Cinder Hill Weir, Porter Brook: Urban Channel Restoration Design and Build Brief

Brief for engineering-led redesign, approvals, construction delivery and handover of fish passage and river restoration works at Cinder Hill Weir on Porter Brook, Sheffield.
Client: Don Catchment Rivers Trust
Project: Cinder Hill Weir Fish Passage and Urban Channel Restoration Project
Commission: Design-and-build commission covering technical design development, planning and Flood Risk Activity Permit submissions, regulator engagement, specialist surveys and assessments, construction delivery and handover.
Location: Porter Brook, from the Decathlon deculverted section to Matilda Street, Sheffield
NGR start / end: SK 35238 86441 and SK3547886619
Riparian ownership: Multiple land interests identified within the project reach
Procurement basis: Tender for a design-and-build river restoration and fish passage contract

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1. Purpose

The appointed contractor shall provide the design development, approvals, specialist coordination, construction delivery and handover needed to deliver fish passage and river restoration works at Cinder Hill Weir and the adjacent upstream and downstream reaches.

The commission shall improve ecological connectivity, fish passage and habitat value within a heavily modified urban reach of Porter Brook while addressing flood risk, heritage, ecology, structural, access and buildability constraints.
The design-and-build approach is intended to take the scheme from existing outline proposals through final design, statutory approvals, construction and completion within the available funding and redevelopment-related delivery window.

2. Project Background

DCRT, with partners Sheffield and Rotherham Wildlife Trust, Sheaf and Porter Rivers Trust and Wild Trout Trust, is seeking engineering-led redesign and delivery of fish passage and river restoration works at Cinder Hill Weir on Porter Brook.
This reach of Porter Brook has been heavily straightened, canalised, reprofiled, paved and sealed through successive phases of industrial and drainage-related modification, including the creation of a highly obstructive weir arrangement.
A key left-bank site within the reach is likely to be redeveloped by Skyhouse over the next 18 months. This presents a potential delivery opportunity, including coordination with a collaborative adjacent contractor, repair of the river retaining wall, and removal of a redundant factory bridge that previously constrained the available space for the rock-ramp design.
However, it also creates a limited window in which access for plant and materials is expected to be easier and lower cost before new homes are completed close to the riverbank.

3. Design Basis and Recommendations to be Taken Forward

DCRT, with parters Sheffield and Rotherham Wildlife Trust and Sheaf and Porter Rivers Trust and Wild Trout Trust, is seeking engineering-led redesign and delivery of fish passage and river restoration works at Cinder Hill Weir on Porter Brook, taking the scheme from outline proposals through final design, approvals and construction.

Consultants should use the Dynamic Rivers outline design, Fish Pass Panel comments and associated responses as background to inform a revised, broadly aligned final design.

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However, it also creates a limited window in which access for plant and materials is expected to be easier and lower cost before new homes are completed close to the riverbank.

4. Design Objectives

The preferred approach is an engineering-led redesign of the existing concept to improve technical robustness, deliverability, fish passage and habitat value. Consultants should assume works at the weir and within the adjacent upstream and downstream reach.

1. Partial weir lowering and/or modification together with a revised rock-ramp or equivalent nature-based fish passage solution, designed to respond to Fish Pass Panel comments and associated hydraulic, geomorphological and structural requirements.
2. Use riffle, grade-control or equivalent nature-like features where appropriate to reduce head difference, improve passability, stability and hydraulic performance, and provide visual benefits for nearby properties.
3. Any such features must avoid covering existing heritage or flood-risk features, be supported by suitable modelling, and have a genuine morphological function from which ecological benefits arise.
4. Include habitat-restoration measures such as boulder features, bedform creation, sediment retention, marginal habitat improvements and naturalised bank treatments where appropriate.
5. Buildable, professionally underwritten proposals suitable for construction in a constrained urban environment.

Key considerations

Excavating or breaking up the concrete channel throughout the reach is not the preferred design basis due to likely contamination risk. Consultants should work with the existing channel form where practicable, using measures that promote sediment deposition, morphological recovery and habitat value.

Consultants may identify opportunities to reuse suitable arisings or materials from adjacent works, subject to acceptability, specification and programme constraints.

Consultants shall apply Appendix B, Wild Trout Trust rock-ramp and constructed riffle principles, and refer to the full appendix for detailed guidance and examples.

In summary, designs should:

- Lower the obstruction as far as practicable where full removal is not feasible;
- Provide nature-like fish passage through the full height of the barrier and into the upstream reach;
- Target shallow gradients, adequate depth, passable velocities and retained surface flow, with resting areas where needed;
- Combine fish passage and habitat function through hydraulic roughness, sediment processes, boulders, graded material and resilient bedforms;
- Avoid stepped pool or pre-barrage sequences where better connectivity and ecological value can be achieved through graded riffles, bed raising and resting areas; and
- Explain trade-offs where site constraints prevent ideal criteria being met.

5. Scope of Technical Design and Delivery

The appointed consultant shall provide a complete service covering design development, specialist coordination, planning and permitting applications, regulator engagement, construction delivery and handover. Consultants may propose an in-house offer or designer-contractor partnership and should explain their delivery model.

As a minimum, the commission should include background review; site verification and required surveys; redesign of fish passage and habitat restoration measures; technical design broadly equivalent to RIBA Stage 4; planning and Flood Risk Activity Permit submissions; liaison with the Environment Agency National Fish Pass Panel; construction methodology, programme and cost planning; and site delivery.

6. Surveys, Assessments and Consents

- Hydraulic and flood risk assessment sufficient for final design, approvals and construction, including available hydrology and water level data, ramp sizing basis, bed shear stress, material stability and scour risk for the ramp and in-channel features.
- Geomorphological and sediment considerations, including channel stability, sediment capture and restoration opportunities.
- Structural and constructability review appropriate to a constrained urban site and retained assets.
- Ecological assessment, mitigation and enhancement proposals proportionate to the project.
- Heritage and archaeological inputs sufficient to support planning and justify the proposed intervention.
- Temporary works, access, sequencing and buildability, including management of seasonal constraints on in-channel works.
- CDM-compliant delivery, clearly allocated design responsibility and professionally underwritten proposals.
- Allowance for design review and input from DCRT, project partners and the client's fisheries expert before submission to regulators and the National Fish Pass Panel.

