River Catchment Restoration Portfolio Project Monitoring Framework

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Background

Why focus on rivers and their catchments?

Rivers are an integral part of the landscape, carrying water, sediments and nutrients from the headwaters of the catchment down to the sea. They provide important habitats for aquatic life, including plants, microbes, fish and macroinvertebrates, and support diverse habitats within adjoining floodplain and riparian areas for invertebrates, birds, mammals, bats and other wildlife. Because they should be connected to the wider landscape, the condition, or health, of a river can be affected by human activities upstream, downstream and throughout the catchment. Likewise, these connections also mean that rivers have important social and community value. Consequently, restoration projects within rivers and their contributing landscape can lead to wider benefits – both ecological and social - beyond a project site.

Funding mechanisms are needed that support a holistic approach to river restoration, where actions are taken strategically and at scale so that they can address key impacts throughout the catchment. Working at a catchment-scale also makes it possible to aggregate the outputs of multiple actions within a catchment, leading to potentially greater and more strategic outcomes for funders. Delivering at a catchment scale can also yield wider benefits, creating nature positive solutions which benefit people who live and work in the catchment, supporting the businesses and organisations that rely on a healthy, functioning catchment and mitigating the combined risks of climate change and biodiversity loss.

The River Catchment Restoration Fund (the Fund) aims to support a range of projects that benefit rivers, including ecosystem restoration approaches and nature-based solutions[1] within the river corridor and broader catchment that can deliver improvements to river ecosystem processes along with wider benefits. Actions that improve ecosystem processes support resilient and diverse biological communities and deliver important ecosystem services.

Within Scotland, there is a recognized need to restore rivers and their catchments. For example, many waters are affected by pressures that

> Ecosystem restoration and nature-based solutions are related terms, which together encompass a range of restoration actions that can benefit river catchments.
>
> In rivers, ecosystem restoration may focus primarily on improving and conserving physical, chemical and ecological processes, while nature-based solutions focus on managing and improving ecosystem services for human or social benefits, e.g., natural flood management.

[1] Waylen, K., Wilkinson, M.E., Blackstock, K.L. and Bourke, M., 2024. Nature-Based Solutions and Restoration are intertwined but not identical: highlighting implications for societies and ecosystems. *Nature-Based Solutions*, p.100116.

impact water quality, physical condition, and the migration of wild fish. This is reflected in the Scottish Wild Salmon Strategy[2] priority to improve the condition of rivers and give salmon free access to cold, clean water. Restoration actions can address key pressures affecting wild salmon and their habitats by reducing human impacts to water quality and quantity, thermal habitats, instream and riparian habitats and fish passage.

Delivering projects that benefit rivers and catchment-scale processes also aligns with a number of international frameworks:

Global Biodiversity Framework[3] (GBF): Within the GBF, there are not only goals related to restoration, but also around creating the enabling conditions for restoration. River and catchment restoration projects align with GBF targets related to areas under effective restoration, conservation and management as well as targets related to maintaining species diversity, addressing impacts of invasive species, delivering ecosystem services, reducing pollution risks, minimizing impact of climate change on biodiversity and increasing resilience, and sustainable agriculture.

Taskforce on Nature-related Financial Disclosures[4] (TNFD): The TNFD highlights the need for businesses to better account for nature in their business decision making, including in understanding their businesses' dependencies and impacts to nature along with their nature positive initiatives. As part of this disclosure process, businesses better understand their interface with nature, which can inform corporate actions or investments in improving the state of nature (condition, extent, connectivity) and delivering ecosystem services. Catchments can provide a good scale for place-based investment.

IUCN Global Standard for Nature Based Solutions[5]: This framework highlights the importance of outcomes related to biodiversity, ecosystem integrity and connectivity, as enhancing ecosystem processes can contribute to the long-term resilience of nature-based solutions.

UN's Sustainable Development Goals[6] (SDGs): SDG targets emphasize the importance of protecting and restoring water-related ecosystems including rivers and wetlands, as well as protecting, restoring and promoting sustainable use of terrestrial ecosystems.

[2] https://www.gov.scot/publications/scottish-wild-salmon-strategy/

[3] https://www.cbd.int/gbf

[4] https://tnfd.global

[5] IUCN Global Standard for Nature-based Solutions | IUCN

[6] https://sdgs.un.org/goals

Why monitor?

The aim of the River Catchment Restoration Fund (the Fund) is to support the delivery of projects that help to restore biodiverse, healthy and resilient river ecosystems within catchments across Scotland. The collective group of restoration projects and activities supported by the Fund represent a 'Portfolio' of projects (Figure 1). Basic monitoring can demonstrate restoration actions have been completed by projects in the Portfolio, which shows Fund contributors that money is being well spent. However, to demonstrate to Fund contributors that projects are trending towards or have achieved their identified objectives and outcomes will require post-project monitoring of key indicators or metrics[7]. Collecting this data before and after a restoration project has been completed can show how an area has changed in response to the project and can help to inform whether the restoration actions have been effective in improving ecosystem condition.

> Well-structured monitoring can communicate progress to Fund contributors with credible data that can evidence this change.

A clear and consistent approach to monitoring can help to ensure projects across the Portfolio are successful in delivering verified, long-lasting, and additional environmental outcomes, consistent with Scotland's principles for high integrity investments.[8] Specifically monitoring can:

- Characterize the existing condition of a river and its catchment, including human pressures and impacts.
- Demonstrate and verify that restoration actions or interventions have been completed as planned.
- Show how the river or catchment condition has changed in response to restoration actions or interventions (both at a local, reach scale but also where multiple projects together could create catchment-scale change).
- Demonstrate whether projects are on track to meet their objectives.
- Reduce the risk of project failure by informing when additional interventions or adaptive management may be needed to make a project successful.
- Provide an opportunity to learn what restoration techniques worked well or didn't work well to improve future designs and support the broader scientific evidence-base around restoration actions and successes.

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[7] Riverwoods Measuring and Monitoring Framework (2024)

[8] https://www.gov.scot/publications/natural-capital-market-framework/pages/3/

The River Catchment Restoration Fund

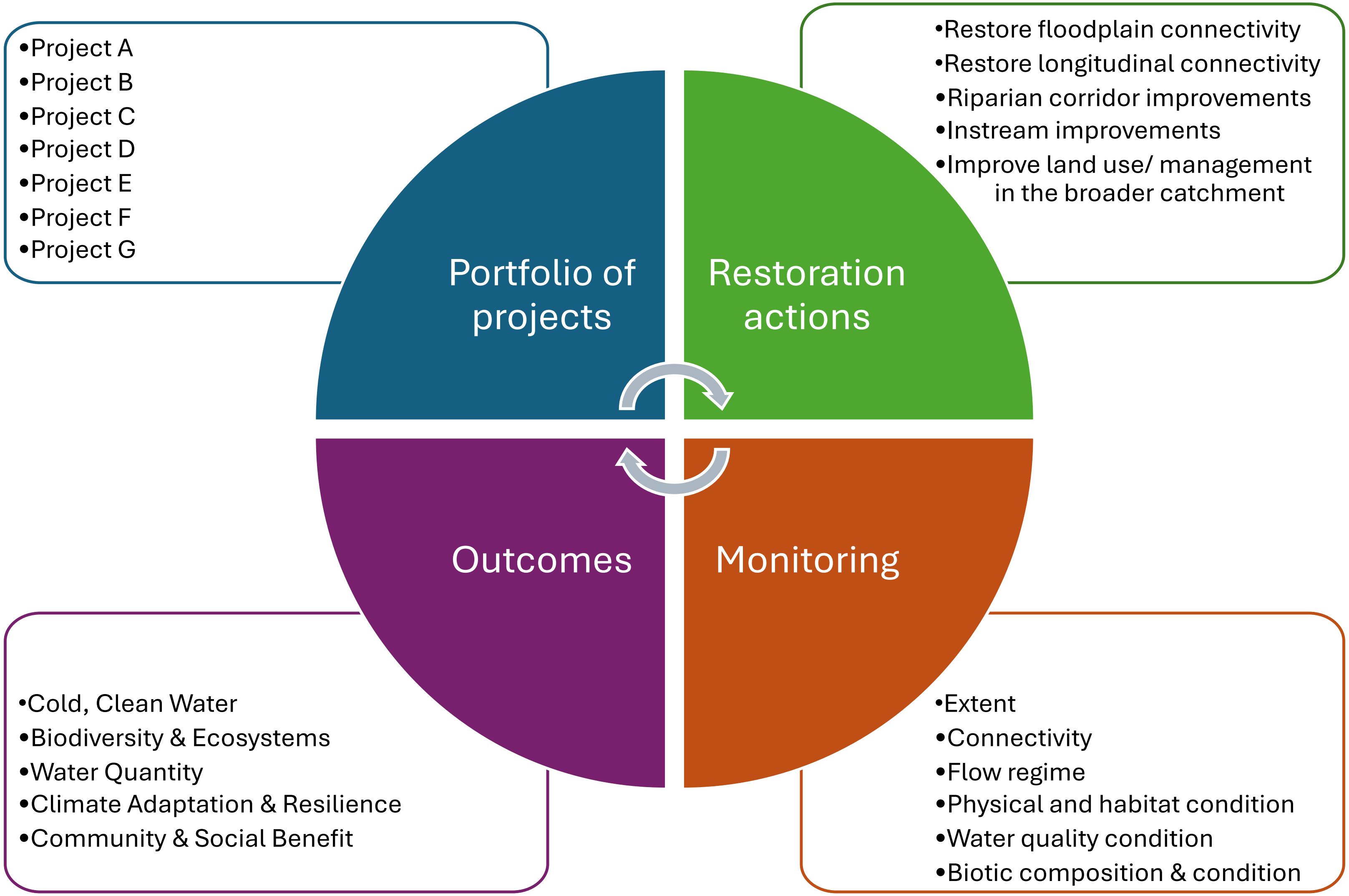

Figure 1: The River Catchment Restoration Fund supports a portfolio of projects. Each project within the portfolio will deliver one or more restoration actions that contribute to Fund outcomes and monitor key ecosystem attributes to document changes in the extent and condition of restored areas over time. This monitoring will inform whether a project has or is on track to achieve Fund outcomes. Outcomes will be summarized and reported at the portfolio-level for Fund contributors.

What does the Monitoring Framework do?

The monitoring framework provides a consistent approach for monitoring and reporting for all projects supported by the River Catchment Restoration Fund. This framework is structured so that outputs, outcomes and performance can be tracked for individual projects and some data about these projects can be summarized and reported at the portfolio-level.

As rivers are naturally diverse and dynamic ecosystems, this framework provides a flexible and adaptable approach, allowing for monitoring plans to be tailored for each project. The approach is proportionate, meaning that larger, more complex or novel projects may monitor differently than smaller projects, for example, to build evidence on effective restoration techniques and ensure use of meaningful indicators and monitoring methods.

The Portfolio will include a range of projects, all at various stages of a project life cycle, which affects what information can be reported when for each project. To address this, the framework identifies key review and reporting milestones within three project stages, including planning, delivery and monitoring:

- Planning – This stage includes projects that have been accepted within the portfolio, but where restoration actions or interventions have yet to be initiated. Early project planning activities may be centred around site selection, capacity building or addressing other resource gaps needed to develop a project pipeline. Later in the planning stage, projects may be more clearly defined and closer to delivering restoration actions, for example, having already completed baseline assessments or conceptual designs. The Fund may allocate funds to support early planning and development activities, but how this would be structured and monitored is yet to be decided.
- Delivery – This stage includes projects that are ready to, or actively initiating restoration actions. This stage includes detailed design and construction. The length of the delivery stage will vary depending on the project and generally includes the time it takes for restoration works or short-term management plans to be completed.
- Monitoring – This stage includes projects that have completed restoration works or short-term management plans and have transitioned into post-project monitoring and/or implementation of long-term management plans.

The framework provides:

- A stepwise process to develop an effective monitoring plan.
- Recommended monitoring and reporting milestones.
- Information on the data needed across all projects for portfolio-level reporting.
- Information on established indicators and methods that could be used for project-level monitoring.

