this is 80+ years).

Key information required

- Evidence of engagement with the landowner regarding the deployment of the proposed scheme.
- Outline details of any in principle, legal or management agreements to secure the land required for the re-naturalisation scheme.

3.3.10. Archaeology, landscape and heritage

Key questions

- **Is there any known archaeological remains or potential for them?** Where a river / floodplain is known to be close to archaeological important sites, excavations investigations may be necessary to ensure there will be no impacts. Areas might include scheduled monuments, Roman remains, peat soils that have preserved records of past landscapes and people, or well-preserved water meadow systems, noting that some maybe scheduled monuments. Early checks are recommended.
- **How might landscapes and heritage be impacted?** Planting trees and vegetation has the potential to disrupt landscape character and heritage features in some areas (e.g historic vistas). This will need to be checked with landowners and bodies such as English Heritage.
- **Has any disruption been accounted for?** The loss of landscape and heritage features can be mitigated through early identification of possible disruptions and the use of suitable mitigation measures. In some cases, a ‘no regret’ policy can be implemented so that any re-naturalised reach can be returned to the previous course, if necessary, but this would have implications for NN.

Key information required

- Archaeological or heritage value risk assessment based on advice from the Local Authority.
- Map of scheduled monuments.

- In areas of high archaeological or heritage risk, a bespoke archaeological risk assessment and any planned mitigation may be required. This will minimise the risk of costly delays during construction and shows that the design is managing risk proactively.

3.3.11. Rights of way and public access

Key questions

- **What if a public right of way is affected by the proposed re-naturalisation measure?** Public rights of way cannot be closed or diverted, even temporarily, without permission from the local authority. Implementing any river and floodplain re-naturalisation scheme has the potential to result in changes in the landscape which could affect public rights of way.
- **Are there wider benefits associated with public access?** Re-naturalisation has the potential to improve the site's amenity value, especially related to walking and angling together with building public awareness of nutrient pollution issues and opportunities to provide benefits for society and the environment through such schemes. Benefits could be considered in terms of better access for all.
- **Where wider benefits have been identified would there be any risk to NN efficiencies?** Bank erosion or riparian soil compaction via access might reduce nutrient removal efficiencies locally so effective measures to avoid this would need to be considered.

Key information required

- Map of the nearest public rights of way and any plans for any required mitigation.
- Demonstration that the local authority has been engaged regarding changes to public rights of way, if required.
- If possible / relevant, consider opportunities available for education and raising public awareness while minimising risks to degradation of the scheme.

3.3.12. Birdstrike risk

Key questions

- **Is the proposed re-naturalisation scheme near an airfield?** A water body can attract birds which may be an issue if the site is near an airfield. This is especially an issue for large birds, such as geese and swans, and for large flocks of birds such as starlings. This is only likely to be an issue if a water course is for example going to be de-culverted and/or there is widespread floodplain inundation that attracts waterfowl. The risk of bird strike will depend on the type of airport and its associated usage by planes. An evaluation of risk needs to be within the context of the type of airport.
- **Will a bespoke birdstrike risk assessment be needed?** Airports may have their own birdstrike risk management programmes or plans. These should be consulted on and any mitigation of birdstrike risk should be derived through consultation and the development of a mutually agreed strategy.

Key information required

- Map showing the nearest airfields and the type of airfield (commercial, military etc) along with any proposed mitigation strategy where necessary.

3.3.13. Nature recovery

Key questions

- **Does the re-naturalisation plan have the potential to be part of a habitat network or natural recovery area etc?** It will be beneficial to look at local plans that support nature recovery plans to establish if the nutrient mitigation provides any opportunity to combine outputs. This should be considered in the context of the most beneficial placement of the nutrient mitigation solution.
- **Does the proposed re-naturalisation plan intersect with other plans identified for alternative nature recovery requirements?** There may be locations in which the NN proposal could displace more valuable habitat nature recovery opportunities.

Key information required

- Map identifying that the location is suitable for re-naturalisation. In time the Local Nature Recovery Strategy (LNRS) should be used to minimise the risk that a nutrient scheme will compromise the local habitat network.
- A sketch of the proposed mitigation design with commentary related to any historic change in planform and extent of modification[19].