7. Deliverables

- Reviewed and revised design basis responding to the outline design, Fish Pass Panel comments and project constraints.
- Technical design drawings, specifications and supporting calculations suitable for approvals, pricing and construction planning.
- Planning application documentation and submission, including all supporting technical information required to validate the application.
- Flood Risk Activity Permit documentation and submission, including hydraulic, geomorphological and ecological inputs as required. NB A joint permit for works involving both the project team and Skyhouse may be possible, and Skyhouse may also be able to contribute to associated costs.
- Final design package for submission to and engagement with the National Fish Pass Panel.
- Construction methodology, temporary works approach, programme and buildability review.
- Itemised construction cost estimate, pricing assumptions and identification of key risks, exclusions and provisional items.
- Completed works, handover information and any recommended maintenance, inspection or post-construction monitoring requirements.

Minimum surveys and assessments expected within the commission

- Utilities search and review of buried or nearby services that may influence design, access, temporary works or construction sequencing.
- Preliminary Ecological Appraisal proportionate to the project, together with identification of any further surveys, mitigation requirements, biosecurity measures and invasive non-native species considerations needed to support planning, permitting and construction.
- Geomorphological and sediment review covering channel stability, bed and bank response, sediment retention opportunities and implications of the proposed fish passage and habitat restoration measures.
- Hydraulic and flood risk assessment to inform final design and approvals, including available hydrology and water level data, need for additional monitoring, flood-modelling requirements, bed shear stress, ramp stability, bed protection, tie-in protection and scour mitigation.
- Structural and constructability review of the existing weir, channel and surrounding assets, including implications for retained structures, temporary works and construction access.
- In line with Sheffield City Council pre-application advice, the consultant shall prepare an updated supplementary report to the heritage assessment for the planning application. This should comprise a covering report or letter addressing the pre-application omissions, rather than a full heritage re-assessment, and should consider additional historic sources, summarise the weir's significance as a non-designated heritage asset, assess the impacts of the proposed works, and append the existing desk-based assessment where appropriate.
- The consultant shall provide drawings, construction details, specifications and technical information sufficient to support the heritage aspects of the planning application, clearly showing retained and removed historic fabric, construction methodology, and proposed stabilisation or protection of retained weir sections during and after construction.
- Identification of any additional specialist surveys, site investigations or monitoring considered necessary to de-risk the design, approvals or construction phase, clearly identified as included, excluded or provisional within the consultant's tender return.
- Biodiversity Net Gain review to identify whether the scheme is likely to qualify for exemption or, if not, what metric, habitat management and supporting information will be needed for planning. Assumptions on riparian extent, temporary works areas and off-site treatment should be stated.

8. Environmental and Construction Constraints

The appointed contractor shall address key environmental and construction risks including protected species, invasive species, vegetation clearance, sediment mobilisation, water quality, contamination risk, made ground, waste, bank instability, access, temporary works, dewatering, pollution prevention, biosecurity, reinstatement, erosion management and constraints associated with working in a heavily modified urban channel.

- The site is in a constrained urban environment with adjacent redevelopment activity that may present a temporary access opportunity for plant and materials.

- Planning permission and Environment Agency permitting are expected to be required, and the appointed team is expected to prepare and submit the relevant documentation.
- The consultant will be responsible for identifying and managing all design, construction, temporary works, health and safety, environmental, permitting and third-party interface risks within its proposed scope.
- The final design and construction methodology must be professionally underwritten, appropriately insured and capable of securing regulatory approval in a constrained urban setting.
- Consultants should assume ecological, flood risk, heritage and constructability considerations will materially influence design development and cost.
- Available background documents will be provided to the successful tenderer to support progression of the commission.
- Skyhouse is understood to be planning removal of the derelict bridge within the site. Consultants may identify whether suitable material from this removal could be reused in the ramp or associated works, subject to feasibility, specification, approvals and programme.

9. Key Decisions to Resolve Before Construction

- Whether the revised fish passage and river restoration design can secure Environment Agency, planning and National Fish Pass Panel acceptance.
- The extent of weir lowering, modification, ramp construction, riffle creation, bed raising and habitat restoration required.
- The final approach to retaining, modifying or protecting heritage and flood-risk features within the channel.
- The final access, compound, temporary works, construction sequencing and safe working arrangements, including any opportunity linked to adjacent redevelopment.
- The final cost, contingency, programme and delivery route, subject to funding confirmation and agreement of scope.

10. Information to be Provided to Designers

The following information will be made available to the appointed designer-contractor to support the commission:

- Dynamic Rivers outline design drawings, method statement, bill of quantities and designer's risk register.
- Relevant comments from the National Fish Pass Panel and associated responses.
- Available biodiversity net gain and ecological information for the reach.
- Structural risk information and location plans.
- Previous project development material, including reach character and restoration context information.
- Available flood modelling, planning or pre-application correspondence relevant to the scheme, noting that the Council is willing to assess a revised design through its flood model once available.
- Other surveys, reports or technical information held by the client and project partners that are relevant to the commission.

- Appendix B: Wild Trout Trust illustrated rock-ramp and constructed riffle principles, to guide fish-passage, riffle and habitat-restoration design.

11. Tender Requirements and Procurement Basis

Tenderers are invited to deliver the design-and-build services described in this brief. The appointment covers design development, surveys, assessments, planning and permitting submissions, Environment Agency and National Fish Pass Panel engagement, construction methodology, construction delivery, completion, handover and maintenance or monitoring recommendations.

Tenderers shall confirm they understand the project context, constraints, deliverables, consent requirements, design responsibility, buildability issues, construction risks, funding position and programme requirements. Any exclusions, assumptions, qualifications or departures from this brief must be clearly stated.