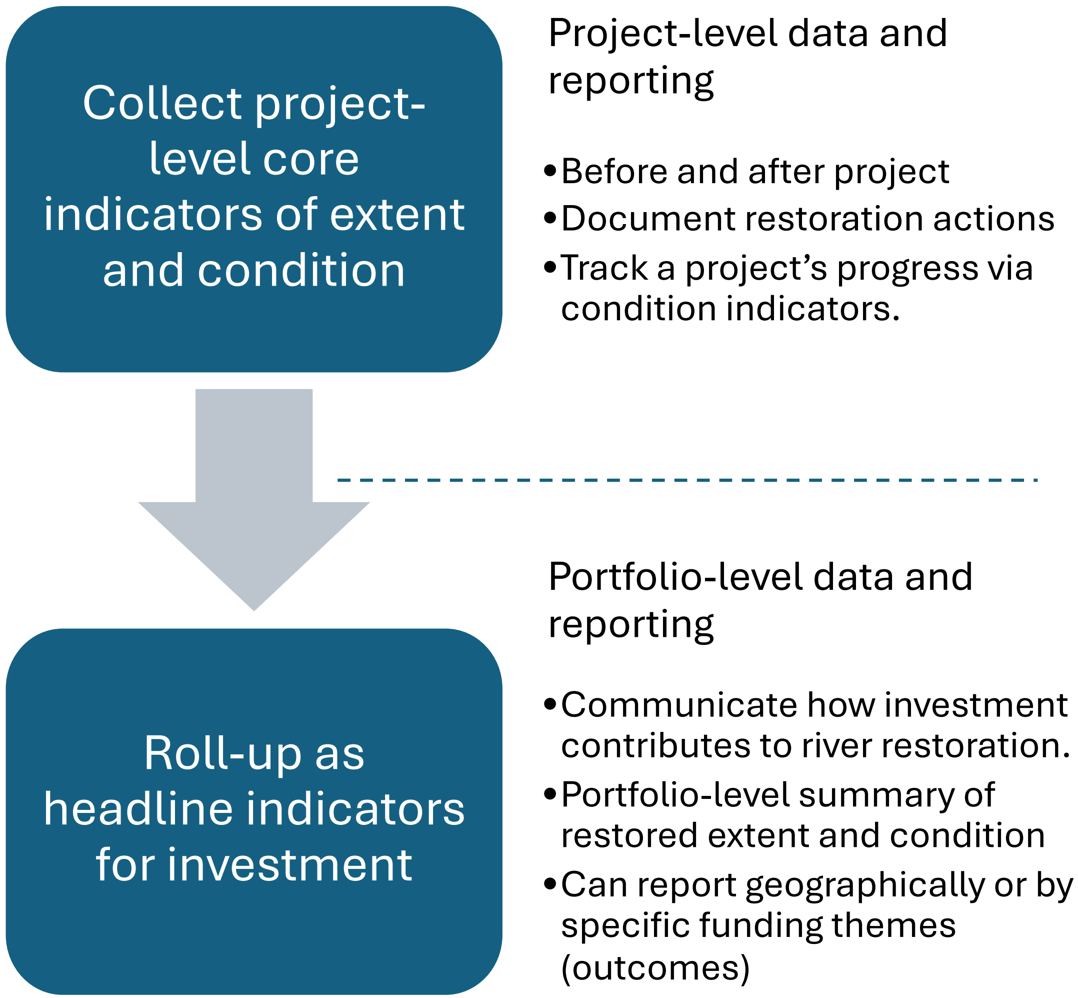

Figure 2: Illustration of how project-level monitoring and reporting can support summary indicators at the portfolio level.

The monitoring framework is organized into two sections – project-level and portfolio-level reporting (Figure 2). At a project level, it's important to collect monitoring data for all projects to understand whether actions have been effective in delivering objectives. The monitoring framework lays out a consistent, stepwise process for projects to develop a monitoring plan for meaningfully tracking changes over time and to report verified, positive outcomes for nature.

At a Portfolio-level, not all the detailed information for each project will be relevant to fund contributors, so monitoring data from each project will be rolled up and reported within a set of headline indicators. For example, these headline indicators illustrate the extent of all project actions and interventions (hectares), as well as how projects improve the state of nature and contribute to key outcomes, including cold, clean water; biodiversity and ecosystems; water quantity; climate resilience and adaptation; and community and social benefits. Additional themes or outcomes can be added to the framework as needed to meet the future interests or reporting needs of fund contributors.

Portfolio-level Indicators and Reporting

The Fund will support a range of restoration actions within rivers and their catchments within the Portfolio. To accommodate a broad range of projects across different spatial scales, monitoring plans will need to be tailored to each project. All projects will collect certain data to communicate that actions have been delivered (outputs) and that the actions are improving the state of nature (outcomes). This information will be summarized at the portfolio level so contributors can see results across all projects within the portfolio via a suite of headline indicators. These headline indicators will provide fund contributors with high-level information about what is being delivered by projects within the portfolio. Communicating project outputs and outcomes with headline indicators at the portfolio level allows the detailed project-specific data to be summarized in a way that is useful and relevant to Fund contributors.

Headline indicators

These are high-level summary indicators that can quickly and clearly communicate the successes of the fund. They will 'roll-up' data from all participating projects and can be presented in a simple infographic or dashboard format.[9] The Scottish Marine Environmental Enhancement Fund[10] (SMEEF), is structured to allow funders to contribute to specific 'themes' or types of projects. Following this model, the portfolio's headline indicators can be communicated for the whole portfolio, by catchment or within specific funding themes.

Headline indicators can capture a range of information about portfolio projects, including the number of projects within the portfolio, the portfolio's contribution to

What are indicators?

Indicators are observable or measurable physical, chemical and/or biological attributes that provide information on the structure, composition and/or function of ecosystems. They can be used to evaluate ecosystem condition, and track progress towards achieving outcomes.

What are outputs?

Outputs are the restoration actions or activities that are delivered as part of a project.

What are outcomes?

Outcomes are linked to a project's goals and objectives and reflect the changes in the ecosystem that occur over time following restoration actions. They are measured using relevant indicators based on consistent and transparent measurement methods.

[9] As an example, see the Catchment Based Approach's 22/23 Monitoring and Evaluation Report

[10] https://smeef.scot/

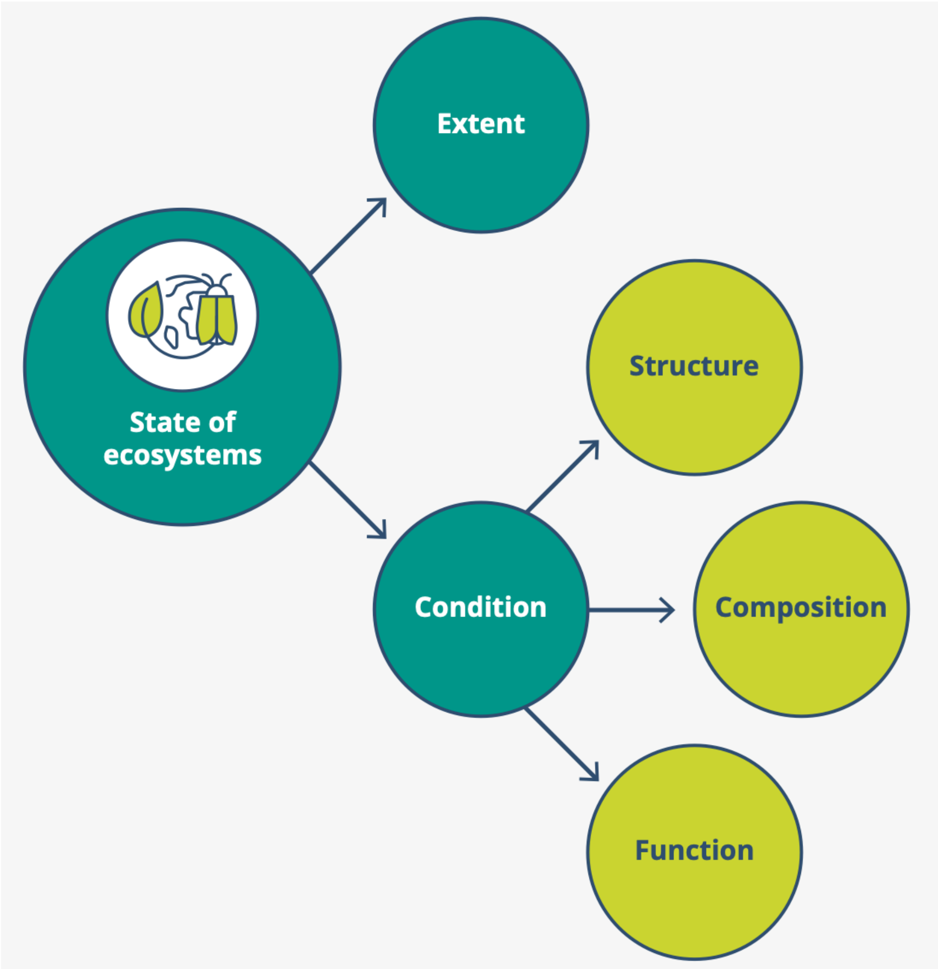

Figure 3. The extent and condition components used to characterize the state of nature. Reproduced from the *Guidance on the identification and assessment of nature-related Issues: The TNFD LEAP approach,* Version 1.1, October 2023

improving the state of nature, and information on whether projects are within the planning, delivery or monitoring stage of a project. Appendix C provides examples of headline indicators.

Both headline and supporting project-level indicators are organized to reflect the state of nature, aligning with the TNFD's Framework and other global strategies[11] (Figure 3). State of nature indicators include measures of extent (e.g., the area being restored) and condition (e.g., physical and ecological indicators of structure, composition and function).

Extent measures are quite simple to report, as they reflect the total area or length being restored within each project.[12] They can easily be 'rolled-up' and summed at the portfolio-level and can be reported for each ecosystem type (e.g., river, floodplain wetlands, non-floodplain wetlands, terrestrial, etc.) or within specific catchments or other relevant geographic areas.

Measures of condition, which capture how an ecosystem has improved following a project, are an important compliment to measures of extent. Condition indicators can vary depending on a project's actions and objectives, and thus they are more difficult to summarize at the portfolio level. Instead of aggregating results for each indicator at each site, the portfolio will instead report on whether each project's condition is improving over time based on the project-level indicator monitoring. At the portfolio-level, this provides a summary of how many projects have demonstrated improved condition via monitoring.

[11] See https://tnfd.global/tnfd-publications/ and https://www.naturepositive.org/metrics/

[12] https://www.wri.org/technical-perspectives/metrics-incentives-corporate-contributions-nature

Delivering on specific themes and outcomes

Headline indicators can be summarized and reported within different themes linked to benefits and outcomes. These themes may be of particular interest to Fund contributors because they address specific types of pressures that relate to business impacts on nature or offer attractive nature-positive opportunities that resonate with contributors' interests. The monitoring framework is designed to aggregate outcomes at the portfolio-level to deliver and report on outcomes within the Fund as a whole, as the Fund does not intend to connect contributors directly to specific projects. However, contributors may be interested in claiming or purchasing specific outcomes, for example, to meet their corporate impact reporting requirements. Portfolio-level outcomes could be allocated to address this need, for example, via a proportional allocation of restored area (hectares) based on the level of contribution over a specified timescale. This 'amount' of restored area could be linked to specific outcomes or geographic location of interest to the fund contributor. For this, the Fund would need to consider governance arrangements around the allocation and verification of outcomes and what allocation approach may best support contributor reporting requirements.

River-related projects create multiple benefits and it's important that these benefits are communicated at the portfolio level in a way that is relevant to Fund contributors who will likely be interested in a wide range of benefits, including positive outcomes for nature[13]. This section outlines four key environmental outcomes and one social outcome for river restoration projects that may align with contributors' nature positive investments and could be used to aggregate reporting on project-level outcomes related to specific funding themes within the Fund. Note that the structure of the Fund, what themes may be included, and how they will be integrated is still being decided.

The four environmental outcomes include biodiversity and ecosystems; cold, clean water; water quantity; and climate adaptation and resilience. Each are described in more detail below. These outcomes are framed to align with the function-based attributes identified within the Riverwoods Measuring and Monitoring Framework (2024). Appendix A outlines additional information on how common river or catchment restoration actions support each of the four environmental outcomes, examples of extent and condition indicators that could be used to demonstrate these outcomes, as well as key references.

The social and community benefits theme focuses on wider benefits e.g., through community engagement, improving nature access, local job creation and skills development, or other social benefits. Information on the community and social benefit

[13] Finance for Biodiversity Foundation and United Nations Environment Programme (2024) *Finance for Nature Positive: Building a working model.*

outcome will be provided in the Community Engagement Strategy paper.[14] Additional social or wider benefit themes could also be added. For example, a ‘capacity building’ theme could focus on advancing scientific understanding through more detailed or rigorous monitoring, building capacity within programs or communities to undertake additional projects or activities, building skills and training for project staff and volunteers, or building strategic catchment partnerships and plans.

Within each theme, additional headline indicators could be reported where contributing projects are consistently collecting the same project-level indicators using comparable methods. For example, this could include the number or % of projects that have documented improvements for key indicators within each theme or provide cumulative totals for outputs or outcomes that are delivered (e.g., number of fish passage barriers removed, number of woody structures installed, total length of riparian buffer established, number of volunteers, etc). The reporting dashboard could also provide examples of the project goals and objectives within each theme so fund contributors can see the types of projects being delivered. Additionally, after monitoring has begun, before and after photographs can illustrate how the state of nature has improved at project sites.