3.3.14. Historical landfill, coal mining and contaminated ground

Key questions

- **Has contaminated land been investigated?** Excavation might be necessary for some floodplain reconnection schemes or where rivers change planform. Historic waste from landfills or industry can be remobilised and released back into the environment during excavation. This could be a source of short-term pollution.
- **Has the risk and any associated costs been considered related to the removal of any contamination?** The risk posed to the efficacy of the project is dependent upon the nature of buried materials. For instance, the potential removal of large volumes of hazardous materials, such as asbestos, may contribute significantly to the project costs. Understanding the risk early will allow for pre-emptive mitigation of the site-specific risks.

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[19] The RRC manual provides examples of outline design diagrams for river restoration and floodplain reconnection schemes. See: [Manual of River Restoration Techniques | The RRC]

Key information required

- Map of historical landfills and contaminated land in close proximity to the designated reach
- Risk assessment based on local knowledge and available data
- **Note:** A site investigation report provides the greatest certainty that historic contamination is not an issue. This may be available for river reaches near to existing sewage treatment works or other significant engineering works. Provide if available.

3.3.15. Unexploded ordnance

Key questions

- **Is there any likelihood of ordnance risk?** The implementation of restorative schemes requiring earthworks has the potential to uncover unexploded ordinance. This will inevitably delay project construction and increase costs.
- **Note**: This is only applicable to schemes requiring earthworks or where plant is required to travel large distances where ordnance potential is uncertain. For example, large-scale re-naturalisation schemes requiring significant channel modifications.

Key information required

- Presence or absence of unexploded ordinance must be identified.
- A suitable mitigation scheme must be provided if unexploded ordinance is present.

3.3.16. Services and infrastructure

Key questions

- **Has an assessment of services both underground and overhead (water, gas, and electricity) been conducted?** Moving services is expensive and time-consuming and requires the involvement of the service provider. Above services may impact the ability to deliver the project during to constraints of plant access the site.

Key information required

- A full search and a map of all local services, if any. The services should be plotted alongside the river re-naturalisation scheme to show their relative locations.
- A mitigation strategy for any services identified.

3.3.17. Regulatory considerations

Key questions

- **Does the re-naturalisation scheme require any environmental permits or permissions?** The regulatory requirements might include, but are not limited to, the following:
    - Environmental permits
    - Flood risk assessment
    - Flood defence consent from EA regarding works within 8m of a main river
    - Archaeology and pathway assessment
    - Wildlife licences
    - Planning permission

Key information required

- A list of the permits and licences required along with an assessment of the likelihood that they will be granted
- A narrative on each permit identifying any engagement with the relevant regulator and advice already received would be useful as supporting information is available.

3.3.18. Constraints and options assessment

Key questions

- **Is the proposed scheme a suitable nutrient mitigation option?** The feasibility assessment may have identified a range of constraints. It is important to consider these constraints and any knowledge gaps that the feasibility assessment has found. This will help to justify that the proposed channel re-naturalisation scheme is a suitable option. It will be useful to condense the key information identified in the feasibility assessment into a summary which, in a successful proposal, will highlight that the proposed deployment location is well suited to the scheme, and that the scheme is the best option available.

  Although this step is not mandatory, it will show that the proposal has given significant thought to the feasibility of the mitigation scheme.

Key information required

- **Optional:** a summary table of the constraints associated with the scheme
- **Optional:** a description of the scheme's suitability in the proposed location, based on the feasibility assessment

3.3.19. Evaluation of feasibility assessment

For a re-naturalisation scheme to pass the feasibility assessment, it must include all required pieces of information from Stage 2 related to topics 3.3.2 - 3.3.18. Providing evidence for each key piece of information shows that the risks have been considered, with plans in place for management and mitigation.

To establish the strength of the feasibility assessment, the tables below can be used. Mapped information is required where possible. Some cells have been left blank.

Report section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.3.2	Topography & levels		
3.3.3	Geology and hydrogeology		
3.3.4	Soil and sediment		
3.3.5	Hydrology and drainage		
3.3.6	Flood risk and floodplain reconnection		
3.3.7	Protected sites, species, and invasive non-native species (INNS)		
3.3.8	Land use		
3.3.9	Ownership		
3.3.10	Archaeology, landscape, and heritage		
3.3.11	Rights of way and public access		
3.3.12	Birdstrike risk		
3.3.13	Nature recovery		
3.3.14	Historical landfill, coal mining and contaminated ground		
3.3.15	Unexploded ordnance		

Report section	Comment	All information has been provided in the relevant format (mapped, tabular, or summary)	There are gaps in the information provided
3.3.16	Services and infrastructure		
3.3.17	Regulatory considerations		
3.3.18	Constraints and options assessment		

	Response statements
If ALL information green (noting that 3.3.18 is optional)	This is a well-structured feasibility assessment that maximises the likelihood that this re-naturalisation scheme will be a sustainable natural asset within this catchment.
If SOME red	The application is missing mandatory feasibility information, as shown by the rows populating the red column. Please provide this information so that the feasibility assessment can be evaluated.

