



Introduction

1 The Manual of River Restoration Techniques

Welcome to the fourth edition of The Manual of River Restoration Techniques (the Manual) produced by the River Restoration Centre (RRC) based in the UK. This update has been funded by the Environment Agency (EA). The overall aim of the Manual is to promote good practice in river restoration and management to support healthy river ecosystems and, wherever possible, work with natural processes. The updated Manual contains 69 technique examples from 39 different project sites across the UK illustrating a wide range of approaches for different types of river.

Each example describes (a) how a particular objective of river restoration or management has been planned and developed by using a particular technique, (b) what the completed works comprise, and (c) how the technique performed and how it has subsequently evolved.

The work to update the Manual was carried out by RRC in 2019 with significant assistance from practitioners associated with the different sites. Four new technique examples from different project sites have been added to the 65 existing examples described in the third edition (RRC, 2012).

The existing examples were updated wherever possible in the light of the performance of the techniques and the evolution of the site concerned. In all technique examples, costs are based on the information provided at the time of the project completion. No inflation has been factored in. Additional information comprises a performance update page and a box which includes WFD, environmental designation status and monitoring information.

Since the Manual was first produced in 1999, a lot has changed in river restoration and catchment management. Although approaches to restoration have changed, the original techniques in the Manual are still relevant, as they show the benefits and drawbacks of traditional techniques. Where the design of a technique has since been adapted, it is described in the subsequent performance section of the case study.

In this electronic version of the Manual, each section of this Introduction can be selected individually, and there is an [Interactive map](#) of all sites. Furthermore technique examples can be viewed by River name, Site Designation, Technique and WFD mitigation measure ([here](#)). In this latest edition, [decision support pages](#) have been added to help users navigate to relevant techniques.

Whilst this Manual provides a stand-alone document it is recommended that it should, where necessary, be used in conjunction with other valuable information that is available from a range of sources. As such the RRC has compiled a [reference list](#) of supporting documentation, guidance and tools which is linked to this Manual. Additionally, if further information is available for a technique, references are provided on the specific technique example page.



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Crucially, the Manual is not a design manual: the techniques cannot be transferred to another site without due consideration and appropriate design (see Section 4)

Introduction

2 How to use The Manual

The Manual is aimed at all river restoration and river enhancement project practitioners who might include engineers, managers, environmental practitioners, planners and river trusts. It is an aid to identifying potential techniques for use in river restoration and enhancement projects across the UK.

The project examples are grouped into overall aims which link to the technique ID: e.g. (1.1) *New meandering channel through open fields*; (1.9) *reconnecting remnant meander*; etc.

There are a number of ways to access content within the Manual. Guidance on catchment scale planning and understanding a site can be found in *Sections 2 and 3*. These sections are important in understanding if the individual techniques are applicable to your catchment. There are [decision support pages](#) which help to navigate to relevant techniques and case studies. These pages are designed to support the decision making process and should not replace it.

If you already know the technique you are looking for, you can access a list of techniques under each overall aim. There is also a search function and a tabular view of all techniques for quicker access to information in the Manual.

The site in each example has been given a general classification (see below) to help the user understand the type of river in which the technique is used. With due consideration, the user might conclude that the technique, or elements of it, can be used successfully in other river types.

The techniques are divided into broadly similar restoration or management aims

- 1 – Restoring meanders to straightened rivers
- 2 – Enhancing historic river features
- 3 – Improving sinuosity of current planform
- 4 – Green bank protection
- 5 – Improving channel morphology
- 6 – NFM: Managing overland floodwaters
- 7 – NFM: Creating floodplain wetland features
- 8 – Providing public, private & livestock access
- 9 – Enhancing outfalls to rivers
- 10 – Utilising spoil excavated from rivers
- 11 – River diversions
- 12 – Removing or bypassing barriers

The generic classification describes

(a) the natural substrate in the locality, expressed as:

- Silt/clay
- Sand
- Gravel
- Estuarine
- Chalk

And (b) the stream energy, for which mean longitudinal slope of the river is used as a surrogate:

• High energy	slope above 1%	(steeper than 1 in 100)
• Medium energy	0.125% to 1%	(1 in 800 to 1 in 100)
• Low energy	slope below 0.125%	(gentler than 1 in 800)

Therefore, an upland river with gravel substrate in a steep catchment would be classified as 'High energy, gravel' and a lowland chalk stream would be classified as 'Low energy, chalk'.