Key themes and outcomes for river catchment projects

Biodiversity and ecosystems

River and catchment restoration projects can improve the quality, extent and resiliency of instream riparian and floodplain habitats, as well as other non-floodplain habitats within the broader catchment. Projects that remove embankments or barriers can increase connectivity between habitats, allowing water, sediment, nutrients, fish and wildlife to move more freely between these habitats. Projects that reconnect rivers and their floodplains can create newly accessible aquatic habitats within the floodplain during higher flows – as vegetation grows and establishes, there will also be more resources to support food webs. Tree planting provides shade, helps to stabilize banks and contributes to more complex habitats. Higher quality habitats can often mean more resilient and diverse biological communities. These benefits can often extend beyond the river environment, providing better habitats and food sources for terrestrial wildlife, including bats, birds and mammals.

[14] The Community Engagement Strategy paper is currently being drafted by FMS as part of the FIRNS project and will be available in Spring 2025.

Outcome-specific indicators could include: the cumulative number of barriers to fish migration removed, kilometres of restored corridor length, or the percentage of projects that include biological monitoring and objectives.

Cold, clean water

River and catchment restoration projects can also improve water quality. Natural riparian corridors act as buffers between rivers and the surrounding landscape, trapping water, nutrients and sediment before they enter rivers. Improved land management, both within the riparian corridor, as well as more widely in the catchment, can improve the way water runs off the land, meaning that less nutrients and sediments reach the river after it rains. Reconnecting rivers to their floodplains can improve regional ground water connections, resulting in improved water quality and moderated instream temperatures. Additionally, improving riparian vegetation cover, e.g., via riparian woodland planting projects can, over time, increase shading, which supports colder waters for fish.

Outcome specific indicators could include the extent of contributing catchment or riparian area that has been restored to more natural vegetation communities or is under improved land management measures. As standardised, cost-effective tools emerge (e.g., water quality and stream shading metrics within the Woodland Water Code), projects contributing to this outcome could estimate the total nutrient reduction associated with their project, and this could be aggregated at the portfolio level.

Water quantity

River and catchment restoration projects can support improved hydrological processes. Improved land management, both within the riparian corridor, as well as more widely in the catchment, can result in more natural runoff and infiltration processes. Restoring connections between rivers and their floodplains within the catchment can improve natural surface water storage and groundwater/surface water interactions, restoring more natural flow regimes and supporting more natural flows within low flow periods.

Outcome specific indicators could include cumulative total increase in the extent of aquatic and floodplain area. As consistent and cost-effective tools emerge, projects contributing to this outcome could estimate the total surface water storage volume or other relevant natural flood management indicators and this could be aggregated at the portfolio level.

Climate adaptation and resilience

River and catchment restoration projects improve a river’s absorbing capacity and thus the ecosystem’s ability to be resilient and adaptable to a changing climate. Actions that support improved habitats, water quality and water quantity outcomes create resilience to changes in temperatures, droughts and flooding associated with a changing climate. Restoration actions like restoring floodplain connectivity and riparian corridors create more space for natural carbon sequestration and cycling, where large wood and organic matter can accumulate, and natural vegetation can grow and establish.

Outcome specific indicators could include the number of trees planted or the area of floodplain/riparian corridor restored (i.e., making space for the river). As consistent and cost-effective tools emerge, projects contributing to this outcome could estimate relevant natural flood management indicators and/or the amount of carbon sequestration. If all contributing projects rely on a consistent, standard set of indicators and data collection methods, these results could be aggregated at the portfolio level.

Community Benefit & Engagement:

Including local communities either in the restoration process itself or by hosting events which seek to improve human-river connection can help increase the chance of successful conservation and restoration efforts. Understanding what matters to communities and how they want to be involved can help inform how these groups are likely to benefit (or not) from river restoration work and what engagement methods may be needed. Each project may require a different approach, depending on the type and scale of the project, the community engagement experience of the project team, and the surrounding social context. Activities could include providing volunteer tree planting opportunities, pilot site demonstrations, citizen science kick sampling, classroom visits, setting up a stall at a local market, and organising forums to solicit feedback. Measuring social impact and benefit can be very difficult given the heterogeneity within communities in what they value, so there is a need to choose indicators that balance data collection effort with information usefulness.

Outcome-specific indicators and guidance for this theme will be outlined in a separate Community Engagement Strategy paper.

How Indicators Track Portfolio Projects Over Time

Projects within the Fund will deliver successful outcomes via a range of restoration actions. The ecosystem won't respond immediately once the work is done - it can take time for river ecosystems to adjust following intervention, which means that it can take time to see results via monitoring. Even when portfolio projects are 'shovel ready,' it can take several years to deliver actions, and longer still to report these outputs and the resulting outcomes to Fund contributors. Because of this, it's important for portfolio reporting to accurately reflect where different portfolio projects are across the planning, delivery and monitoring stages of a project life cycle.

By reporting indicators differently within each stage, the portfolio can communicate progress towards outcomes before the outcomes can be evidenced (Figure 4). This allows Fund contributors to see how projects come together, and the time that is required within each stage to deliver meaningful actions. For example, the portfolio may include a collection of projects, which, in total, are committed to restoring 500 kilometres of river and riparian corridor. This reflects an anticipated outcome that could be reported at the outset. However, to demonstrate that the portfolio has achieved this outcome, there would need to be evidence that project-related actions took place during the delivery stage (**outputs**), and that improvements in condition were documented through monitoring (**outcomes**).

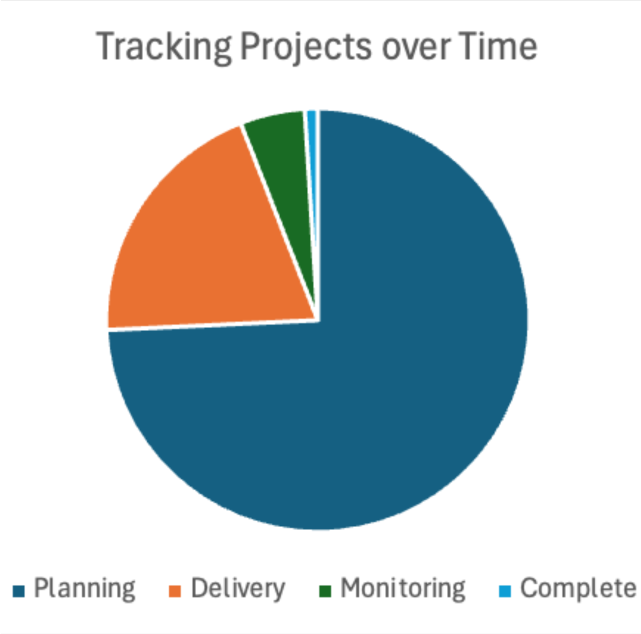

Figure 4. Example infographic to communicate where different portfolio projects are within a project life cycle.

When a project completes the relevant reporting milestone(s) within each stage, the project would transition to the next stage in the life cycle (Figure 5; also described in the Review and Reporting Milestones section below). In the planning stage, headline and themed indicators would be reported as committed outcomes/outputs. Once a project moves to the delivery stage, the reporting shifts to capture the projects' outputs. The length of the delivery stage will vary depending on the project - for some projects, all works may be completed within a single season, however other projects may involve more complex works that will be phased across multiple years. Once all works have been completed and documented, projects move into the monitoring stage, where portfolio-level reporting will communicate whether projects are 'on track to achieve' or 'have achieved' outcomes as monitoring data are collected and reported. The monitoring length may range from 5 to 15 years, depending on what is outlined in each project's monitoring plan; the portfolio-level reporting can communicate the average funded monitoring length across all projects.

	Portfolio-level	Project-level
Planning	• Communicate basic information and anticipated outcomes • **Example Indicators:** No. of 'verified' projects, total area/length committed for restoration, % of projects contributing to each outcome	Define outcomes and establish baselines **Review Milestones:** - *Interim:* Provide basic project information, a description of the site and catchment context and proposed restoration actions. - *Final:* Identify project extent, develop a monitoring plan outlining clear objectives, indicators and methods, collect baseline data
Delivery	• Communicate outputs, showing that the money is being well spent • **Example Indicators:** 'verified' extent of areas under restoration or improved land management (hectares/km) and outputs delivered (e.g., number of trees planted, number of barriers removed, etc.)	Document Outputs **Interim/Final Review Milestones:** Document site activities, including any variations from the plan, and provide maps and photographs
Monitoring	• Communicate progress towards delivering outcomes • **Example Indicators:** Area being monitored, average length of monitoring period, % of projects on track to achieve objectives, % that require adaptive management, % with monitoring complete	Track progress towards outcomes **Interim/Final Review Milestones:** Collect post-project data per monitoring plan, report on indicators to document change over time, assess whether adaptive management is needed or a project is on track to achieve outcomes

Figure 5: This figure illustrates how portfolio and project-level reporting and review milestones will vary across the three different stages within the life cycle of a project. It includes milestones and reporting within the planning stage, although possible early planning stage activities are not captured (e.g., catchment planning, site selection, or capacity building that happen prior to identifying a specific project).

Project-level Indicators and Reporting for Environmental Outcomes

What are the aims of project-level monitoring?

Project-level monitoring can be used to evaluate improvements in ecosystem extent and condition against a documented baseline and to inform portfolio-level reporting to fund contributors. The nature of a river changes as you move upstream and downstream within a catchment, both naturally and because of the human activities affecting different parts of the landscape. Because each part of a river is unique, it's important for project actions to be place-based. Different approaches may be needed to address the key pressures and impacts, and this means that each project may have different goals and objectives that reflect this context. The aim of this framework is to provide a consistent approach to monitoring, while allowing flexibility for each project to propose appropriate restoration actions, with goals and objectives that are tailored to the site and catchment-specific context of the project.

The framework outlines a consistent, stepwise process for identifying objectives and selecting indicators to be monitored. It is not prescriptive but instead allows projects to tailor indicators and monitoring approaches to the proposed restoration actions, which may also vary in their spatial scales and complexity. This creates flexibility for each project to develop relevant monitoring plans that suit their project.

Why is it important think about river functions?

Rivers are the result of many processes occurring at different spatial and temporal scales, which shape the way that water moves across and through the landscape.[15] At a catchment or landscape scale, factors like climate, geology, catchment size and land use will influence the movement of water and sediment, in turn shaping the type of river that flows through different parts of a catchment. Within the river itself, different processes interact to create the resulting physical, chemical and biological conditions that, when functioning, create dynamic, resilient systems. Hydromorphic functions represent the hydrologic, hydraulic and geomorphic processes that create the physical environment of rivers. Water quality functions represent the chemical environment and the nutrient and chemical processing that occurs within river systems. Biological processes represent the aquatic and terrestrial organisms who depend on the aquatic and riparian environment. Oftentimes, restoring the physical environment (i.e., hydromorphic processes) within rivers, riparian corridors and contributing catchment areas can lead to improved habitats and biodiversity, greater climate resilience, as well as improved temperature regulation,

[15] See Appendix A for a list of key references related to rivers and their processes.

soil quality and nutrient processes. These functions can take time to establish and may also be limited by pressures and impacts occurring at broader spatial or temporal scales.

Figure 6 illustrates these interactions in a pyramid shape, representing how some functions provide support for other functions, and local geology and climate influence all functions by the way water moves from the broader catchment into the river. Key hydromorphic functions, like how water and sediments move from the catchment into and through rivers, will affect the water quality and biodiversity within rivers. Note that the opposite can also occur - sometimes beavers, large wood, and deeply rooted vegetation can influence hydromorphic processes. Given the complexity of interactions, it's important for river and catchment restoration projects to consider how these processes interact to a create resilient environment within the project area when developing objectives and planned activities.