3.4. Stage 3 – Design Process

3.4.1. Introduction

There is no standard procedure regarding the use of river re-naturalisation schemes to achieve NN since success and design is very dependent on location, geology, and topography etc. as outlined in **Part 1** (the literature review). Each proposal will therefore need to be assessed individually based on best available information with a set of key design principles needed to achieve desirable water quality objectives and provide confidence that its function will be maintained in-perpetuity within the bounds of reasonable scientific certainty based on current knowledge. The scheme design should be based on the *best available evidence* of how the scheme functions to remove or immobilise the sources of nutrients set out in the design objectives. This will in turn show that the scheme will achieve nutrient mitigation *beyond reasonable scientific doubt* and meet the requirements of the Habitats Regulations. A robust scheme design should also help to show that the re-naturalisation scheme will provide mitigation *in perpetuity.*

The sections below provide additional details on the design criteria deemed to be essential to reduce nutrient concentrations as well as essential practical considerations. Further optional design criteria are provided that will help to increase the certainty with which the scheme will deliver nutrient removal. The design will ideally incorporate details on how the re-naturalisation will realise additional environmental benefits.

This document does not cover the detailed design requirements for on-the-ground delivery of a re-naturalisation scheme.

Design processes outlined in this document are related to key requirements to support the understanding of the confidence in the scheme being used as NN mitigation in the context of channel re-naturalisation.

A design engineer will be required to take this forward using supporting information provided in the feasibility stage.

3.4.2. Essential design criteria

Table 3:2 provides a summary of the minimum design criteria which must be met to improve nutrient removal resulting from a river channel re-naturalisation scheme. The evidence required from Table 3:2 must be provided. Additionally, Table 3:3 provides a summary list of documentation that should be covered as part of the detailed design. It should be used as a 'tick list' and to check key statements related to success. Where not completed, a justification will be needed. This will be used to provide details of on-the-ground design criteria at a level that can be used by a contractor. Confidence factors of success for re-naturalisation and NN should be included based on physical, water quality and ecological parameters. Any uncertainties should be flagged using RAG risk register.

Table 3:2 Minimum design criteria

Design criteria	Minimum requirements	Evidence required
General design	To implement a re-naturalisation scheme there is a requirement for the scheme to be robustly designed. Please consult the River Restoration Centre's Manual of River Restoration Techniques[20] with specific reference to Section 3a – Understanding your river and Section 3d – Design and implementation. The Environment Agency's Fluvial Design Guide[21] also provides engineering advice with reference to re-naturalisation schemes.	Evidence that the Manual of Restoration Techniques has been consulted and included in the design process. The required evidence will vary significantly from one project to another depending on the proposed scale of intervention. Stage 2 will provide an indication of the level of detail required for the design together with the relevant supporting evidence.
Channel heterogeneity	The scheme must increase the heterogeneity of the river to promote sedimentation, infiltration, increased hyporheic exchange and increased residence times. All of these outcomes encourage natural nutrient removal processes to occur at an increased rate. The heterogeneity of the channel flow's path can be increased via floodplain reconnection which increases	A mapped design plan evidencing the plans for increased channel heterogeneity. Flow paths should be characterised with consideration of how these will impact the relevant nutrient removal processes.

[20] See: Manual of River Restoration Techniques | The RRC

[21] See: Fluvial design guide - GOV.UK (www.gov.uk)

Design criteria	Minimum requirements	Evidence required
	lateral connectivity, re-meandering, or by connecting rivers to online wetlands, disconnected side channels and oxbow lakes.	The design must be specific to the site in question.
Future maintenance requirements	It is important to understand what sort of maintenance and monitoring the scheme will require and allow for access to conduct this maintenance where necessary. The design should account for the type of access that will be required and whether vehicular access be necessary.	Evidence that the design accounts for the required access for maintenance and monitoring.