12. Tender Submission Returns

Return item	Requirement
Tender submission letter	Confirm acceptance of the brief, validity period, lead organisation, key contact and any qualifications, exclusions or departures from the brief.
Method statement	Describe the proposed approach to design development, surveys, approvals, Fish Pass Panel engagement, risk management, buildability, construction delivery and handover.
Programme	Provide a task-by-task programme showing design stages, surveys, review points, planning and permit submissions, regulator engagement, procurement, mobilisation, construction sequencing, completion and handover. Tenderers shall include a Gantt chart or similar programme showing key tasks, deliverables, dependencies and decision points.
Team structure and CVs	Identify the project director, project manager, lead designer, construction lead, specialists and subcontractors, including relevant experience, responsibilities and whether services are provided in-house or through a designer-contractor partnership.
Relevant experience	Provide examples of comparable fish passage, rock-ramp or constructed-riffle, river restoration, constrained urban watercourse, permitting and design-and-build projects.
Fee and cost proposal	Provide a fee and cost breakdown by task, discipline, deliverable and construction element, identifying design fees, surveys, planning, permitting, Fish Pass Panel engagement, estimated or provisional build costs, contingency, expenses, subcontractor costs, exclusions and day rates for additional services.
Assumptions and risks	Set out key assumptions, dependencies, information requirements, client inputs, programme risks, cost risks, buildability risks, proposed mitigation measures and justification for any additional surveys, investigations or visits.
Insurances and compliance	Confirm professional indemnity, public liability, employer's liability and relevant contractor design or product insurance levels, together with health and safety arrangements, CDM compliance, quality assurance procedures, warranties and any proposed reliance on third-party liabilities.

13. Pricing Requirements

The tender price shall cover the design-and-build commission, with a clear breakdown by discipline, task, deliverable and construction element. Tenderers shall identify provisional sums, optional services, exclusions, disbursements, survey allowances, third-party costs, contingency and day rates for additional services.

Fees and costs shall include inception, design reviews, regulator discussions, National Fish Pass Panel engagement, specialist coordination, preparation of deliverables, construction methodology, site delivery, handover information and reasonable responses to client comments. Tenderers shall state whether prices are fixed, estimated or provisional and explain any implications for scope, cost, approvals or delivery. VAT shall be stated separately where applicable.

It is intended that the appointment and delivery of the works will be procured under a JCT Design and Build form of contract, with the appointed contractor accepting responsibility for both final design development and construction delivery, subject to any agreed client requirements, approvals, exclusions and amendments.

Pricing element	**Description**	**Price / allowance**
Design development	Engineering-led redesign, coordination and technical design development	
Surveys and investigations	Hydraulic, ecological, structural, utilities or other supporting investigations	
Planning application	Preparation and submission of planning documents and supporting information	
Environment Agency permitting	Preparation and submission of Flood Risk Activity Permit and associated technical inputs	
Fish Pass Panel engagement	Preparation of submission material and attendance / response as required	
Construction delivery	Estimated or provisional construction cost, including temporary works and site establishment	
Exclusions / provisional sums	Any exclusions, assumptions or separately identified allowances	

14. Tender Evaluation

Proposals will be evaluated on a 60% cost / 40% quality basis. Quality assessment will consider technical understanding and approach, relevant experience and team capability, deliverability within programme, risk management, buildability, design responsibility and confidence in achieving the required outputs.

DCRT may seek clarification on submitted proposals and discuss delivery structure or scope refinement with preferred tenderers before appointment.

15. Tender Programme and Communications

The tender programme will be confirmed before issue. Tenderers shall submit clarification questions by the stated deadline. Material clarifications will be shared with all tenderers where appropriate. Submission validity will be confirmed in the tender invitation.

Consultants should provide a realistic programme for design, surveys, approvals, procurement and construction. The aspiration is to start enabling or preliminary site activities in September 2026 within an overall programme of approximately 18 months.
Consultants should assume significant river works are more likely during Spring/Summer 2027 and programme around seasonal and permitting constraints.
The programme should include sufficient time for design review workshops with DCRT, project partners, the client's fisheries expert and regulators, including allowance for design iteration following feedback before key approvals are submitted.

Milestone	Date / requirement
Tender issue	06/08/26
Clarification deadline	19/08/26
Tender return deadline	9am, Monday 7 September 2026
Expected notification of outcome	Monday 21 September 2026
Indicative project start	ASAP, once appointed and funding confirmed
Indicative start on site	September 2026
Preferred in-channel works window	Spring/Summer 2027
Indicative overall programme	Approximately 18 months

16. Permissions and Approvals

- The appointed consultant will prepare and submit planning and permit applications on behalf of the client, coordinate supporting technical information, engage with the National Fish Pass Panel once final designs are developed, and support the client through any clarification process.
- The works are considered likely to constitute a low-risk impounding activity. The consultant shall follow the relevant low-risk impounding activity protocol when preparing and applying for the licence, confirming requirements with the Environment Agency as necessary.

17. Funding and Appointment Position

This tender is issued before final funding approval to establish a realistic total project cost and match funding requirement. Funding is not yet fully secured and DCRT cannot award or enter into contract until it is confirmed; however, the scheme is considered highly likely to proceed, with funding expected to come from GYR and other match funding sources.

Summary of surveys and assessments undertaken during feasibility and outline design

Survey / assessment type	Description / details
Desk study (maps and aerial photographs)	Historical and recent review of the system and surrounding reach.
Walkover survey	Field verification of desk-based findings and site conditions.
Fluvial audit	Assessment of channel form, sediment behaviour and geomorphological processes.

Topographic and Lidar data	High-res topographic surface data Updated cross-sections and weir level LIDAR Data
Existing Environment Agency hydraulic model data	Previous cross-sections and model information relevant to hydraulic assessment.
Engineering survey	Structural assessment of the weir and associated infrastructure.
Hydrological analysis	Flow estimation undertaken using software-based methods.