Thinking about rivers, how they function, and how some functions support others can lead to better restoration projects, as it allows for a more integrated way to address the pressures and impacts affecting rivers. This type of integrated strategy is a key aspect of the Convention on Biological Diversity's ecosystem approach, which highlights the importance of not only considering biodiversity, but also the supporting processes and interactions between organisms and their environment.[16]

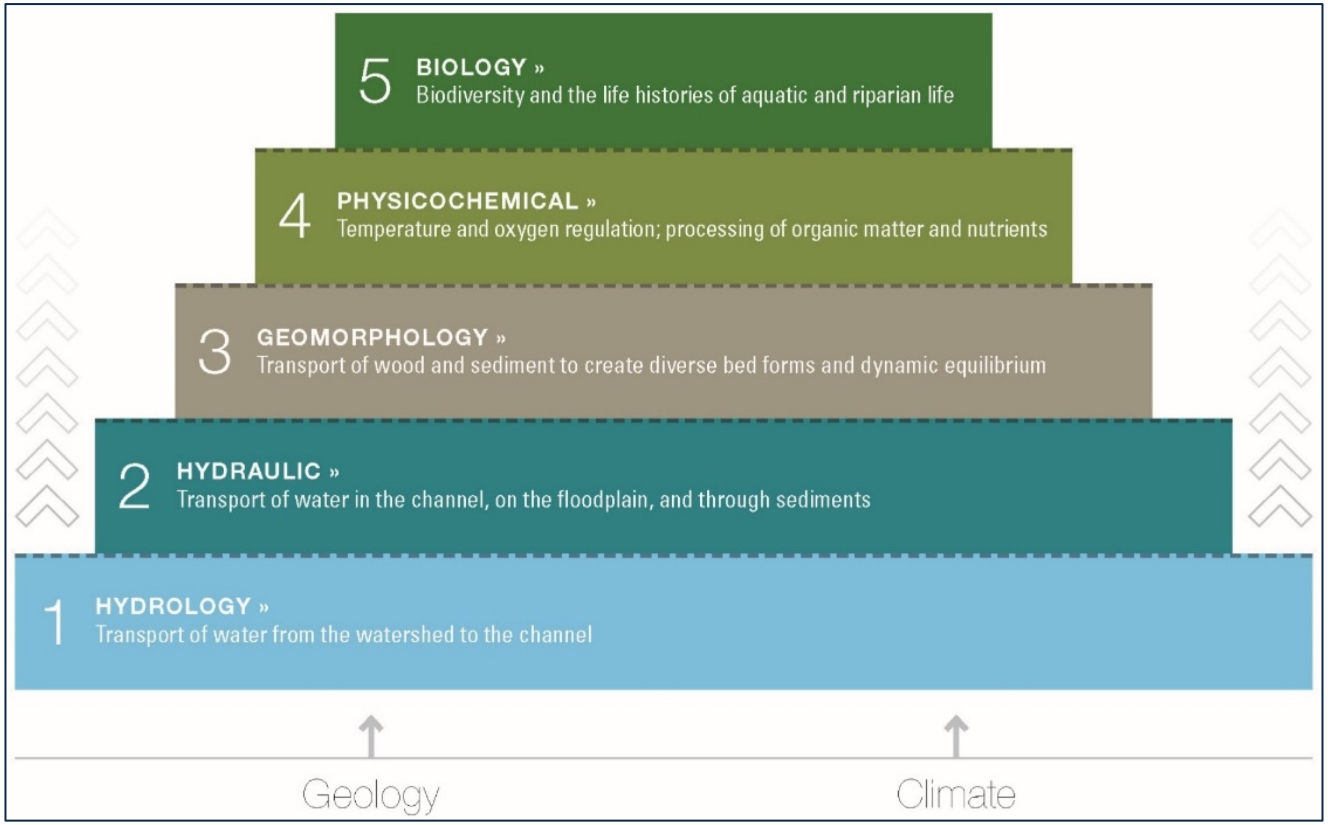

Figure 6. The stream functions pyramid; reproduced from Harman et al. (2012).[17]

[16] Secretariat of the Convention on Biological Diversity (2004) The Ecosystem Approach, (CBD Guidelines) Montreal: Secretariat of the Convention on Biological Diversity

[17] Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

Developing an effective monitoring plan

A key to developing effective monitoring is to think about project evaluation right at the start. For monitoring to be effective, it's important that the baseline and monitoring data are relevant to the project and that the resources needed to collect and report on these data are appropriately factored into project costs. Data that are collected should inform observable or measurable ecosystem indicators that can be used to track and communicate how well a project activity is working to achieve a project's goals and objectives. When monitoring is done effectively, it not only provides meaningful data to demonstrate changes over time and communicate environmental outcomes, but it also can provide early indication of challenges or difficulties, allowing for rapid intervention when actions fail to achieve their objectives. This allows for projects to adjust course, as needed, to ensure that projects are successful.

This section outlines a series of steps to aid in selecting relevant indicators and meaningful methods for monitoring. They are informed by well-established good practice guidelines[18] and are intended to align with the proposed approach for monitoring and assessment currently being developed under the Riverwoods Blueprint Project[19]. These steps help to highlight key information needed to develop a monitoring plan and to provide a clear picture of how monitoring can evaluate success (Figure 7).

Appendix E provides a template for documenting the key elements for a monitoring plan. Worked examples using the first part of this template are provided in Appendix B.

Having a written monitoring plan creates a clear understanding of:

- What success will look like
- How progress will be monitored
- How a project will contribute to portfolio-level outcomes
- When adaptive management measures will be needed.

Monitoring plans should be detailed enough to ensure consistency throughout the monitoring period, e.g., in the case of new staff. They should describe:

- Which indicators will be monitored
- How they will be measured
- The location, frequency and timing of monitoring
- How indicators or evidence will indicate that adaptive management is needed to achieve objectives.

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18 See for example, the River Restoration Centre's Practical River Restoration Appraisal Guidance for Monitoring Options (PRAGMO), the European Centre for River Restoration's How to do river restoration and Roni and Beechie (eds). (2013) *Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats*

19 https://www.riverwoods.org.uk/streams/blueprint/

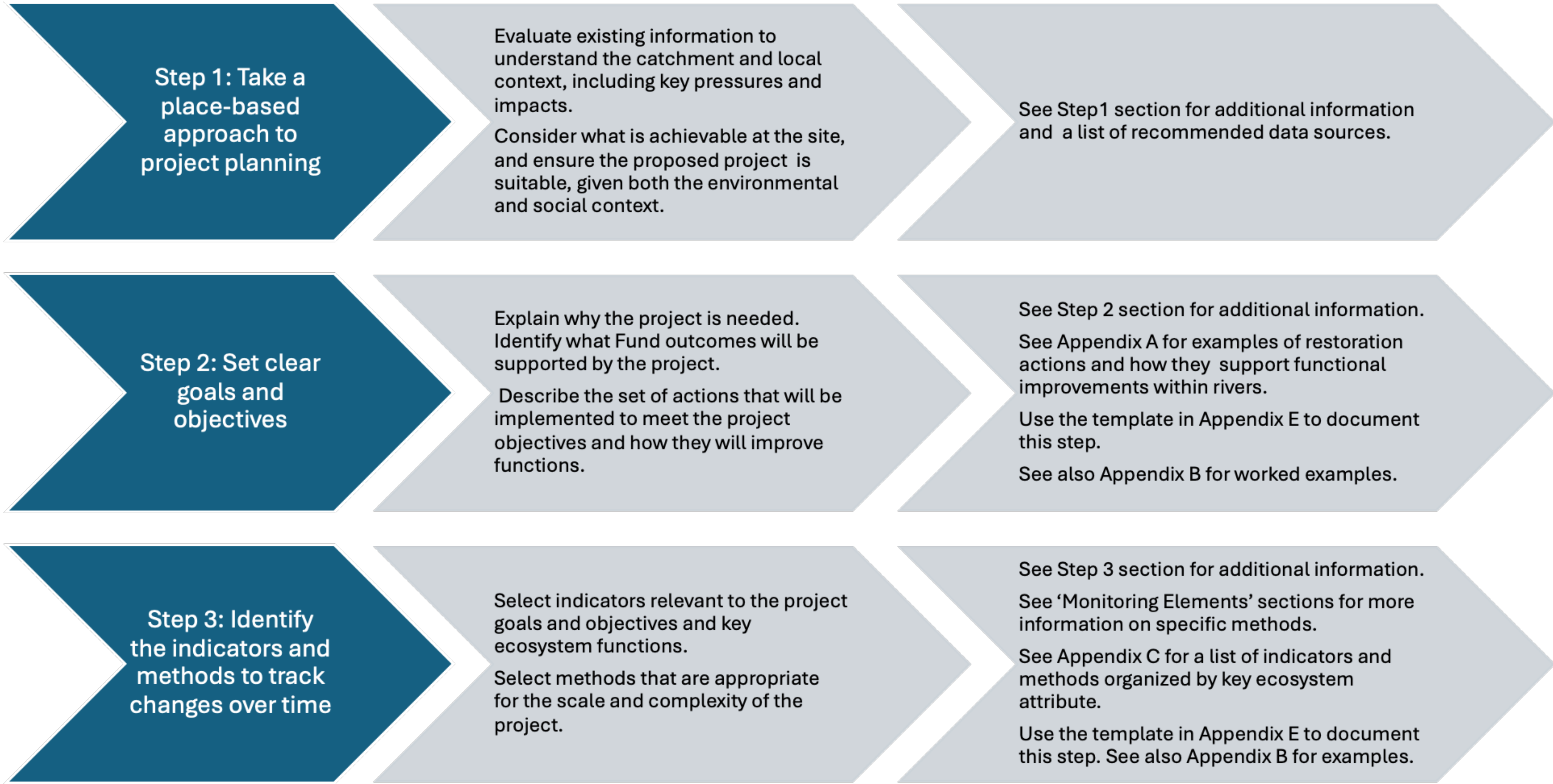

Figure 7: This figure illustrates the stepwise process to developing an effective monitoring plan, highlighting what needs to be done as part of each step and where relevant information can be found within the document.

Step 1: Take a place-based approach to project planning

There is not a one-size-fits-all approach to restoration in rivers - the actions needed to improve or restore river ecosystems across Scotland will vary depending on the catchment and local context. In project planning, it's important to take a place-based approach to ensure the project actions are suitable for the site, given both the environmental and social context. Project developers should consider the catchment characteristics, current river classification and condition, key pressures and impacts, and reach-scale constraints that could limit the outcomes or affect the types of action appropriate for the site. It's also important to consider the social and community context and integrate insights from any community collaboration or engagement efforts. Information can be gathered from a range of existing sources to inform site context (see box below).

In this step, it's important to think about what may be achievable at a site, based on what is known about the existing condition in relation to similar rivers within the catchment and whether pressures or constraints can be addressed by a project. For example, in some cases, a project may be in an area where water quality and the surrounding catchment are in relatively good condition. In this instance, restoration actions that address instream or floodplain impacts could have the potential to restore the site to a high natural or near-natural condition. Similarly, in these settings, actions could be put in place to maintain good condition and ensure resiliency in the face of emerging pressures and impacts, e.g., from climate change. In other cases, where a catchment is no longer in good condition, a project may be able to improve some functions compared with pre-project or baseline conditions, but catchment pressures or reach-scale constraints prevent the site from achieving natural or near-natural conditions. In the latter example, projects can still be beneficial even if restoring a high-functioning natural ecosystem may not be possible, but the projects may not result in measurable improvements to water quality or biological condition due to limiting factors external to the project.

Figure 8. Examples highlighting the diversity of river systems in Scotland.

Potential data sources to inform site context include:

- Catchment-scale plans: Consider how the project fits within the overall catchment strategy or priorities outlined in Fisheries Management Plans[20] or other catchment-scale planning effort. River Trusts or other catchment partnerships may have catchment management plans in place, or one could be developed[21].
- Scotland River Temperature Monitoring Network[22]: Where available, data includes daily temperature metrics (mean, max, min), as well as degree days and temperature exceedance data for specific fish and invertebrate species.
- National Electrofishing Programme for Scotland[23]: Survey data from 2018, 2019 and 2021 can provide baseline estimates and benchmarks for salmon and trout density, as well as introgression and water quality variables across all catchments within Scotland.
- Scotland's River Basin Management Plan[24] and Water Classification Hub[25]: Aligned with the Water Framework Directive, the River Basin Management Plan provides a river basin perspective for addressing pressures and impacts, including information on existing conditions, pressures leading to less than good condition; potential restoration actions and outcomes following implementation. The water classification hub allows you to view these classification results and evidence, along with routine water monitoring data at the waterbody (river reach) scale for baseline rivers (i.e., those with catchment size >10 km^2).
- Scotland's Environment Map[26]: This online mapper includes a number of useful data layers, including River Recovery Potential, Recommended Riparian Corridors, Riparian Vegetation Planting Opportunities, River Anthropogenic Modification Index, River Classification, Sites of Special Scientific Interest, Special Areas of Conservation and other protected areas, Native Woodland Survey, etc.

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[20] These have been developed for each Fisheries Management District in Scotland. https://storymaps.arcgis.com/collections/0f6b2fbb82cd4785b29b268aebce38a9?item=1

[21] The River Restoration Centre offers training and guidance on developing catchment plans: https://www.therrc.co.uk/catchment-planning

[22] https://scotland.shinyapps.io/sg-srtmn-data/

[23] https://scotland.shinyapps.io/sg-national-electrofishing-programme-scotland/

[24] https://www.sepa.org.uk/media/594088/211222-final-rbmp3-scotland.pdf

[25] https://informatics.sepa.org.uk/WaterClassificationHub/

[26] https://map.environment.gov.scot/sewebmap/

- SEPA's River Recovery Potential – Will the River Do the Work[27]: context on the river type and energy environment, indicating the level of intervention that may be needed to restore a particular reach. Note that a River Recovery Potential data layer is available in Scotland's Environment Map; however, because of the resolution of mapped data, it may also be useful to conduct a field assessment for the project area.
- Biodiversity datasets: Local biodiversity data can be accessed via a number of sources (see NatureScot's website[28] for up-to-date links). Data may also be available from citizen-science monitoring efforts, including Riverfly[29] and SmartRivers[30] programmes.