Table 3:3 Key information to include using data from Stage 2

Key information to include (using data from Stage 2)	*Why*
Hydraulic modelling	Supports key design criteria. Must include sediment-rating curves, flow frequency and effective discharge rates. Modelling may be needed but will depend on regulatory requirements and flood / erosion risk. Extent of modelling required will depend on flood risk and design criteria.
Land access statement	Identify risks, required mitigation to avoid damage and permits.
Method Statement	Planned construction with associated maps. This should include information on slope, cross section dimensions, requirements to remove current trees or other infrastructure, requirements for pre-construction surveys, materials, specific design features and proposed timing relative to environmental considerations.

Key information to include (using data from Stage 2)	***Why***
Construction Design and Management (CDM) statement[22]	To support health and safety.
Bill of quantities	To support construction. This should include volumes of required excavation of materials, construction, silt removal[23], import of material to support cost estimation and how this links to land access. Reference should also be made to what is going to be done with any excavated materials. This information supports future cost estimations for material and labour.
Monitoring plan[24]	To demonstrate success in the context of NN and determine any future maintenance requirements. Upstream and downstream monitoring can support the precautionary approach to avoid overly favourable estimates from being calculated. See also Stage 5 (Section 3.6).
Report of the combination of the above	***To provide details for on-the-ground design criteria and confidence factors of success for re-naturalisation and NN based on physical, ecological and water quality parameters.***

[22] See: The Construction (Design and Management) Regulations 2015 (legislation.gov.uk)

[23] See Section 3.5.3 for more information regarding removal of excavated materials.

[24] Using a planner to support your monitoring may help. See: https://www.therrc.co.uk/monitoring-planner

3.4.3. Advantageous design criteria for optimization

Key questions

- **Have design requirements beyond the minimum criteria been met?** Although not mandatory, designing the scheme with advantageous design criteria for the purpose of NN and wider benefits in mind is beneficial to evidence the robustness of the scheme. Refer to the River Restoration Centre's Manual of River Restoration Techniques[25] for clarity on these.

Key information required

- **Optional:** Evidence that design criteria beyond the minimum requirements have been included.

3.4.4. Evaluation of the design process

For a scheme to be conducted with reasonable scientific certainty that it will reduce nutrient loading downstream, the design must consider and provide the necessary information explained in Stage 3 (Section 3.4). This process aims to minimise the uncertainty associated with the mitigation scheme whilst mitigating any possible risks. The below table should be filled in at this stage to ascertain firstly if the scheme is suitable, and if relevant, where further information needs to be provided. Some cells have been left blank.

Report Section	Comment	All information has been provided	There are gaps in the information provided
3.4.2	Essential design criteria		
3.4.3	Advantageous design criteria for optimisation		

[25] See: Manual of River Restoration Techniques | The RRC

	Response statements
If ALL green (noting that 3.4.3 is recommended, not required)	The information provided regarding the design detail is appropriate and sufficient.
IF SOME red (noting that 3.4.3 is recommended, not required)	Not enough information has been provided regarding the design detail proposed for the scheme. Additional information is required regarding 3.4.3. Without this information the scheme designs cannot be evaluated.

3.5. Stage 4 – Implementation Process

3.5.1. Introduction

The design of a re-naturalisation programme must be supported by an implementation plan outlining the stages and issues which need to be addressed before the scheme is deployed. For the plan to progress, consideration also needs to be given to the management and maintenance requirements of the scheme. These are outlined below to support the eligibility of the proposal by ensuring a plan is in place to support the operation and maintenance requirements of the scheme in perpetuity.

Headline Messages:

Re-naturalisation schemes must be supported with an implementation plan. This plan must outline the following subsections:

- Constraints
- Site clearance
- Management plan

A checklist for these points is provided below.

3.5.2. Consideration of constraints

Key questions

- **Have any constraints been identified in the feasibility and design assessment?** There may have been constraints related to project deployment identified during Stage 2 – Feasibility and / or Stage 3 – Design Processes. The implementation plan should consider how these constraints will impact the implementation.

Key information required

- A description of how constraints identified will be mitigated to reduce risks both to design and nutrient uptake.
- Provide a risk RAG to demonstrate that the design has accounted for interaction with the hyporheic zone[26] for the delivery of NN benefits. This is important to promote nutrient cycling to enhance the nutrient removal potential of the scheme.