Each case example has a drop down box that identifies which Water Framework Directive (WFD) mitigation measure(s) the technique might deliver. These measures are classified differently for England and Wales, Scotland and Northern Ireland - [see reference list](#). Each example also indicates whether the river has any designation for nature conservation. For example, the site may be a Site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC), Special Protection Area (SPA), Ramsar site or a Local Nature Reserve (LNR).

When using the Manual, the planner or designer must consider whether the use of any single technique or combination of techniques, or some element of one or more techniques, is appropriate to the overall restoration or management objectives and to the type of river at their site. In most cases, such consideration will be part of the investigation, planning and design work associated with a project as described in *Section 3*.



3 Planning catchment scale river restoration

Understand your catchment

The starting point for planning any river restoration project is to understand your catchment. It is suggested that a catchment is split into hydromorphologically homogeneous reaches to help with the collection and analysis of data and information.

The next step is to collect information on each of the reaches. This includes information that can be collected in a desktop study, as well as walkover surveys such as the River Habitat Survey, MoRPH and Fluvial Audit. It is important that all issues (pressures and impacts) are recorded in this step.

Pressure and impact assessment

A pressure is the cause of an issue (e.g. channel realignment), whilst an impact is the end result (e.g. poor habitats). It is important to consider pressures and impacts separately because it helps to locate and address issues on a catchment scale. It can also be useful to split impacts into morphological and ecological impacts.

The links between pressures and impacts need to be assessed in each reach as well as the catchment as a whole to identify the most significant issues within a catchment.

Part of this assessment should include the contribution of each reach to the main catchment impacts. This will help to target river restoration within the catchment.

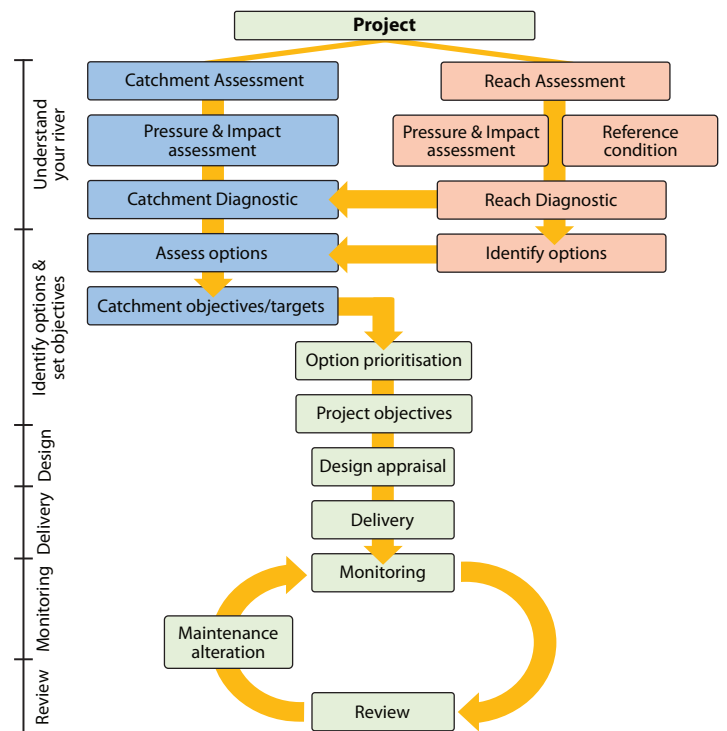
Identify restoration options

At this point restoration options also need to be identified. Depending on their level of experience, a surveyor might be able to identify options based on the catchment's pressures and impacts. In some cases, external advice and resources such as the Manual of Techniques and the '[Working with natural processes to reduce flood risk](#)' evidence base may be required to help guide the identification of options.

Where possible, options should be informed by a reference condition, as well as taking into account constraints to determine the degree of restoration that can be achieved.

Set catchment objectives

Objectives should be set once you have an understanding of your catchment. Objectives set before this are likely to be unrealistic and not achievable. Catchment objectives should be focused on catchment impacts (e.g. poor habitat) rather than pressures (e.g. realignment). This is because we want to see a reduction in impacts, achieved by addressing the pressures.



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River restoration process diagram

Prioritise options

The prioritisation process should select options which reduce the top catchment impacts by addressing reach pressures. Options can be single measures or groups of measures to address catchment issues. The process of prioritisation should consider the following:

- The most important catchment issues to address;
- The reaches which have the biggest contribution;
- The options which will best address the issues.

Constraints, costs and multiple benefits can also be taken into account to help with the prioritisation processes.