STEP 2: SET CLEAR GOALS AND OBJECTIVES

Monitoring is needed to show that restoration actions have improved condition and contributed to broader ecosystem outcomes. Setting clear function-based goals and objectives is particularly important to ensure that the project addresses and improves key functions within the ecosystem and that monitoring aligns with these functions.

When developing goals, portfolio projects should consider how restoration actions could contribute to the key environmental outcome themes outlined for the Fund, including biodiversity and ecosystems; cold, clean water; water quantity; and climate adaptation and resilience. Aligning goals under Fund themes helps to communicate to fund contributors how projects and monitoring will be relevant to their interests. See Appendix B for examples of project goals and objectives.

The place-based context described in Step 1 above will inform what is achievable and realistic at a site. Predicting or forecasting outcomes can sometimes be challenging given the dynamic nature of river systems. It's important that objectives are achievable and flexible enough to accommodate a range of conditions that may be appropriate for the site context and catchment setting. Here, considering what may be unacceptable as well as what is achievable can be useful to decide when adaptive management measures may be needed to adjust course to meet objectives.

[27] https://www.sepa.org.uk/media/ifcaytdm/will-the-river-do-the-work.pdf

[28] https://www.nature.scot/scotlands-biodiversity/biodiversity-where-find-data

[29] https://riverflydata.org

[30] https://wildfish.org/project/smart-rivers/

It's also important to consider what is achievable within the length of the monitoring period. For example, it may only take 1-10 years to influence functions in a positive direction, however the timescale to recover full benefits may be much longer (e.g., 10-50 years depending on the function)[31]. Therefore, it's important to not only think of the longer-term outcomes, but also what interim targets may be achievable within monitoring timeframes to demonstrate that a project is on a recovery trajectory towards longer-term outcomes.

When setting objectives, consider the specific actions or activities that will be needed to meet them. For example, restoring a natural riparian corridor (the goal) may involve expanding the width of the corridor (the objective) through multiple actions including changes in land use, fencing, planting, etc. Understanding how project actions will contribute to goals and objectives is useful to inform project design, as well as which indicators and methods should be included within the monitoring plan. When deciding what actions may be most successful within the site context, it's useful to consider what evidence is available for what has, or has not worked, within similar settings. This type of evidence-based approach to project planning can help to identify actions with higher likelihood of success, leading to better outcomes.

Appendix A provides examples of common restoration actions and how they could support functional improvements within rivers, including actions that improve floodplain connectivity, longitudinal connectivity, riparian corridors, the instream environment, and runoff processes within the broader catchment.

What are goals?

Goals are statements that explain *why* a project is needed. Well-crafted goals clearly and concisely describe intended outcomes.

What are objectives?

Objectives are statements that describe *how* a project will address identified impacts and improve river functions. Well-crafted objectives are SMART and help to link project activities to specific outcomes.

What does SMART mean?

Specific: what will be accomplished?

Measurable: how to measure change?

Achievable: what is the target condition?

Realistic: what is realistic, given the resources available?

Time-bound: when will objectives be met?

[31] Monitoring timescales are identified for a range of attributes within the Riverwoods Measuring and Monitoring Framework (2024). SEPA is currently working to provide further information on timescales for recovery as part of the Riverwoods Project.

STEP 3: IDENTIFY THE INDICATORS AND METHODS TO TRACK CHANGE OVER TIME

The monitoring framework provides a proportionate approach to monitoring. There is flexibility to select indicators and methods based on the size and type of each individual project. The measures, or indicators, that are selected for monitored should relate to the goals and objectives of a project. Building from earlier steps, projects should select indicators that relate directly to the functions that will be improved by restoration actions. For example, if a project is aiming to restore a natural, wooded riparian corridor through reduced grazing and tree planting, the project should select indicators that can illustrate how the extent and condition of woody vegetation will change over time.

Often, direct measures of function can be complex, costly and time consuming; it can be more efficient to focus on condition indicators informed by structure or composition, which offer a 'snapshot' or point-in-time measure that can tell us how well the ecosystem is functioning. Appendix D provides a list of potential indicators and methods organized by key ecosystem attribute,[32] including extent, connectivity, hydrology, physical habitat, water quality and biotic condition.

A range of established methods are available to measure indicators, ranging from rapid visual assessments to more detailed, quantitative protocols. Simple methods, such as fixed-point photography and visual surveys, will require less time, training and/or expertise, but may not always be enough. These could be supported by hydromorphic, habitat and/or ecological assessments which provide an integrated assessment of condition, capturing a range if indicators within a single protocol. Additional indicators or more detailed methods may

What are indicators?

Indicators are observable or measurable attributes that provide information on the structure, composition and/or function of ecosystems. They can be used to evaluate ecosystem condition, and track progress towards achieving outcomes.

Key attributes that support river ecosystem integrity include:

- Hydrologic regime and environmental flows
- Connectivity
- Water Quality
- Physical Habitat
- Biotic Composition

Under TNFD's essential criteria for assessing ecosystem condition, indicators should be:

- Credible and science-based
- Ecologically connected
- Responsive
- Relevant
- Verifiable

[32] Moberg, T., Abell, R., Dudley, N., Harrison, I., Kang, S., Rocha Loures, F., Shahbol, N., Thieme, M., & Timmins, H.L. (2024). *Designing and managing protected and conserved areas to support inland water ecosystems and biodiversity*. IUCN WCPA Technical Report Series No. 8. IUCN.

Key recommendations to select indicators and monitoring methods:

- Select indicators that can inform project goals and objectives.
- Select indicators that relate directly to key functions and attributes.
- Consider what is appropriate for the scale and complexity of the project.
- Apply established methods that are sensitive enough to detect changes over time and differences among sites.
- Ensure the approach meets the needs of the project.
- Consider the cost and skills needed and ensure adequate resource capacity.
- Consider any monitoring or methods that may be required under other project funding.
- Consider how monitoring could create opportunities for engaging community members or volunteers.

also be needed for larger or more complex projects, or to inform specific goals and objectives not captured within integrated condition assessments. For each method, it's important to consider the right sampling design, i.e., the location, frequency and timing of data collection. More information on methods is provided in the 'Monitoring Elements' sections below.

When selecting monitoring methods, projects should consider the level of detail and rigor that may be needed given the project's scope, complexity, level of risk and likelihood of success (Figure 9). For small-scale or well-evidenced restoration actions, simple methods may be sufficient to monitor and evaluate indicators. However, as projects increase in scale and complexity, or where interventions are associated with greater levels of risk or uncertainty, more comprehensive monitoring may be needed. In some cases, this may simply mean conducting an established hydromorphic or ecological assessment. In other cases, additional quantitative approaches may be needed to track progress towards specific outcomes and objectives. Note that projects may also have monitoring or reporting requirements for other funding sources or outcomes generated under nature market mechanisms (e.g., credits).

As projects become more complex, the level and breadth of expertise needed to plan, deliver and monitor a project will increase. It's important to engage early with interdisciplinary partners that have the requisite expertise.

Additional resources on indicators and methods, as well as applying a matrix-based approach are available through a number of sources, including the Riverwoods Blueprint Project, the River Restoration Centre's Practical Restoration Appraisal Guidance for Monitoring Options (PRAGMO)[33] and SEPA (e.g., methods to support the Water Framework Directive and the Natural Flood Management Handbook[34]).

[33] https://wiki.therrc.co.uk/index.php/PRACTICAL_RIVER_RESTORATION_APPRAISAL_GUIDANCE_FOR_MONITORING_OPTIONS_(PRAGMO)

[34] https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

Risk and complexity	Small	Medium	Large
High	Innovative projects with risk of failure. Monitor using detailed hydromorphic studies (e.g., fluvial audit) and established ecological methods.		Complex and innovative projects. Consider engaging academic or research partners with experience conducting large-scale scientific studies.
Medium	Established techniques in new environments or relatively untested techniques. Combine simple methods with hydromorphic/habitat assessments or additional function-based indicators that inform specific project objectives. Use methods that can be applied at the reach or project scale.		Same as <- but consider monitoring methods that are applicable at larger scales. Consider linking into citizen-science or other established catchment-scale monitoring efforts.
Low	Established techniques over small scales, where objectives also relate to water quality or biological communities. Monitor using simple methods (below); add ecological indicators to inform water quality and/or biological objectives. Rely on established methods.		Established techniques over a large scale where objectives also relate to water quality or biological communities. Monitor using simple methods (as below); but also include ecological indicators and established methods to inform water quality and/or biological objectives. Consider linking into citizen-science or other established catchment-scale monitoring efforts.
Low	Established techniques over a small scale where objectives focus on restoring the physical environment. Monitor using simple methods such as fixed-point photography and visual surveys.		Established techniques over a large scale where objectives focus on restoring the physical environment. Same as <- but also consider linking into citizen-science or other established catchment-scale monitoring efforts.
	Scale		

Figure 9. Matrix for selecting indicators and methods for monitoring based upon the project-specific scale, risk and complexity. Adapted from RRC's Practical River Restoration Appraisal Guidelines for Monitoring Options (PRAGMO).

Reporting and Review Milestones

> Milestones represent points where activities or information from each stage of the project can be reviewed and validated to create consistent accountability and Fund integrity.

The monitoring framework provides a consistent approach for portfolio projects to report on outputs and outcomes. The Fund will need to consider governance arrangements around the verification and validation of these outputs and outcomes and how they relate to contributor reporting requirements. To support this effort, a set of recommended review milestones is outlined below (also see Figure 5). Note that these are recommendations only and could change as further decisions are made around Fund governance. Templates can be developed to support consistent reporting for review milestones (see Appendix E for an example of a monitoring plan template). It may also be useful to include site visits as part of one or more review milestones. Reporting documentation can be developed into a set of digital templates, forms or dashboards to satisfy the interests or requirements of River Catchment Restoration Fund contributors.

Planning Review Milestones:

- **Early:** For the Fund to be widely accessible, support for early planning activities may be needed prior to a specific project or site being selected. As noted above, a 'capacity building' theme could support early planning, for example, by building skills and training for project staff and volunteers or funding the development of strategic catchment partnerships and plans. The Fund would need to consider what reporting may be needed under such a theme and/or within this milestone.
- **Interim:** After specific project(s) are identified, projects should provide general project information along with a brief description of the site and catchment context, outlining how the project will address key impacts and contribute to environmental outcomes, and describing the proposed restoration actions and where they will occur. At this stage, projects should also estimate the level and cost of monitoring that would be needed given the scale, risk and complexity of their proposed project (Figure 9).
- **Final:** All planning stage documentation should be reviewed and verified at the end of the planning stage and prior to a project advancing to the delivery stage. Documentation should include the project's monitoring plan, as well as other necessary items such as permits, landowner permissions, etc. To support Fund accessibility, the Fund could offer a brief, funded co-development stage where the project partners work with the Fund to develop their monitoring plan. This would ensure that goals, objectives and actions are appropriate given the site context, and that the monitoring plan includes appropriate indicators and methods to evaluate success. Note that Community Benefits and Engagement outcomes may be delivered within this, or any stage.

Delivery Review Milestones:

These milestones document the actions completed as part of the project. Some projects may complete all works within a single season, and only the final milestone is needed. Other projects may involve more complex works that will be phased across multiple years or may involve implementing multi-year management plans. For these, annual interim progress reports may be needed. Community Benefits and Engagement outcomes may be delivered within this, or any stage.

- **Interim:** Review annual updates to ensure project is on track to deliver restoration actions.
- **Final:** Review site action logs and verify outputs.

Monitoring Review Milestones:

Within the monitoring period, regular monitoring and reporting should occur on an agreed upon schedule. The scope and schedule for monitoring and reporting should be outlined in each project's monitoring plan. Monitoring efforts will vary depending on the interventions and objective set, e.g., ranging from relatively simple annual visits requiring minimal effort, expertise and equipment to more detailed monitoring at set timescales requiring specialist expertise and/or equipment. The monitoring length may also vary, ranging from 5 to 15 years, depending on what is outlined in each project's monitoring plan. Community Benefits and Engagement outcomes may be delivered within this, or any stage.

- **Interim:** Review of regular monitoring reports to verify if a project is on track to achieve objectives or whether adaptive management is needed. Together, monitoring and adaptive management ensure that a project can achieve its objectives. Therefore, these milestones should be used to initiate early corrective actions to adaptively address foreseeable and unforeseeable issues that could affect a project's success. The Fund would need to identify a process for implementing adaptive management actions, including how they would be funded.
- **Final:** Review final monitoring report to ensure project has achieved its objectives and that provisions are made if any long-term management measures are needed to ensure sustainability of outcomes.