3.5.3. Site clearance related to implementation works

Key questions

- **Will the location for deployment of re-naturalisation require preparation?** This should be provided as part of the design specification and related to a statement of risk related to current state of proposed re-naturalisation. This will be highly dependent on the design and what is currently present (i.e. a concrete channel re-naturalisation will be very different to in-channel enhancement measures). It is recommended that the design is reviewed, and key related elements checked.

Key information required

- An environmental management plan must be provided. This must ensure that:
    - Existing biodiversity is protected;
    - Trees and vegetation are not detrimentally impacted unless they need to be cleared to plant replacement vegetation;
    - Soil compaction is minimised during construction;
    - Soil erosion and sediment pollution is mitigated during construction;
    - Buried services are protected; and,
    - Topsoil and subsoil are handled separately, and the disposal of surplus soil is suitably managed.
- There must also be an indication of what site clearance and earthworks procedures are likely during the implementation phase.
- Information regarding incident management and waste management, if relevant, should be provided.
- This should be completed as part of the design criteria: review recommended.

[26] The area of rapid exchange beneath streams where constant mixing occurs between shallow groundwater and stream water. Water, dissolved gases, solutes, contaminants, and microorganisms are exchanged. This can support nutrient removal processes.

3.5.4. Outline management plan

Key questions

- For a re-naturalisation scheme to provide effective treatment in perpetuity, a robust management and maintenance plan must be formulated prior to implementation. Any routine operation and maintenance requirements must be identified and there must be certainty that these will take place. The maintenance plan is highly dependent on the observations gained from the monitoring as described in section 3.2.2.

Key information required

- Operator and stakeholder's responsibilities should be clearly identified and outlined within the management plan, covering the key roles and responsibilities related to the scheme.
- A monitoring plan that is appropriate for adaptive management that ensures continuation of processes necessary to achieve NN. Key assessment should include:
    - Channel bed scouring to ensure the longevity of the scheme.
    - Flooding that was not predicted via modelling.
    - Unexpected bank failure with an investigation as to what is the cause
    - Vegetation establishment and management since this is essential to supporting NN.
    - Any areas identified for needing either vegetation introduction or removal.

3.5.5. Evaluation of the implementation process

For the proposal to progress, all pieces of information outlined above in Stage 4 (Section 3.5) must be provided to show evidence that all possible risks associated with implementation have been reduced as much as possible and that any remaining risks will be mitigated against. If necessary, the tables below can be used to identify which pieces of information are missing and the applicable response statement will outline exactly what steps are necessary to complete this stage. Some cells have been left blank.

Report Section	Comment	All information has been provided	There are gaps in the information provided
3.5.2	Consideration of constraints		
3.5.3	Site clearance related to implementation works		
3.5.4	Outline management plan		

	Response statements
If ALL green	This provides comprehensive information regarding the implementation process for the river re-naturalisation scheme and maximises the likelihood that this re-naturalisation scheme will be constructed appropriately and managed effectively.
If SOME red	The application is missing mandatory information from Stage 4 (Section 3.5). Please provide this information so that the implementation process assessment can be evaluated.

3.6. Stage 5 – Post-Implementation Monitoring and Evaluation

3.6.1. Introduction

Either monitoring or using secondary datasets is required to estimate the baseline nutrient load that will enter the defined reach. To prove the nutrient load reduction that has been achieved, robust post-implementation monitoring, or relevant secondary datasets are required. The specifics regarding credit generation are outlined in the subsections below.

Monitoring requires a plan that is bespoke to the individual scheme, therefore the following subsections must be considered alongside the site-specific environment.

These sections **MUST** be included, regardless of the desired credit outcome:

- Baseline monitoring.
- Post-implementation monitoring to support adaptive management focusing on scheme function.
- Post-implementation monitoring to gain credits.

3.6.2. Post-implementation monitoring to gain credits

Key questions

- **What is post-implementation monitoring to gain credits?** Post-implementation monitoring is the only way to gain N and P credits as insufficient data is available to calculate an upfront efficacy figure to estimate nutrient reductions (see **Part 1**). To gain these credits, the scheme must have robust baseline monitoring methods and be monitored post-implementation to be able to robustly characterise the nutrient reduction caused by the scheme. The results of post-implementation monitoring will be used to compare nutrient loads in the receiving environment against baseline monitoring[27], which will enable a determination of the actual nutrient reduction delivered by the scheme.