Hydrology data for Porter Brook is limited, with no local gauge. If suitable measured data is unavailable, consultants may refer to modelled values already identified for fish pass purposes. Consultants should also review whether a full flow duration curve is available or can be derived, noting previous values were reportedly derived using Low Flows 2 and may reflect naturalised conditions only. Where modelled water levels are used instead of measured levels, consultants should comment on confidence, sensitivity testing and whether level loggers or other verification measures are needed for final design and approvals.

18. Queries and Submission

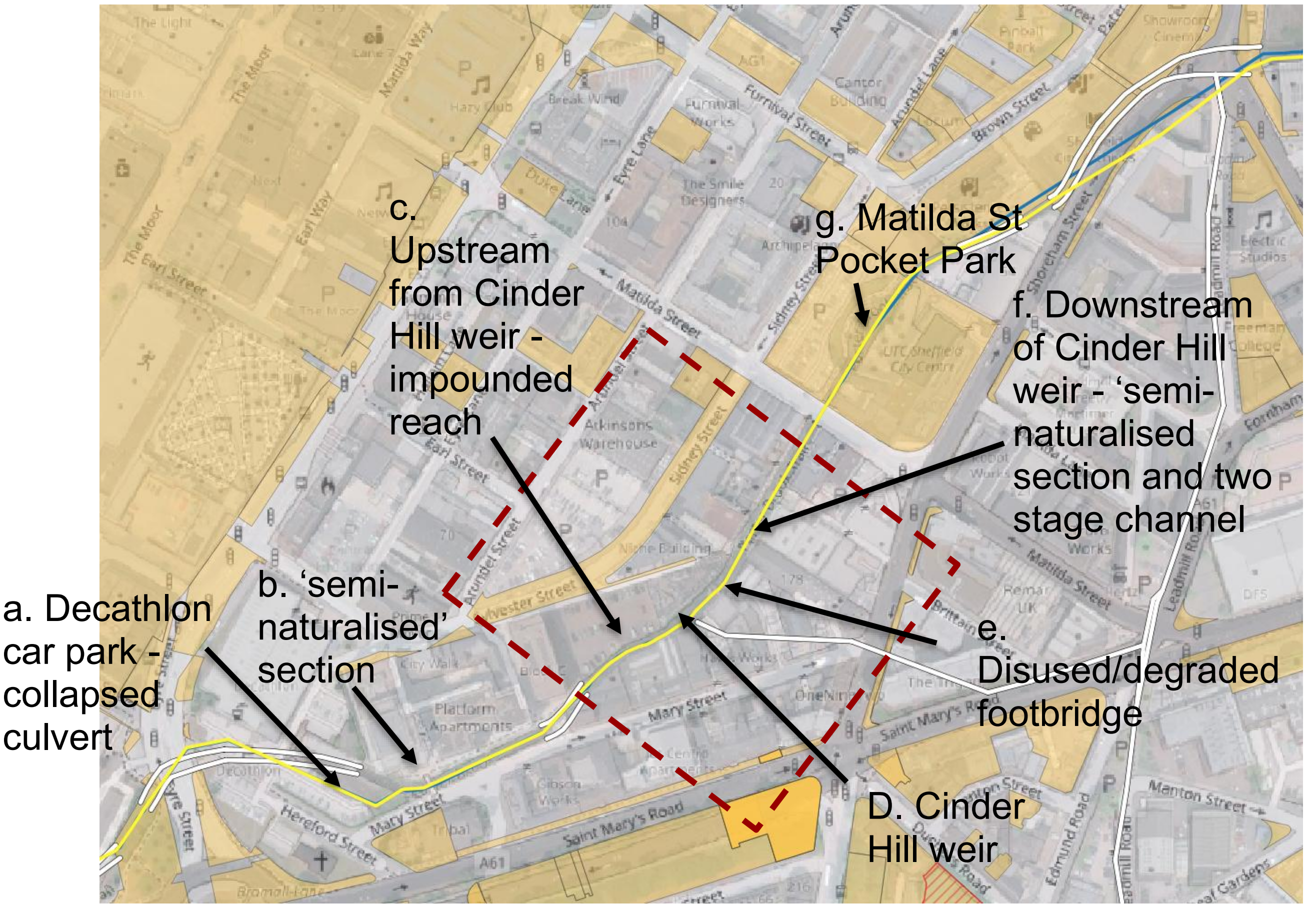
Please submit proposals electronically and direct any queries to:

Matt Duffy
Fishery Habitat Officer, Don Catchment Rivers Trust
matt.duffy@dcrt.org.uk
07825 911973

Partners

Appendix A: Reach character summary

Brief summary of reach character - Walk over March 2026 (Claire Bithell, SRWT)



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Appendix B: Wild Trout Trust rock-ramp and constructed riffle principles

The full Wild Trout Trust illustrated guidance appended here for reference. Consultants must use it to inform the rock-ramp, constructed riffle and habitat-restoration design, while adapting the principles to the specific constraints, approvals and opportunities at Cinder Hill Weir.

Ecological Principles for Rock Ramp & Constructed Riffle Interventions

Adaptable Solutions Guidance from the Wild Trout Trust

Introduction

Barrier removal is always the preferred ecological solution when addressing obstacles to fish passage. Where complete removal is not feasible, rock ramps offer a nature-like alternative that creates diverse flow patterns and opportunities for passage across a wide range of flow conditions and species.

Rock ramps are generally preferred over more engineered fish passes, which tend to be effective only within a narrower band of river flows and for certain fish species or sizes. This document sets out the key principles that should guide design and appraisal of any rock ramp or constructed riffle intervention, together with an adaptability checklist that acknowledges the wide variety of real-world constraints encountered in practice.

Aims

- Provide desirable performance principles against which to appraise designs.
- Establish that different specific interventions can achieve the same desired result, adapting to circumstantial constraints and opportunities.

Principles Checklist

The following principles should be applied to every rock ramp or constructed riffle project. Where site conditions prevent full compliance, the aim is always to maximise ecological benefit within the available constraints.