Monitoring Elements – Data for Portfolio-level Reporting

Some data will need to be consistently collected across all projects for portfolio-level reporting, including general project information, as well as specific data to inform headline indicators and document outputs and outcomes.

General information should be provided about each project (see box on right), which will allow for reporting basic project information, summarizing headline indicators by Fund theme or geography, and highlighting other portfolio trends. This data can often be easily acquired and should be compiled at the start of the project.

Headline indicators report broadly on what is happening within the footprint of a project, including where management or restoration actions will occur. They are reported differently depending on the stage of the project:

- **Planning stage:** Baseline data on project length and area can be used to document the extent committed for restoration. In general, these data will include the length of the project reach (km), the extent of natural riparian or floodplain corridor (both width and length) within the project area, any areas of natural land cover or aquatic habitats that will be established or restored as part of the project, and connectivity measures where projects contribute to greater connectivity with nearby habitats. More detailed examples of how to report on extent can be found in Appendix C.
- **Delivery stage:** The extent of area under improved management or restoration is reported once project actions have been completed. During the delivery stage, reporting should include annual updates on restoration activities with a site actions log (see below).
- **Monitoring stage:** Headline indicators for condition are reported, including whether a project is 'on track to achieve' or 'has achieved' specific objectives or whether adaptive management is required. These outcomes are documented via regular (e.g., annual) monitoring reports on the state of nature which summarize progress towards objectives, and whether adaptive management is needed. These reports should include baseline and monitoring data for relevant extent and condition indicators (see below and Appendix D). Additional data or photographs from site-specific monitoring could be collated into a Fund impact report to meet the emerging needs or interests of Fund contributors.

General Project Information:

- Catchment
- River Name(s)
- Contributing catchment area (ha; from the downstream extent of the project area)
- Project partners
- Related or connected actions with other funding sources? Y/N
- Estimated timelines for planning, delivery and monitoring
- Restoration action categories (select from list)
- Relevant outcomes or themes (select from list)

Monitoring Elements - Site Action Log

A site action log documents the works that have been completed as part of the project. This should be accompanied by fixed-point or aerial photographs documenting completed actions (see below). Explanations should be provided where actions may have deviated from proposed design. At this stage, updated mapping should also be provided to inform headline indicators for extent (See Appendix C). Site action logs are also a component of monitoring under the Riverwoods Measuring and Monitoring Framework (2024) and a common or shared template could be developed.

Monitoring Elements - Fixed Point/Aerial Photography supported by site visit observations

Monitoring points should be established prior to the project to capture baseline condition, with regular (e.g., annual) monitoring throughout the monitoring period to document change over time. Fixed point photography, video or aerial photography can be useful to illustrate how relevant indicators have changed over time both within rivers (e.g., channel habitat units, channel shape, large wood, organic matter retention, riparian vegetation structure/cover, bank erosion, etc.) and in catchment projects outside the river corridor (e.g., documenting peatland restoration, land use change, etc). Fixed photo points could include established bankside permanent photo points, or aerial surveys. In general, monitoring should include photographic documentation of the project area, with a supporting narrative describing how key indicators have changed over time. See Skinner and Thorne[35] for more information on fixed point photography for documenting geomorphic changes and Scottish Fisheries Coordination Centre (SFCC)[36] for more information on use of aerial photography.

When collecting photographic documentation, it's also useful to walk the extent of the project to observe condition indicators throughout the project area. Rapid visual assessments of common field indicators, such as SFCC's walkover survey, can provide a useful starting point to assess existing condition, track overall improvements and can also provide an early indication of project failures (i.e., where adaptive management measures may be needed). The SFCC's walkover survey includes observations of human pressures and impacts, including obstacles to fish movement, bankside erosion and changes to riparian or instream characteristics.

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[35] Skinner, K. and C. Thorne. (2005) Review of Impact Assessment Tools and Post Project Monitoring Guidance. Prepared for SEPA.

[36] https://fms.scot/sfcc/data-collection-protocols/

Monitoring Elements - Ecological Indicators

Ecological indicators should be assessed where project objectives extend beyond improvements to the physical environment to also include improvements to aquatic or terrestrial biological communities, biodiversity or changes in water quality. There are well established methods and protocols for sampling fish, macroinvertebrates and various terrestrial species (see Appendix D). Different approaches will require varying levels of training and expertise. For example, for macroinvertebrates, citizen-science based approaches (Extended Riverfly and SmartRivers) can be applied at project sites to track changes in water quality and aquatic communities; these are designed for use by non-scientists after training. Alternatively, species-level surveys could be conducted by professional, qualified biologists.

A few additional considerations:

- Consider a sampling design that includes sampling sites within the project area, as well as at a control site. Populations and communities naturally fluctuate from year-to-year, and a nearby (upstream) control site helps to understand whether changes are a result of the project. This is commonly referred to as a before, after, control, impact (BACI) design.
- Use the same methods and sampling design before the project and for all post-project monitoring. Biological sampling for terrestrial and aquatic life includes a range of traditional and novel survey methods and techniques, such as eDNA and acoustic sensors. It’s not always clear how well results from these emerging methods align with those from traditional sampling methods. Unless there is clear evidence that they can be used interchangeably, it’s best to stick with one approach.
- Post-project biological monitoring may not need to occur immediately (e.g., within the first 2 years) after restoration because ecological communities can take time to recover from site disturbance and may continue to change with recovery of the physical environment (e.g., as riparian vegetation establishes and organic matter inputs change).
- Consider whether project monitoring can connect with other monitoring efforts within the catchment, e.g., citizen-science monitoring or other regular fish or macroinvertebrate monitoring initiatives. Aligning methods, indicators and sampling designs with these broader efforts can provide a bigger picture of what is happening within the catchment. Note that results from regular electrofishing surveys could be used to report and track changes/patterns over time at a catchment scale, however, if each survey year captures different site sampling locations, results will not provide repeatable data over time unless subsequent monitoring revisit the same sampling sites.

Monitoring Elements: Hydromorphic and Physical Habitat Surveys

There are several established geomorphic and habitat assessment approaches that, by evaluating multiple indicators within a single assessment, can be used to provide an integrated perspective of the physical river environment. While all methods require some level of training, some have been developed specifically for citizen-science and can be used by non-experts. Typically, these types of assessments are reach-based, evaluating a suite of indicators within a defined length of river. This means that, depending on the length of a project, some, but not all, portions of a project length would be monitored. Two relevant, rapid approaches are summarized below. More information on indicators and methods is available in Appendix D.

More detailed approaches to hydromorphic assessment can also be conducted. For example, Fluvial Audits/MimAS[37] and LIDAR or field-based topographic surveys can provide more detailed quantitative information on channel geometry and geomorphic units[38]. See also Skinner and Thorne (2005)[39] and Papangelakis et al. (2023 a and b)[40] for additional background on a range of geomorphic assessment approaches.

Scottish Fisheries Coordination Centre (SFCC) Habitat Survey:

The SFCC Habitat Survey[41] is a detailed habitat survey method specifically tailored for evaluating juvenile Atlantic salmon and brown sea trout habitat. It provides a comprehensive assessment of key habitat indicators, including channel geometry, substrates, flow and channel complexity, riparian vegetation, bank stability, spawning locations and human impacts such as land use, grazing, pollution points, bank/bed modification and obstacles. It is based on visual observations supported by fixed-point and/or aerial photography.

Survey data recording is standardized via forms. These data can be digitised and imported into mapping software to display via map format along with other spatial datasets. Training is needed before using the method; training in electrofishing techniques is also recommended.

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[37] SEPA's Environmental Standards for River Morphology

[38] See RRC's PRAGMO and the Riverwoods Measuring and Monitoring Framework (2024)

[39] Skinner, K. and C. Thorne. (2005) Review of Impact Assessment Tools and Post Project Monitoring Guidance. Prepared for SEPA.

[40] Papangelakis, E., Hassan, M.A., Luzi, D., Burge, L.M. and Peirce, S., 2023a. Measuring geomorphology in river assessment procedures 1: A global overview of current practices. JAWRA Journal of the American Water Resources Association, 59(6), pp.1342-1359. And Papangelakis, E., Hassan, M.A., Luzi, D., Burge, L.M. and Peirce, S., 2023b. Measuring geomorphology in river assessment procedures 2: Recommendations for supporting river management goals. JAWRA Journal of the American Water Resources Association, 59(6), pp.1360-1382.

[41] https://fms.scot/sfcc/data-collection-protocols/

MODULAR RIVER (MORPH) SURVEY:

The MoRPH[42] survey approach represents modular adaptation of established hydromorphic methods. The modular design allows the approach to be applied at multiple scales, and by both professionals and non-experts as part of citizen-science monitoring efforts. The modular surveys evaluate the extent and character of bank and bed sediments, morphological features, hydraulic features, riparian and aquatic vegetation extent and structure, as well as the presence and extent of non-native invasive plant species, riparian land use pressures, and human impacts to the river channel and its dimensions. The survey is based on visual observations supported by mid-module photo points. The MoRPH manual recommends a sampling design that follows a before, after, control, impact (BACI) design, with modules both within the project area and an upstream control site. Surveys are recommended at least once before an intervention, again after completion of activities, and then following a sufficient interval to allow for the river to adjust to the actions (e.g. 5 years).

Survey data can be recorded directly into the Cartographer app. The app provides a single platform for storing and displaying survey records, including in map format, and allows multiple modules to be linked together to provide more complete information about river condition. Training is needed before using the method. Training and accreditation is required for applying the River Condition Assessment (MoRPh Pro).

Monitoring Elements - Habitat, Land Use and Land Management Changes

Improving land management and restoring natural habitats within the broader catchment represent an important set of actions to address catchment pressures related to runoff processes which affect a river’s hydrologic regime and water quality condition. Mapping habitat condition and/or land use change can serve as a simple indicator for runoff, however more quantitative or detailed methods may be needed to evidence specific outcomes, e.g., related to soil loss or quality, or other changes to sediment or nutrient inputs to rivers. Condition assessments may also be available to document change within specific non-river habitat types, e.g., woodlands and peatlands. A common approach to habitat mapping, UKHab, is described below. More information on indicators and methods is available in Appendix D.

[42] https://modularriversurvey.org/morph-rivers/

UKHab Survey:

UKHab surveys[43] can be used to identify, map and describe terrestrial, freshwater and marine habitats within the UK. It could be used to provide a consistent approach to baseline and post-project mapping, for example, where project objectives relate to land use changes within terrestrial habitats or to document other changes in habitat type (both freshwater and terrestrial) as part of a project. UKHab offers a hierarchical approach to primary habitat classification, along with secondary codes to accommodate habitat mosaic and complexes. Conducting a survey involves a combination of walkover surveys and mapping to identify habitat classes. It is becoming a common alternative to JNCC's Phase 1 Habitat surveys[44], as it offers a wider variety of habitat types for classification. Training is needed before using the method, and both botanical and GIS mapping expertise are needed to complete a survey.

Monitoring Elements: Additional indicators, detailed methods and emerging approaches

For some projects, there may be a need for additional indicators and/or more rigorous sampling methods beyond fixed point photography or the rapid hydromorphic and biological assessments described above. This will depend on the specific objectives of the project, the complexity of the project, and/or whether there is a need to support the scientific evidence base (e.g., for novel techniques, or to assess efficacy of additional quantitative indicators desired by Fund contributors). For example, indicators of hydrologic alteration are useful to evaluate and quantify outcomes for projects restoring one or more aspects of a natural flow regime in regulated rivers. Note that as projects and their monitoring become more complex, the level and breadth of expertise required to plan, deliver and monitor projects will also increase. For these projects, it's important to rely on expert advice for selecting indicators, appropriate methods and sampling designs.

The conversation around indicators and methods is rapidly evolving, and there are a range of guides that identify additional indicators and methods that could be used to assess the state of nature related to different types of projects or within different habitats. The methods and indicators in Appendix D represent examples of indicators for key river and riparian functions. This list of indicators could be expanded as new indicators and metrics emerge within rivers, or to accommodate a broader range of projects occurring within catchments, e.g., to evaluate the delivery of ecosystem services via natural flood

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43 https://ukhab.org

44 https://jncc.gov.uk/our-work/terrestrial-habitat-classification-schemes/#phase-1-habitat-classification

management[45], nature-based solutions[46] or other approaches. When considering the use of emerging methods, indicators, mapping applications and calculators, it's important to consider the availability and quality of underlying datasets and whether adaptation may be required to apply them within the Scottish context.

Looking to the future, it's important for the Fund to consider the need for updates and revisions to the monitoring framework as it is piloted and implemented, as well as to keep pace with emerging approaches, good practice and the best-available science. The monitoring framework is currently structured to provide a standard process for monitoring and reporting but allow projects flexibility in selecting indicators and methods, for example, to accommodate simple approaches requiring minimal effort, expertise and equipment as well as more detailed monitoring requiring specialist expertise and/or equipment. It's likely that this will evolve over time. For example, in the future, the monitoring framework may need to be more prescriptive to provide greater consistency across portfolio project monitoring, to ensure accurate demonstration of outcomes from an evidence standpoint (e.g., for certain indicators or types of projects), or to meet specific reporting requirements of Fund contributors.

