

Guidance for run-of-river hydropower

December 2013

Geomorphology (including weir pools)

This document is part of our set of advice notes to help you design your hydropower scheme. You should read our [Guidance for run-of-river hydropower development](#) first, which contains an overview of our guidance and a glossary of technical terms.

The physical form of the water environment (such as river banks and beds) and the processes of sediment erosion, transport and deposition are collectively known as geomorphology¹. These changes can alter physical habitats in rivers and could cause fish, aquatic plants and invertebrate populations to deteriorate. As part of our abstraction and impoundment licensing process for proposed hydropower schemes, we may require you to undertake a geomorphological assessment to help identify any possible environmental impacts that may compromise the objectives of the Water Framework Directive (WFD) or other environmental legislation. The geomorphology assessment will form a core component of your WFD assessment.

You should talk to your Account Manager as soon as possible as part of our pre-application process to determine whether this applies to your scheme.

When do you need to carry out a geomorphology assessment?

The [Environmental site audit checklist](#) is a key tool in identifying when a geomorphology assessment is needed for a proposed hydropower scheme. Section 1 of this checklist on 'Water resources and hydromorphology' asks you key questions about the proposed scheme. You should expect to complete an assessment for most schemes if:

- Your scheme will change the way water and/or sediment moves through the river channel.
- You construct a new weir or impoundment (see also our advice note on [Impoundments: the use of weirs](#)).
- You raise the height of an existing weir /or the level of impoundment upstream of the weir.
- You create a depleted reach.
- You significantly reduce the flow over the weir and/or affect the characteristics of the weir pool.
- Your scheme (including associated depleted or impounded reaches) is within or close to a water body with river improvement or restoration plans that are designed to achieve WFD or designated site objectives and may be compromised by your proposals.²

¹ Geomorphology may also be referred to as morphology or hydromorphology. Geomorphology and morphology are interchangeable terms and relate specifically to the physical form of a river, whereas hydromorphology also includes components of flow.

² Refer to the [River Restoration Centre website](#) for details of the Restoring Designated Rivers project.

The list above isn't exhaustive; we may ask for a geomorphology assessment in other circumstances. These may relate to particular aspects of the scheme, site sensitivity or other legal requirements (see our advice note on [Water Framework Directive, nature conservation and heritage](#)).

How can a hydropower scheme affect geomorphology?

Weirs

Weirs can reduce or stop the development of natural channel forms or physical habitats by:

- reducing the movement of sediment downstream and changing patterns of sediment transfer, thus changing the supply of material that builds and maintains physical habitats
- reducing flow variability within upstream impounded reaches, thus reducing the processes by which channel features and physical habitats are created and maintained
- creating areas of bed scour immediately downstream of a weir face

Weir pools are typical features that develop in response to bed scour below a weir. We have provided specific guidance for assessing possible impacts to weir pools and their ecology at the end of this section.

Depleted reaches

In combination with the potential impounding effect of weirs, reduced flows in depleted reaches may alter natural channel forms and critical physical habitats such as fish spawning gravels.

The length of a depleted reach, the nature of the flow alteration and the geomorphological characteristics and sensitivity of the reach can determine the extent of geomorphological impact.

Associated infrastructure

A hydropower scheme may involve engineering works on the bed and banks of the channel and may affect important geomorphological processes. For example, introducing bed and bank reinforcement upstream or downstream of the impounding structure might cut off the source of sediment which forms physical habitat in the river. It may also cause erosion elsewhere within the channel.

What should you include in your geomorphology assessment?

Scope

The scope of any geomorphology assessment will depend on the specific details of your scheme.

Talk to your Account Manager to help define the specific requirements of your assessment.

Table 1 highlights some of the key areas to consider in defining the scope. Your answers should demonstrate that your scheme will not damage the environment. This list isn't exhaustive and these considerations will not be relevant to all schemes.