Barrier Height & Feasibility

- Where complete removal of a barrier is not feasible, the impounding structure should be **lowered as much as possible**.
- Engineering experts should be involved from the outset to ensure **feasibility** and long-term **resilience** of any constructed feature.

Figure 1: This rock ramp feature fails to address passage at the crest of the structure. It also makes poor use of the available lateral space.

Passage Through the Full Height of the Obstruction

- A rock ramp must not terminate at or below the crest of an obstruction. It must provide complete passage through to the upstream reach, finishing at a level **above** the crest.

Managing Flow Through Notches and Slots

Where a slot or notch is cut into a weir to reduce total vertical head, additional downstream measures are essential:

- **Water depth:** The slot should be drowned out to the height of the remaining weir crest by the design of the downstream ramp and/or riffle installation(s), maximising available water depth through the notch.

- **Flow velocity:** The same measures should minimise flow velocity through the notch to levels passable by target species.

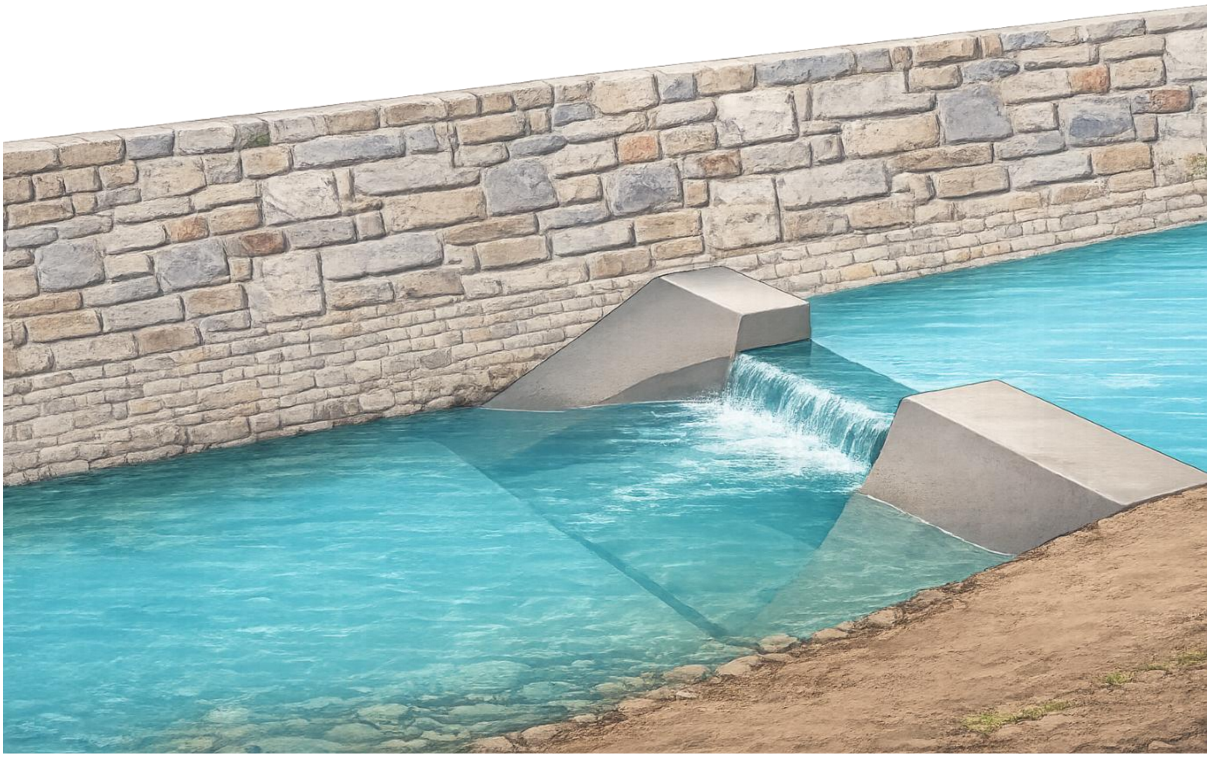

Figure 2: A slot cut into a weir without further easement measures. If the slot were small enough to be drowned out simply by restricting its cross-sectional area, the resulting water velocity would be too great for effective upstream passage.