Water body planning

In larger catchments, river managers and practitioners may not work at the full catchment scale. Instead, their work may be focused on individual water bodies.

The same principles can be applied at the water body scale. It is extremely important that the water body is still considered within its catchment, and linked to a wider catchment plan. This is because pressures and impacts will not all be contained within the water body boundaries.

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3a Understanding your river

Use of any technique must be considered in the context of your site, water body and its catchment, including:

- Natural environmental processes (e.g. hydrological, geomorphological, ecological);
- Existing development, land ownership and future development plans;
- Functional use (e.g. conservation, amenity, flood risk management, angling);
- Local site conditions (e.g. existing flora and fauna, river flows and levels, sediment movement, geotechnical);
- Operational window of opportunity (e.g. weather, funding budget, fishing, bird-nesting);
- Relevant policies, strategies, designations and regulation

Planning river restoration at a catchment scale requires information on all reach and catchment aspects. Gaps in the collection of information can lead to key pressures, impacts and opportunities being missed. Information is collected in desktop assessments and walkover surveys, and should be based around an understanding of natural processes.

It is important to understand the energy of a river because many restoration techniques are only applicable to certain levels of energy. A river's energy is a function of the discharge, channel slope and channel dimensions. It is often expressed as stream power. Energy is therefore influenced by catchment factors, such as urban land use increasing run-off; as well as reach factors, such as channel realignment increasing the slope. Energy is the driver of change in river processes, habitats and species.

An understanding of hydromorphology and sediment is vital for any river restoration work. Sediment movement depends on the river's energy and the supply of sediment. However, channel dimensions and flow patterns also influence sediment erosion and deposition locally. For example, the outside of a meander bend is a zone of erosion, whereas the inside of the bend is a zone of deposition. Also, zones of high turbulence – for example downstream of a weir – will tend to result in localised scouring, while areas of slack water behind will tend to result in localised deposition. This is a simplistic explanation for a very complex process (see [Environment Agency Sediment Matters Handbook](#)).

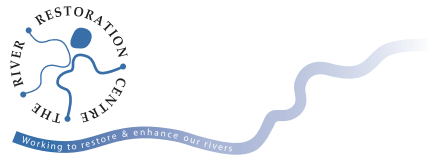
In many places, rivers have been modified historically for a number of reasons including industrial use, flood risk prevention and agriculture. These pressures need to be identified and linked to the impacts that they are having on natural river processes and biodiversity. Once the links between pressures and impacts are understood, options to address them can be identified.

As well as assessing the current condition of the river, it is also important to understand its reference condition. A reference condition is the expected state of the river if modifications and impacts were not present. This is also known as the semi-natural condition. Reference conditions can be used as a baseline to measure the impacts of modifications, as well as a target for river restoration projects.

Similar or nearby stretches of river can be used as a reference condition. Models, old maps and aerial imagery can also help to piece together the pre-modification condition of a river. Reference conditions are often hard to identify because of the lack of semi-natural rivers in the UK, with many modifications pre-dating mapping records.



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3b Identifying river restoration options

What needs restoring?

River restoration options should be selected based on an understanding of the pressures and impacts at both the reach and catchment scale. When used alongside the reference condition, this can define the main issues with the river and how far it deviates from its semi-natural state.

Identify general restoration aims

Once the main catchment impacts have been identified, measures can be proposed to address the reach scale pressures which are causing the impacts. At first, these will be general aims which describe how the pressures will be addressed. For example, for a straightened river the general measure would be to increase sinuosity; and for a river with barriers to migration, the general measure would be to increase connectivity. This Manual groups techniques into overall aims (see *Section 2*).

Specific techniques to achieve the general aims can then be identified. At this point, someone with experience of relevant techniques should be involved to identify and appraise suitable measures for the site. These measures need to take into account the river's energy, sediment supply, reference condition and surrounding constraints. The case studies and decision support pages in this Manual can be used to identify potential techniques, but they will still need to be considered within the context of the site.

River restoration options

Once suitable techniques have been identified, they can be turned into costed options which are ready to go to the detailed assessment and design phase. These options will often contain multiple techniques which make up the overall project.

3c Creating objectives

The objectives for river restoration or the management of a site must sit logically within the plans for the catchment. These include, in particular, the plans for the WFD catchments, SSSI and SAC plans, development plans, flood risk management plans, and plans of established local groups seeking to implement a catchment-based approach.

Objective scales

Two scales of objectives are required for river restoration as part of a catchment plan. These are catchment-scale objectives which focus on catchment impacts, and project objectives which focus on project outcomes. This will allow the success of works to be measured at both the project and the catchment scales.