For Scotland's freshwater systems, there are several concurrent efforts related to freshwater monitoring and assessment, which could also influence the future direction of this Monitoring Framework:

- Riverwoods Blueprint Project[47] – In this project, Riverwoods partners are working to develop a 'digital centre for excellence' which will serve as a central repository for relevant data, good practice guidance, and more to facilitate knowledge sharing. Under this project, the partners will continue to develop their Measuring and Monitoring Framework outlining surveying and monitoring protocols to build evidence of effective riparian woodland restoration. There are also efforts within this project to establish MoRPH citizen science training and monitoring within Scotland.
- Centre for Expertise in Water project on creating healthy and resilient river systems across Scotland[48] – This project builds on the Riverwoods evidence review, with the aims of prioritising the research and development gaps identified in this earlier effort and identifying opportunities to address these gaps.

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45 See SEPA's Natural Flood Management Handbook

46 See The Nature Conservancy's Benefit Accounting of Nature-Based Solutions for Watersheds

47 https://www.riverwoods.org.uk/streams/blueprint/

48 https://www.crew.ac.uk/project/crw202302-creating-healthy-and-resilient-river-systems-across-scotland-prioritising-research

- Centre for Expertise in Water project providing a review of monitoring approaches to deliver healthy ecosystems for Scotland's protected fresh waters and wetlands[49] - This project aims to provide recommendations on relevant ecosystem health indicators and metrics that could be measured to support site condition monitoring within Scotland's protected freshwaters and wetlands.
- Scotland's current River Basin Management Plan (RBMP)[50], which sets the wider context for restoration projects, spans 2021 to 2027. Consultation on the next RBMP(4) will likely begin next year and there may be opportunities to consider how indicators or monitoring methods could better align with this, as well as other efforts, within SEPA. For example, it may be useful to consider how, at a portfolio-level, the Fund could evaluate project outcomes in relation to catchment-scale ambient monitoring to see whether portfolio actions at a programmatic level are contributing to catchment-level changes, e.g., via temperature monitoring networks, juvenile fish densities, or river classification.
- Scottish Biodiversity Metric[51] – NatureScot is currently undertaking an effort to adapt England's Biodiversity Net Gain metric for use within the Scottish context. In England, the BNG metric currently relies on the MoRPH-based River Condition Assessment to inform the watercourse module. The first (current) phase of adapting a Scottish metric will include addressing foundational elements, including the watercourse / river assessment methodology.
- Woodland Water Code[52] – Forest Research is currently developing evidence and methods to support water quality, flood alleviation and shading metrics. Their intended use is within a Woodland Water Code nature market framework, although the metrics themselves may also be useful outside this context. The current version of the Water Quality Calculator estimates nutrient reduction using the Farmscoper tool, which can be used on a farm-by-farm basis with site-specific data but may require additional adaptation to be applied at scale within the Scottish farming context.

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[49] https://www.crew.ac.uk/project/crw202315-review-monitoring-approaches-deliver-healthy-ecosystems-scotland%E2%80%99s-protected-fresh

[50] https://www.sepa.org.uk/environment/water/river-basin-management-planning/

[51] https://www.nature.scot/doc/biodiversity-metric-scotlands-planning-system-key-issues-consultation

[52] https://www.forestresearch.gov.uk/research/developing-a-woodland-water-code/

Appendix A – Restoration Actions and their links to Fund Outcomes

This appendix provides examples of common restoration activities organised within five types of restoration actions:

- Improving floodplain connectivity
- Riparian corridor improvements
- In-stream improvements
- Improving longitudinal connectivity
- Integrated land management within the broader catchment.

As part of the broader FIRNS project that this Monitoring Framework supports, Fisheries Management Scotland has evaluated the pipeline of potential projects within Scotland and results from this effort was used to inform the example activities and types of restoration actions described below. For each of the five types of restoration actions, the tables provide a summary of how actions may improve key functions and support four environmental Fund outcomes, along with examples of indicators that could be used to evidence outcomes. More information on example indicators can be found in Appendix D. Note that this summary is not comprehensive. A list of key references is provided.

Improve floodplain connectivity		
Example Activities: Natural flood management measures, levee/embankment removal or setback, reconnection of floodplains (e.g., by raising streambed or excavating/lowering floodplain), beaver reintroductions, stage 0 restoration in response reaches, installation of beaver dam analogues or other structures in incised channels, re-meandering, and restoration/ reconnection of aquatic features (ponds, scrapes and wetlands)		
Outcomes	**Functional linkages between actions and outcomes**	**Example indicators for key functions and attributes**
Cold, clean water	Hydrologic and hydraulic processes are improved which support temperature regulation, sediment dynamics and nutrient retention and cycling. Geomorphic processes are also improved, as energy from high flow events is spread across the floodplain, improving the flow and channel features and erosion processes within the channel. Water quality processes (e.g., temperature regulation, nutrient processing, suspended sediment transport) are improved.	• Extent of restored areas • Hydrology: indicators for instream flow and runoff • Physical and Habitat Condition: indicators for floodplain connectivity, large wood, lateral migration, hydromorphic features, bed material and substrate and vegetation structure. • Water quality condition: indicators for temperature, nutrients or other water quality variables (as appropriate). This can also be evaluated via biological condition indicators related to water quality like macroinvertebrates (e.g., Extended Riverfly Silt and Flow).
Biodiversity and ecosystems	Hydrologic and hydraulic processes are improved which support improved riparian and floodplain habitat condition, extent, diversity and resilience. Increased connectivity will create newly accessible aquatic habitats within the floodplain during higher flows, as well as greater exchange/processing of resources to support food webs. Restoration of floodplain systems creates additional aquatic-terrestrial linkages, and can provide improved food sources for terrestrial vertebrates, including bats and birds, and habitats for mammals and invertebrates. Depending on other pressures and impacts within the catchment, natural biological communities may also improve.	• Extent of restored areas by ecosystem type. • Hydrology: flow diversity and sediment deposition • Physical and Habitat Condition: indicators for floodplain connectivity, large wood, lateral migration, hydromorphic features, large wood and other structures, bed material and substrate, vegetation structure and composition. • Biological composition and condition: indicators could include fish, macroinvertebrates, riparian-dependant terrestrial wildlife, aquatic plants, riparian plant communities, riparian/terrestrial soil communities. Biological communities can be monitored directly, although measurable changes may be limited by the broader catchment condition. Consider methods that can demonstrate use of newly connected habitat areas (e.g., P/A or changes in occupancy of target species).
Water Quantity	Hydrologic and hydraulic processes are improved which supports natural surface water storage processes, groundwater/surface water interactions and natural flow regimes.	• Extent of restored areas by ecosystem type. • Hydrology: indicators to demonstrate flow diversity and sediment deposition. This could be further supported by drone/LiDAR imagery that maps inundation area under different flow magnitudes, or other methods as outlined in the NFM Handbook. • Physical and Habitat Condition: indicators for floodplain connectivity, large wood, hydromorphic features, large wood and other structures and vegetation structure, e.g., to demonstrate increased floodplain connectivity, roughness and sediment deposition.
Climate Change	Hydrologic and hydraulic processes are improved, which improves the river corridor absorbing capacity and creates a more dynamic and resilient ecosystem in the face of a changing climate, including increased temperatures. This also creates greater resiliency to droughts and flooding via improved surface water storage processes, groundwater /surface water exchange and natural flows. There is more space for natural carbon sequestration and processing within the floodplain.	• Extent of restored areas by ecosystem type. • See Hydrology and Physical Habitat Condition indicators described for Biodiversity and Ecosystems and Water Quantity above. • Water quality condition: indicators for temperature. • Carbon sequestration and storage: indicators could include large wood and riparian plant community/structure, as well as more detailed indicators outlined in Appendix C.

Riparian corridor improvements		
Example activities: Riparian planting/revegetation, natural buffer establishment, fencing, improved agricultural practices (e.g., fencing, grazing strategies or livestock access), restoration/establishment of riparian buffer, removal/control of invasive species, riparian planting/revegetation, large wood within floodplain, natural flood management techniques (e.g., floodplain/riparian woodlands and land management measures) See lateral connectivity.		
Outcomes	**Functional linkages between actions and outcomes**	**Example indicators for key functions and attributes**
Cold, clean water	Riparian corridor processes are improved, which support temperature regulation, runoff infiltration, organic matter retention, and reduce the delivery of nutrients, sediments, pesticides and other pollutant to streams. Water quality processes (e.g., temperature regulation, nutrient processing, suspended sediment transport) are improved.	• Extent of restored areas • Hydrology: indicators for runoff • Physical and Habitat Condition: indicators for floodplain connectivity, large wood, lateral migration, hydromorphic features, bed material and substrate and vegetation structure. • Water quality condition: indicators for temperature, nutrients or other water quality variables (as appropriate). This can also be evaluated via biological condition indicators related to water quality (e.g., macroinvertebrate indices).
Biodiversity and ecosystems	Riparian and floodplain corridor processes are improved, which support improved terrestrial and aquatic habitat condition, diversity, extent and connectivity for aquatic and other wildlife species recovery and migration pathways. Improvements in riparian corridor functions will create greater exchange/processing of resources to support food webs, and provide shading, bank stability, floodplain roughness and other key functions that support instream hydromorphic condition, Improved riparian habitats also provide improved food sources for terrestrial vertebrates, including bats and birds and habitats for mammals and invertebrates. Depending on other pressures and impacts within the catchment, natural biological communities may also improve.	• Extent of restored areas by ecosystem type. • Connectivity: extent of restored connectivity of natural riparian corridor. • Physical and Habitat Condition: indicators for riparian vegetation structure, e.g., as part of hydromorphic assessments or other assessments specifically designed to evaluate some habitat types (e.g., Woodland Condition Assessment). Where riparian activities could result in improved instream habitats (e.g., via hydraulic lifting), other indicators could also be assessed. • Biological composition and condition: indicators of riparian plant communities, riparian/terrestrial soil communities, riparian-dependant terrestrial wildlife. Where riparian activities could result in improved instream habitats, fish, macroinvertebrates or aquatic plants could also be assessed, although measurable changes may be limited by the broader catchment condition. Consider methods that can demonstrate use of newly connected habitat areas (e.g., P/A or changes in occupancy of target species).
Climate Change	Riparian vegetation contributes to carbon sequestration and storage, and a functioning riparian corridor also improves temperature regulation, runoff infiltration, and nutrient, sediment and organic matter retention. This improves resilience and adaptation to a changing climate, including in the face of increased temperatures, droughts and flooding. Riparian vegetation (including trees) can also slow the flow, supporting natural flood management processes, although there can is lag time (e.g., years) as the vegetation establishes (NFM handbook).	• Extent of restored areas by ecosystem type. • Hydrology: indicators for runoff • Water quality condition: indicators for temperature. • Carbon sequestration and storage: indicators could include large wood and riparian plant community/ vegetation structure, as well as more detailed indicators outlined in Appendix D.

In-stream improvements		
Example Activities: Instream interventions such as bank stabilization (e.g., bioengineering), culvert removal or replacements, dam/barrier removal, fish passage structures, stabilizing or upgrading road crossings, aggradation of incised channels, bedform changes (e.g., to promote substrate diversity and flow complexity), installation of instream structures (e.g., engineered logjams, brush or other cover, large wood or boulder structures), gravel/substrate additions, re-meandering and other natural flood management techniques.		
Outcomes	**Functional linkages between actions and outcomes**	**Example indicators for key functions and attributes**
Cold, clean water	Hydromorphic processes are improved within the project area which support sediment dynamics and organic matter retention. Water quality processes (e.g., temperature regulation, nutrient processing, suspended sediment transport) are improved.	• Extent of restored areas • Hydrology: indicators for instream flow • Physical and Habitat Condition: indicators for large wood, lateral migration, hydromorphic features, bed material and substrate and vegetation structure. Indicators could include changes in fine sediment deposition, reduced streambank erosion, large wood and organic matter retention. • Water quality condition: indicators for temperature, nutrients or other water quality variables (as appropriate). This can also be evaluated via biological condition indicators related to water quality (e.g., macroinvertebrate indices).
Biodiversity and ecosystems	Hydromorphic processes are improved within the project area which improve instream habitat condition and extent. Depending on other pressures and impacts within the catchment, natural biological communities may also improve (e.g., fish, macroinvertebrates, amphibians, aquatic and riparian plants).	• Extent of restored areas by ecosystem type • Connectivity: (for relevant activities, see Improving Longitudinal Connectivity below) • Physical and Habitat Condition: indicators for floodplain connectivity, lateral migration, hydromorphic features, flow types, large wood and other structures, organic matter retention, and riparian vegetation. • Biological composition and condition: Aquatic plants, fish, macroinvertebrate or amphibian populations (densities, abundance) or communities (via indices or targeted indicator taxa) could be monitored directly, although measurable changes may be limited by the broader catchment condition. Methods could include electrofishing, eDNA, citizen science monitoring, etc.
Water Quantity	Hydraulic processes are improved, which support natural flow regimes, surface water storage and improved groundwater/surface water exchange functions.	• Extent of restored areas by ecosystem type. • Hydrology: indicators to demonstrate flow diversity and sediment deposition. This could be further supported by other methods as outlined in the Natural Flood Management Handbook. • Physical and Habitat Condition: indicators for large wood, channel planform, floodplain connectivity or surface water storage, vegetation structure and hydromorphic features, e.g., to demonstrate increased groundwater/surface water interaction.
Climate Change	Hydromorphic processes are improved within the project area which support increased groundwater/surface water exchange and organic matter retention and carbon cycling, resulting in improved resilience and adaptation to a changing climate, including increased temperatures, droughts and flooding.	• Extent of restored areas by ecosystem type. • Hydrology: indicators for runoff • Water quality condition: indicators for temperature. • Carbon sequestration and storage: indicators could include large wood and riparian plant community/ vegetation structure, organic matter retention.