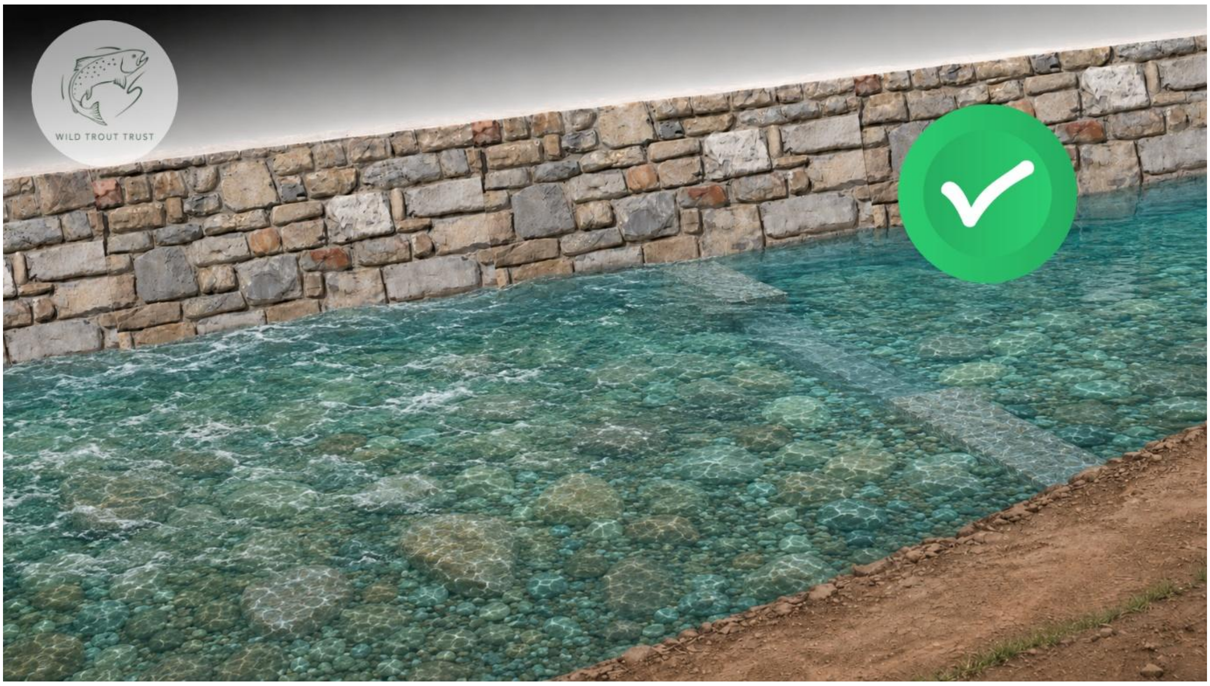

Figure 3: Here the slot is drowned out to its full height, and the density of rock placements creates sufficient hydraulic roughness to reduce velocities to passable levels.

Gradient & Length

- A single rock ramp should only be used to overcome a structure with a maximum vertical head of **1 m**.
- Any constructed intervention should have a typical **design target of 1–4%** gradient (maximum **5%)**. A gradient at or below 2% is preferable where space allows.
- Where achieving gradients of 5% or less produces a ramp or riffle longer than 20 m, **resting pool** conditions should be incorporated at intervals of less than 20 m. The precise requirement will depend on flow depth and velocities at the site.

Water Continuity

- Losses of water to percolation, **resulting in a dry upper surface of substrate**, must be prevented. See the subsequent Adaptability Checklist for approaches to achieve this.

Habitat Value

- Prioritise solutions that create **diverse and ecologically valuable habitat**, providing passage for the widest possible range of species and fish sizes.
- Favour solutions that incorporate natural processes of **substrate deposition and remobilisation** and encourage colonisation by river corridor flora and fauna, generally in preference to a completely immobile foundation.
- Design structures to be **maintenance-free**, mimicking natural stream bed conditions while retaining long-term structural stability.

Avoiding Stepped Pool Sequences

Pre-barrage solutions involving stepped pool sequences should be avoided where possible, for the following reasons:

- Lower passability across species and size ranges.
- Reduced habitat value.
- Requirement to maintain clear slots.
- Potential for infilling and acting as sediment traps.
- Greater localised shear stresses causing structural damage.

Instead, **favour downstream graded riffle** habitat creation and **bed-raising** using naturalistic substrate wherever the objective is to raise downstream water levels.

Adaptability Checklist

The means by which the preceding principles are met will vary significantly according to site constraints and opportunities. The following options illustrate the range of approaches available.

Multiple Downstream Riffles

- Consider using **multiple installed riffles** downstream of a weir to maintain any single flight of ramp below 1 m. Interventions need not be limited to a single rock ramp at the site of the barrier.
- Extend the resting pool concept to the spaces **between** as well as within multiple installed riffles:
    - **Do not restrict formal resting pools** to occur only **within** individual rock ramp or riffle structures.
    - **Distribute constructed riffles** to deliberately produce a **desired sequence of pools** on the upstream side of each riffle, maximising flow **sinuosity** and heterogeneity within the channel.
    - This approach is fundamentally different from stepped pool/pre-barrage designs, which are merely a series of smaller obstructions. Thoughtful riffle and rock ramp construction typically offers much better connectivity.

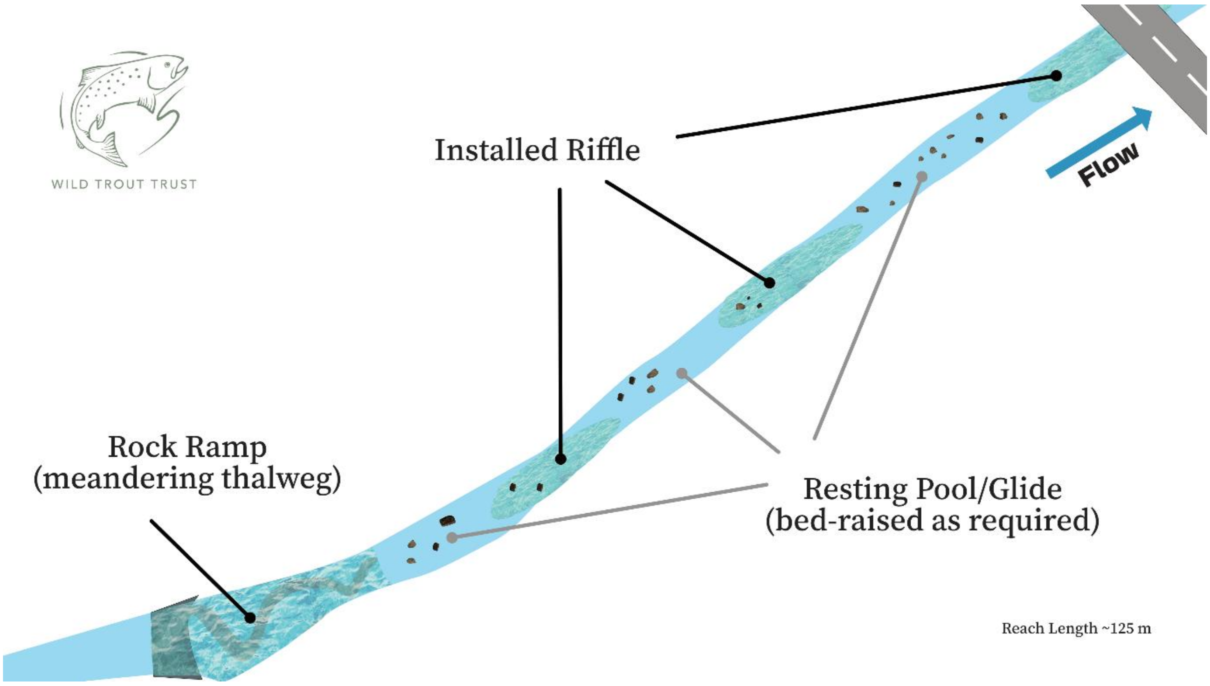

Figure 4: Downstream riffles installed and separated by lower-gradient, slower-flow resting areas.