SMART objectives

Specific

Measurable

Achievable

Realistic

Time-bound

SMART objectives are essential for reviewing the success of works at the project and catchment scales. Good SMART objectives make the monitoring and evaluation process easier. It is important that objectives are set once catchment pressures, impacts and options are understood. Setting objectives before this may make them unrealistic.



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3d Design and implementation

Key points related to carrying out restoration works are given below:

- The starting point for considering the use of any river restoration technique is to develop clear objectives bearing in mind, among other factors, the assessment of the existing site and relevant attributes of the catchment.
- The initial assessment of the works site will build on past assessment, survey or monitoring activities to decide the degree of restoration that can be achieved.
- Detailed assessment is likely to require further specific studies to plan and investigate options once the decision to make an intervention is made. 'Plan and investigate' may cover environmental studies, feasibility assessments, engineering studies (e.g. foundation investigation, hydraulic loads, etc.) and socio-economic studies. The term 'intervention' is used to describe an action that changes the physical state of the river.
- Some design activities must always be carried out to establish the composition, size and location of the physical works and to specify appropriate aspects of implementation and maintenance. The extent and the output of this design work will depend on the nature and scale of the physical works and how they are to be implemented and maintained.
- In all cases, the design and implementation must be fit-for-purpose and include multiple design phases depending on the project complexity. Large civil engineering projects need to involve appropriately qualified engineers and specialist contractors. This is particularly important where

the elements of the works are subject to significant loading or public safety is involved (e.g. CDM regulations). At the other end of the spectrum, some river restoration works will be low-cost and carried out with volunteer labour and simple equipment, but still to a predetermined design. For further guidance on river engineering works, see the Environment Agency's [Fluvial Design Guide](#).



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3e Monitoring

A monitoring plan should be put in place before the works go ahead. This is so that a baseline can be established and the impact of the works assessed afterwards. Your plan should be related to your project and catchment objectives, and your methods need to be appropriate for measuring the impact of your chosen techniques.

The process of monitoring the state of the site following the restoration works should lead to (a) confirming that the objectives have been achieved and there is no need for further intervention, and (b) a simple on-going cycle of monitoring and maintenance. Often, however, some further small intervention may be needed to 'fine tune' the state of the site if the environmental objectives are not being achieved. This process of making successive interventions to optimise or modify the restoration works is referred to as 'adaptive management'.

An appropriate and robust monitoring plan will allow you to appraise success and identify the need for adaptive management. RRC's [River Restoration Monitoring Guidance](#) can assist in determining the appropriate level and type of monitoring.

Where restoration techniques involve establishing vegetation (e.g. bankside willows or marginal reeds), aftercare should be available until the plants are well-established, or allowance for the lag-time associated with natural colonisation must be made explicit.



4 Decision support pages

Decision support pages have been created to help users navigate to case studies and techniques which may be relevant to their site. These have been split into general project aims (listed in *Section 2*). There are different types of support for each aim because of the different types of project found underneath them. Some decision support pages group case studies based on the extent to which they work with natural processes, whilst others take a more structured approach to selecting the right example for a site. A description of each decision support page is provided below:



Restoring meanders to straightened rivers

This page describes the principles behind re-meandering and the different types of meandering channels that can be restored. Case studies are separated based on the level of physical and historic evidence available, as this heavily influences the design process. Users are able to navigate to case studies with similar levels of evidence to their site.



Improving channel morphology

Case studies are split into 'over-deepened' and 'over-widened' based on their pre-restored state. This allows users to navigate to case studies with similar modifications to their site. Case studies are sorted further based on the degree to which they work with natural processes which is often defined by site constraints such as urban land use and infrastructure.



Removing or bypassing barriers

This page provides a decision support process for selecting techniques to mitigate the effects of barriers. Users can identify an example of a suitable technique which maximises the benefits for fish passage, hydromorphological processes and biodiversity within the constraints and characteristics of their site.



Green bank protection

Case studies are grouped by channel gradient so that users can easily identify case studies relevant to the energy at their site. A further grouping is based on the degree to which they work with natural processes, which is often defined by site constraints such as urban land use and infrastructure. Links to other decision support resources are also provided.



Natural flood management

This page groups case studies based on the level of energy to allow users to identify case studies relevant to their catchment. Case studies are sorted further based on the degree to which they work with natural processes. This page also provides links to resources which contain more evidence, guidance and case studies.