- **How should post-implementation monitoring to gain credits be carried out?** Post-implementation monitoring to gain credits should be carried out using the same monitoring design as used for baseline monitoring but with the flexibility to add additional sampling points where deemed necessary to account for any potential mitigation and / or any minor on-site design alterations (See Section 3.2.2).
- **How long is post-implementation monitoring to gain credits required for?** To gain credits, post-implementation monitoring should be conducted for a minimum of three years to capture seasonal variation in nutrient removal efficacy at inter-annual timescales to claim credits. It should continue at least until the system can be shown to have reached a quasi-equilibrium whereby its nutrient removal efficacy is approximately stable over time. More frequent monitoring, particularly in the initial few years, may make it quicker to identify when stabilisation has occurred
- **Can secondary data be used for post-implementation monitoring to gain credits?** It is possible that existing monitoring programmes may provide a source of post-implementation monitoring. Secondary datasets will require documentation that details the sampling methodology, frequency and duration of the sampling programme to determine if any supplementary monitoring is needed. The requirements determining the suitability of a secondary dataset are the same as the requirements outlined for baseline monitoring (e.g. length of sampling, locations, etc.).
- **What should happen to the monitoring data?** This should be decided and agreed at the beginning of the monitoring programme including approaches to assess data. It is likely to be of interest to LPAs, Natural England and other third-party stakeholders (e.g. local catchment groups and academics). Building a supporting open-source database including the efficacy rates will be highly beneficial for future programmes.

Key information required

- For nutrient credits to be quantified, an evidence base of robust, consistent monitoring before and post implementation and both upstream and downstream is required. The nutrient credits should be calculated from a monitoring plan that demonstrates at least a minimum of three years of water quality and flow data beyond the baseline. Consistent monitoring will be required to prove that an equilibrium has been reached.

[27] Credits can only be gained with baseline and post-implementation monitoring, not modelling.

- If using secondary data: An assessment of the validity of the secondary datasets for use in this context. Justification for using the relevant dataset must be provided.

3.6.3. Post-implementation monitoring to support adaptive management

Key questions

- **What is monitoring to support adaptive management?** As well as being required to claim credits, monitoring should also be undertaken with a focus on ensuring the scheme's function is maintained (for both N and P schemes). Regular visual inspections and repeat photography will support early identification of any requirements for adaptive management and may help to highlight conditions whereby the nutrient removal being delivered could start to reduce; for example, problems related to vegetation or bank erosion. The monitoring data should be used in an adaptive management regime that can highlight when different aspects of the management plan detailed in Section 3.5.4 may be required.
- **What are the requirements of monitoring to support adaptive management?** Regardless of whether the scheme has been implemented for N and / or P, visual inspections and repeat photography should begin after the scheme has been implemented. The period and regularity of inspections will depend on the scheme, location, and if other schemes are likely to be implemented. The scheme must be reviewed for at least 3 years annually and then the future required monitoring plan and timelines should be determined. This plan should ensure the scheme's in-perpetuity benefits.

Key information required

- A post implementation monitoring plan to support adaptive management. The monitoring plan does not need to specify water quality monitoring unless it is required to instigate maintenance. It should include consistent visual inspections and repeat photography to support adaptive maintenance.

3.6.4. Summary evaluation

Monitoring needs to be proportional to need. The required information outlined above in Stage 5 should be provided to evidence that the proposed scheme has accounted for the need to monitor its performance and use this monitoring to guide any adaptive management. If necessary, the tables below can be used to identify which pieces of information are missing and the applicable response statement will outline exactly what steps are necessary to complete this stage. Some cells have been left blank.

Report Section	Comment	All information has been provided (where relevant)	There are gaps in the information provided
3.6.2	Post-implementation monitoring to gain credits		
3.6.3	Post-implementation monitoring to support adaptive management		

	Response statements
If ALL green (where relevant)	The application provides comprehensive information regarding the monitoring and evaluation process for the re-naturalisation scheme and maximises the likelihood that this re-naturalisation scheme will be designed appropriately, function as intended and be managed effectively.
If SOME red	The application is missing mandatory information from Stage 5. Please provide this information so that the implementation process assessment can be evaluated.

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