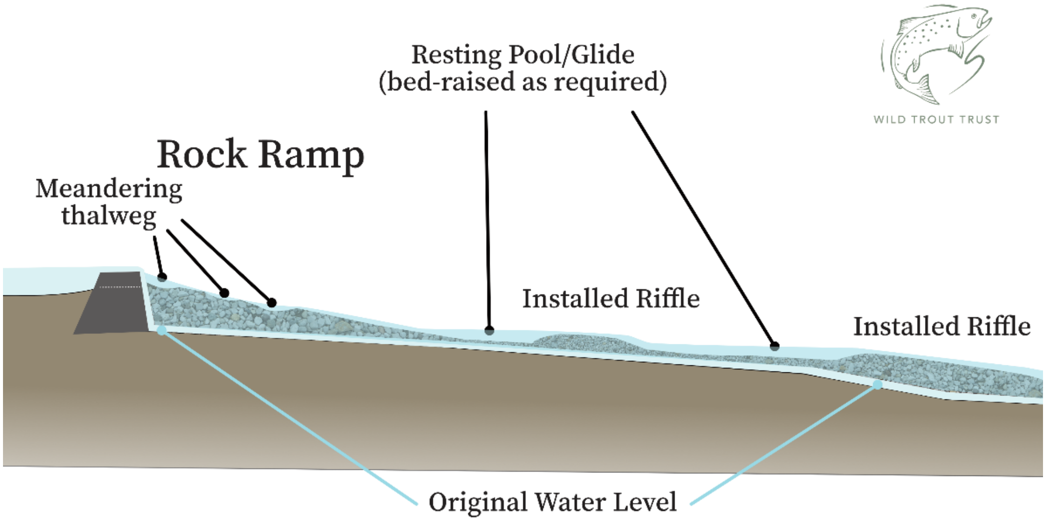

Figure 5: Bed raising and downstream riffle installation can increase habitat quality and overcome a vertical head difference in several steps, rather than relying on a single rock ramp.

Meandering Low-Flow Channel

A meandering low-flow channel and multiple resting pools can be created within any constructed riffle or rock ramp using the following methods:

- **Perturbation boulders:** Carefully selected and strategically placed large rocks to generate hydraulic diversity.
- **Sculpted base material:** The **low-flow** and **resting pool** outline can be formed in larger rock, concrete or other base material as the foundation of an embedded construction, which then accumulates natural substrate over time.
- A **combination** of the above approaches may be applied in different zones of the same design.
- The meandering inset low-flow channel also **further reduces the effective gradient** experienced by a fish compared to the shortest direct path from the base to the top of the feature.

Figure 6: A meandering thalweg (deeper channel carrying most of the flow) concept under low-flow conditions. Perturbation boulder size and placement density must be sufficient to maintain adequate water depth through the slot under low flows. This approach is also likely to produce more ecologically valuable riparian vegetation than the more uniform structures associated with coir roll and pallet installation.

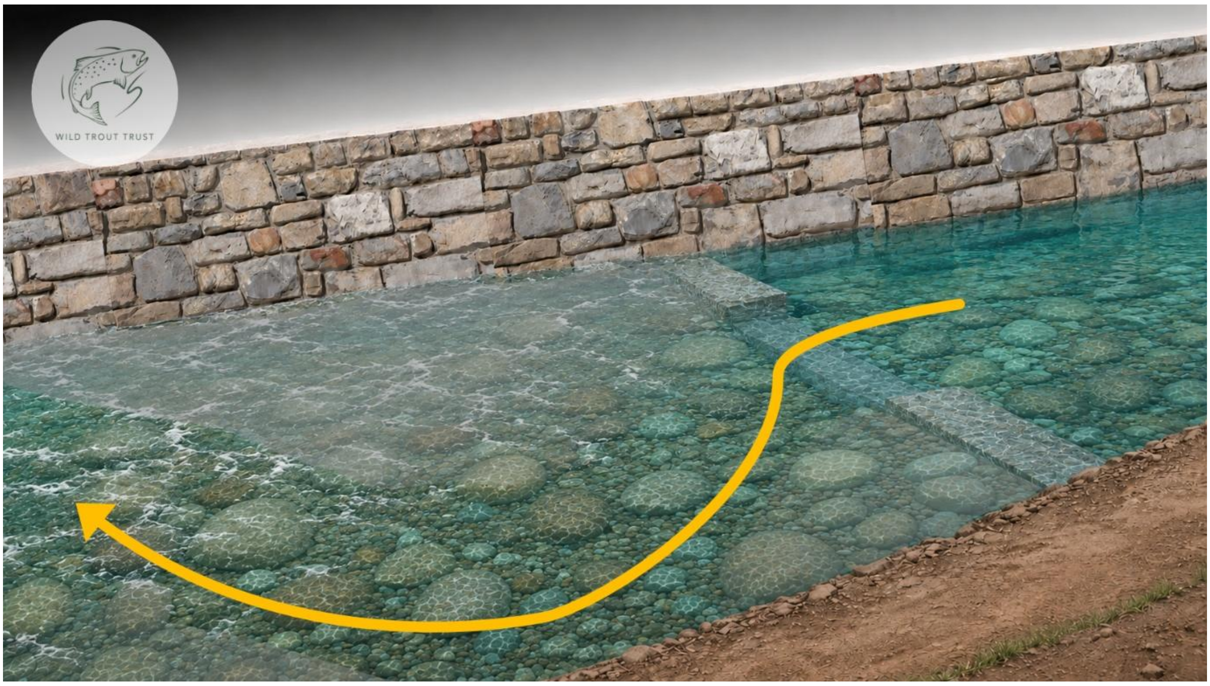

Figure 7: Meandering thalweg under normal flow conditions. This design can also incorporate deliberate resting pool areas within a longer rock ramp. Note by comparison with Fig. 6 the potential for plug-planting and natural colonisation of vegetation. It's important to appreciate that locally-appropriate plants will be adapted to the wetting and drying regimes of the channel and the riparian zone.