Improve longitudinal connectivity		
Example Activities: Culvert removal or replacement, installation of fish passage structures, barrier, weir or dam removal; removal of impoundments or other structures affecting natural flow regime.		
Outcomes	**Functional linkages between actions and outcomes**	**Example indicators for key functions and attributes**
Biodiversity and ecosystems	Hydrologic connectivity is restored, increasing connected habitats for species recovery and migration pathways. Habitat condition is also likely to improve in the area immediately affected by the structure and its impounded area. Depending on other pressures and impacts within the catchment, natural biological communities are improved (e.g., fish, macroinvertebrates, aquatic and riparian plants).	• Extent of restored areas by ecosystem type. • Connectivity: extent of re-connected instream habitats for migratory/target species • Hydrology: indicators to demonstrate flow diversity and sediment deposition, possibly supported by more detailed indicators of hydrologic alteration where the activity results in changes to one or more aspects of a natural flow regime (e.g., timing, frequency, magnitude, duration or rate of change). • Physical Habitat and Condition: see In-stream Improvements section above • Biological composition and condition: Biological communities can be monitored directly, e.g., to evaluate presence/absence of target fish species presence/absence in the newly connected habitat areas. Also, see In-stream Improvements section above.
Water Quantity	Hydrologic connectivity is restored, improving continuity of flows and sediment, contributing to more natural storage patterns and flow regimes.	• Extent of restored areas by ecosystem type. • Hydrology: indicators to demonstrate flow diversity and sediment deposition, possibly supported by more detailed indicators of hydrologic alteration where the activity results in changes to one or more aspects of a natural flow regime (e.g., timing, frequency, magnitude, duration or rate of change). • See also indicators described in In-stream Improvements section above.

Integrated land management (within broader catchment)		
Improved agricultural practices (e.g., good practice approaches for managing runoff, rest-rotation or grazing strategies), impervious surface reductions and other natural flood management measures within the broader catchment. Land use changes, land and soil management practices, agricultural and upland drainage modifications and overland sediment traps to reduce runoff, restoration or rehabilitation of peatlands or other non-floodplain wetlands and woodlands within the broader catchment.		
Outcomes	**Functional linkages between actions and outcomes**	**Example indicators for key functions and attributes**
Cold, clean water	Runoff processes are improved within the contributing catchment, reducing inputs of nutrients and sediments. Water quality processes (e.g., temperature regulation, nutrient processing, suspended sediment transport) are improved.	• Extent of restored areas and/or areas under improved land management • Hydrology: indicators for runoff Note that projects that are large in relation to the catchment area may result in measurable changes within the stream; consider also evaluating hydrologic, physical, water quality and/or biological indicators within the downstream, receiving river reaches where impacts may be observable.
Biodiversity and ecosystems	Runoff processes are improved within the contributing catchment, reducing sediment inputs and improving water quality, channel morphology, and other processes that support natural biological communities and their habitats (e.g., fish, macroinvertebrates, amphibians, aquatic and riparian plants, soil microbes, terrestrial wildlife).	• Extent of restored areas and/or areas under improved land management • Physical and Habitat Condition: soil or vegetation condition assessments, vegetation surveys, or other assessments specifically designed to evaluate relevant habitat types (e.g., Woodland Condition Assessment, peatland condition, etc.). Fine sediments could also be monitored within the downstream environment, although changes may not be detectable depending on the scale or proximity of land management changes. • Biological composition and condition: indicators of plant, soil or wildlife communities (e.g., occupancy or use of habitats via camera traps, acoustic monitoring, eDNA or traditional taxa-specific survey methods, as aligned with project objectives). Also, where water quality is a limiting factor for aquatic communities, land management change at a sufficient scale could result in improved water quality, so longer term monitoring of fish, macroinvertebrates or aquatic plants within downstream river reaches could be considered.
Water Quantity	Runoff processes are improved within the contributing catchment, resulting in improved hydrological processes, including more natural flow regimes and storage patterns. For example, improved water infiltration and retention can delay runoff and support baseflows.	• Extent of restored areas and/or areas under improved land management • Hydrology: indicators to demonstrate changes in runoff. Flow measures could be directly monitored, as outlined in the NFM handbook.
Climate Change	Runoff processes are improved within the contributing catchment resulting in Improved resilience and adaptation to a changing climate, including droughts and flooding.	• Extent of restored areas by ecosystem type. • Hydrology: indicators for runoff • Carbon sequestration and storage: indicators could include soil or plant community/vegetation structure.

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Appendix B – Worked Examples

This appendix provides three examples of project goals, objectives and indicators using the template provided in Appendix E. These examples are followed by an illustration of how results from these three projects could ‘roll-up’ and be reported together within the Portfolio.

Project 1: A small gravel augmentation project, where substrate will be added to targeted riffle sections within a 100m project reach.

Project:	Gravel Augmentation	
Committed restoration extent:	Area (hectares)	0.6
	Project length (km)	0.1
	Connected corridors (km)	
Outcome Themes:	☐	Cold, Clean Water
	☑	Biodiversity and Ecosystems
	☐	Water Quantity
	☐	Climate Adaptation and Resilience
Level of complexity:	Established techniques over small scales, where objectives also relate to water quality or biological communities. Monitor using simple methods; add ecological indicators to inform water quality and/or biological objectives. Rely on established methods.	
Describe the goal(s) of the project:	**For each goal, describe the objective(s) for the project:** *Remember that objectives should be specific, measurable, achievable, results-oriented and time-bound*	**List the specific indicator(s) to monitor:**
To improve instream habitat for [fish species/life stage]	Increase the area of juvenile fish habitat within the project reach.	Area of aquatic ecosystems restoration
	Improve hydromorphic complexity, flow diversity and bed material patterns by adding substrate in targeted sections of the project reach.	SFCC Walkover or MoRPH surveys and fixed-point photography to assess indicators for hydromorphic units, bed material/substrate and flow diversity
To improve [fish species/age class] populations within the project reach	Increase spawining activity for [fish species] within [x] years of augmentation	Redd Surveys
	Increase [fish species/age class] densities by/to [target condition] within [x] years of augmentation	Fish Density - electrofishing

Project 2: A project to restore meanders and reconnect the river to the adjacent floodplain within a 600m project reach.

Project:	Remeandering and floodplain reconnection	
Committed restoration extent:	Area (hectares)	6.3
	Project length (km)	0.6
	Connected corridors (km)	
Outcome Themes:	☑	Cold, Clean Water
	☑	Biodiversity and Ecosystems
	☑	Water Quanity
	☑	Climate Adaptation and Resilience
Level of complexity:	Innovative projects with risk of failure. Monitor using detailed hydromorphic studies (e.g., fluvial audit) and established ecological methods.	
Describe the function-based goal(s) of the project:	**For each goal, describe the objective(s) for the project.** *Remember that objectives should be specific, measurable, achievable, results-oriented and time-bound*	**List the specific indicator(s) to monitor:**
To restore a dynamic floodplain by reconnecting to the river, which will slow the flow, improve biodiversity and habitat diversity and increase resilience to flood and drought events.	Design new bed level to increase freqency of out-of-bank-flows and reconnect the river to existing and historic aquatic features within the floodplain at high flows.	Extent of restored areas; drone/LiDar imagery to map inundation area under different flow magnitudes; indicators of floodplain sediment deposition (e.g., depth, grain size, extent) and roughness (e.g., large wood, organic matter deposition and other indicators of vegetation structure; depth to water table measures
	To restore a meandering channel within the target reach by incresasing channel length and restoring characteristic sinuosity for [x] river type.	Measurement of increased extent; key hydromorphic indicators (e.g., floodplain connectivity, lateral migration, hydromorphic features, flow types, large wood and other structures, organic matter retention) via fluvial audit or similarly detailed method.
	Improve riparian vegetation structure and complexity within [x] growing seasons by re-seeding and promoting establishment of native woody and non-woody vegetation communities on the edge, top of bank and within the floodplain of the re-meandered project reach.	Indicators of riparian and bank condition, including large wood, bank erosion, organic matter retention and other indicators within vegetation structure, e.g., as monitored via SFCC or Morph surveys;
	increase macroinvertebrate diversity by increasing channel and floodplain variability (e.g., instream habitats, permanently and seasonally wet floodplain areas)	Species richness, or other relevant indices to document diversity
	Increase numbers and species of over-wintering birds	Bird counts, species richness

Project 3: Large scale riparian planting, with multiple, smaller project sites within a 9km stretch of the river.

Project:	Large scale riparian planting project (includes multiple project sites within the catchment)	
Committed restoration extent:	Area (hectares)	5
	Project length (km)	2.5
	Connected corridors (km)	9
Outcome Themes:	☑	Cold, Clean Water
	☑	Biodiversity and Ecosystems
	☐	Water Quantity
	☑	Climate Adaptation and Resilience
Level of complexity:	Established techniques over a large scale where objectives also relate to water quality or biological communities. Monitor using simple methods; but also include ecological indicators and established methods to inform water quality and/or biological objectives. Consider linking into citizen-science or other established catchment-scale monitoring efforts.	
Describe the function-based goal(s) of the project:	**For each goal, describe the objective(s) for the project.** *Remember that objectives should be specific, measurable, achievable, results-oriented and time-bound*	**List the specific indicator(s) to monitor:**
To restore a natural, functioning riparian corridor that improves water quality, expands wildlife habitat corridors, and improves climate adaptation and resilience within the catchment.	Reduce agricultural runoff from adjacent fields by establishing [x] meters of natural riparian vegetation on both sides of the channel in multiple reaches through fencing and land use changes.	Capture extent via restored area, km of restored riparian zone length and riparian zone width measurement. Monitor indicators for silt/fine sediment (Extended Riverfly) and runoff (land use change).
	Improve riparian vegetation structure and complexity within [x] growing seasons by re-seeding and promoting establishment of native vegetation communities on the edge and top of bank at each project reach.	Indicators of riparian and bank condition, including large wood, bank erosion, and vegetation structure, as well as excessive siltation as monitored via SFCC or Morph surveys; monitor tree survival and natural sapling recruitment; aerial photography to capture changes in canopy cover.
	Establish prevalent woody vegetation and canopy cover within [x] growing seasons by promoting natural recruitment and planting trees in strategic locations along each project length.	
	Reduce the extent of exessive bank erosion to less than [x]% of total bank length witihn each project reach through targeted riparian planting in multiple reaches.	
	Increase length of connected riparian habitat corridors by strategic site selection within broader catchment.	Total length (km) of connected natural riparian corridor

Summary of how these projects could be 'rolled up' and reported together within the portfolio:

Portfolio Totals:	3 projects	11.9	hectares of restored area
		3.2	kilometres of stream length restored
		9	kilometres of connected corridors

Totals per outcome:

Cold, Clean Water		Biodiversity and Ecosystems		Water Quantity		Climate Adaptation and Resilience	
66% of projects are contributing to this outcome		100% of projects are contributing to this outcome		33% of projects are contributing to this outcome		66% of projects are contributing to this outcome	
11.3	hectares of restoration contributing to water quality outcomes	11.9	hectares of restored area contributing to biodiversity and ecosystem outcomes	6.3	hectares of restoration contributing to improved flow regimes	11.3	hectares of restoration contributing to climate outcomes
3.1	kilometres of stream length restoration contributing to water quality outcomes	3.2	kilometres of river and riparian habitats restored	3.2	kilometres of stream length with improved flows	3.1	kilometres of stream length supporting climate resilience
		9	kilometres of connected corridors to improve biodiversity and ecosystems				

Appendices C through E

[attached]