Preventing Water Loss Through Percolation

- **Embedded construction:** Set the foundational rock matrix within a concrete or similarly impermeable base. This approach offers a more precisely engineered shape but is less naturalistic and may require more specific maintenance over time.
- **Graded substrate infilling:** Add finer grades of material to the rock fill to infiltrate interstices and 'dress' a loose rock-fill construction. This can allow geomorphological processes to continue but requires an adequate supply of appropriately graded material.
- Incorporate **thin transverse sections of clay** within the ramp.
- Incorporate an impermeable or low-permeability **membrane** at points **crossing** the structure.

Promoting Spontaneous Riffle Formation

- Consider the use of baffles or other bed-roughening measures (such as scattered resin-bolted stone) to promote **spontaneous riffle or rock ramp** formation.

Note: This approach relies on a sufficient supply of in-stream mobilised substrate. Without it, stepped pre-barrage pools may form instead of the desired riffle.

Heavily Modified or Constrained Channels

- Highly constrained sections of heavily modified channel require careful and creative consideration of solutions.
- Sometimes, constraints will be such that even the most optimal set of provisions falls outside ideal performance criteria. In these circumstances, the aim is to ensure **maximal possible benefit** and to avoid selecting an option with lesser overall ecological value.
- It is important not to allow a 'do nothing' outcome where a better, **even if imperfect**, solution is available.

Working through the Principles and Adaptability checklists in this guidance, *in consultation with a range of stakeholders and subject experts*, should improve the chances that projects arrive at, and can justify, optimal fish passage and river habitat improvement interventions.

Two Real-World Examples

Given the highly variable challenges faced by different rock easement projects, it is valuable to consider case studies that have accommodated real-world constraints. Opportunities to improve on both examples are highlighted, while acknowledging that fish passage at each site will have been meaningfully improved by the work already carried out.

Example 1: Embedded Design with High Boulder Density

This example involves an embedded design that tackles the full height of the obstruction effectively. Key features include:

- An **embedded construction** using impervious concrete base (**minimising water lost** to percolation) combined with dressing of the gaps around each large stone with smaller substrate (**increasing roughness** and minimising boundary-layer flow velocities to aid **passage of small fish**)
- A high density of perturbation boulders, which appears to have been necessary to achieve the required degree of hydraulic roughness to **hold an appropriate depth of water throughout the easement** and through the culvert obstacle.
- Large boulders positioned at a suitable level above the crest to partially drown out the entire length of the culvert, providing free swim-through conditions.

Figure 8 (construction phase): The embedded design under construction, showing dressing with smaller-diameter substrate around the base of each large boulder.

Figure 9 (completed installation): The high placement density of perturbation boulders is clearly visible. The crest of the obstacle appears well drowned out and there is a sufficient depth of water throughout the upstream culvert.

The principal query regarding this installation is whether the ramp gradient slightly exceeds the ideal target of less than 5%. Even so, both upstream and downstream passage appears to have been significantly improved.

Example 2: Large-Scale Rock Ramp at a Navigation Lock

Figure 10: : Good use of channel width to minimise path-length gradient, with robust construction methods.

This example involves a large-scale rock ramp addressing a very significant vertical head difference at a navigation lock. Its strengths include:

- Good use of channel width to create a shallow gradient, maximising passage opportunities across a wider range of species and flow conditions.

- Innovative use of rounded piling to aid retention of stone substrate around a curved section of channel at the **lock entrance** (Fig. 10; upper right of frame).

At first glance it **appears** that a significant constraint to effective passage is that the easement seems to terminate below the crest of the obstruction. Specifically, the crest section shown in Fig.11 shows a full step remaining at the top of the rock easement, and the laminar flow of water over the angled face is powerful (Fig. 11).

Figure 11: The step remaining at the weir crest is visible between the wooden platforms (lower left of frame). The installed easement measures do not extend to that crest, meaning an obstruction to fish passage remains at this point along the crest of the weir.

However, at the right hand bank (when facing downstream), there is a slot cut into the crest that is drowned out by the rock ramp boulder clusters (Fig. 12). Compare the sloping weir face and crest visible in both Figs. 11 & 12 to the drowned-out crest and slot shown at the lower edge of Fig. 12:

Figure 12: Slot cut into the crest (lower edge of the frame) with installed boulder cluster ensuring slot is drowned out while maintaining low flow velocity through the slot.

The main remaining consideration is the likelihood that this rock ramp probably addresses a greater than 1-m head obstacle. Mitigating elements here would include both the significant length of the rock ramp and also the good use of the very wide channel to reduce the effective gradient that the fish experience. The width has also been well exploited by the intelligent placement of substrate so as to create resting areas within a meandering ascent/descent path.

Concluding remarks

Both of the preceding real-world examples represent valuable interventions in the face of challenging constraints. They are both significantly better than a "do nothing" option. There is also a wide range of criteria across which they would also outperform either technical fish pass or less imaginative rock ramp options. By understanding the principles outlined in this guidance, it should be possible to design and defend the options that are likely to yield the greatest ecological gains.

Given the varied nature of site-specific challenges and constraints, it's extremely valuable to note that the improved outcomes seen in the featured examples have been achieved. These brief case studies are excellent reminders that idealised guidelines provide important reference points. However, the ability to understand and offer a considered rationale for proposed interventions is equally valuable. Where strict adherence to particular performance criterion could result in a "do nothing" recommendation, it's essential to understand what the true opportunity cost of that decision would be. Applying the principles shared in this guide should help maximise positive outcomes and reduce opportunity costs within this complex area of conservation biology.