Table 1 What to include in a geomorphology assessment

Assessment	Considerations to help define your geomorphology assessment
Flows	What are the effects on water levels, flow diversity and physical habitats (for example bar features, marginal habitats) within the impounded reach?
	What is the likely extent of sedimentation within the impounded reach, upstream of the weir?
	What are the implications of the scheme on channel forming flow events within the depleted reach? Will key geomorphological processes and resultant channel forms be impacted?
	Will 'flushing' or maintenance flows (particularly during the summer months) decline in frequency and impact the quality of physical habitats (for example for fish spawning, invertebrates and aquatic plants)?
Sediment dynamics	What are the implications for sediment movement over the weir and through the off-take pipe/channel?
	If a depleted reach is created, what effect will the altered flows and impounding structure have on sediment transport, deposition and erosion?
	What are the effects of the weir and any associated infrastructure on flows dynamics in and around the structure? Will any changes lead to increased rates of erosion/deposition?
Bed / bank erosion	Will any flow or sediment depletion lead to bank erosion, scour or collapse?
	Will any associated structures (for example bank revetment, channel realignment work) lead to bed or bank erosion immediately upstream or downstream of the structures (including tailrace or outfalls)?
Riparian zone	Will the structure and composition of the riparian zone be affected as part of the scheme works (especially during the construction phase?). Are any impacts likely to be permanent?
Scale of geomorphological impacts	What is the spatial extent of any likely geomorphological impact? This needs to be considered at the water body scale and impacts to any other 'connected' water bodies.
	What is the duration or permanency of any likely geomorphological impact?
Ecological impact	What are the ecological consequences of any potential geomorphological impacts? These should be considered in relation to WFD objectives and other environmental objectives.

Style and level of detail

You should present your assessment as a component of the WFD assessment within your environmental report. If appropriate, you should include a non-technical summary. You may need to employ suitably qualified geomorphologists to carry out surveys and advise on design options and mitigation measures.

The level of detail in your assessment and report will reflect the complexity of your scheme, the proposed abstraction regime and the characteristics or sensitivity of the site/catchment to potential environmental impacts. Table 2 gives examples of different levels of assessment we may require. This list isn't exhaustive; we may ask for other forms of assessment.

Table 2 Levels of geomorphology assessment

Level of assessment	Example	Typical tasks
Light-touch review: desk-based	Minor amendment to existing hydropower scheme	<ul style="list-style-type: none"> discussion with Environment Agency short review of scheme proposals and any related environmental reports short statement of report highlighting any issues
Detailed review: desk-based with site visit where necessary	Turbine installation on or adjacent to existing weir, utilising former wheel pit.	As above, plus: <ul style="list-style-type: none"> expert review of proposals geomorphological reconnaissance survey of the site if appropriate (e.g. habitat mapping, photographic survey) reporting of assessments undertaken
Bespoke data collection and analysis	New high head hydropower scheme incorporating new weir and offtake	As above, plus: <ul style="list-style-type: none"> site-based data collation and mapping (topographic survey, sediment character, detailed physical mapping) bespoke sediment and geomorphology modelling

Standard information

You must include standard information in your report. We suggest you use the following requirements as section headings in your report. The level of detail we require in each section will depend on the proposed scheme design and site characteristics. A light-touch, desk based review, for example, may typically only require a short statement against each heading. Your Account Manager will help you define the scope of your assessment.

Geomorphology site overview: to describe and quantify the geomorphological characteristics. The nature of your proposals and site characteristics will inform the scale of your assessment, but is likely to include an evaluation of:

- channel forms and processes
- channel bed and bank sediment characteristics
- flow quantities and dynamics
- existing artificial structures or modifications

River Basin Management Plan baseline data: to help determine if the proposed scheme will impact on the current status and future objectives for the water body and any adjacent water bodies. You should indicate how far any potential impacts from your scheme will reach. Ask your Account Manager for the most up-to-date data.

Scheme description to include:

- a summary of the purposes of the work
- a description of the proposed work including relevant design drawings hydrographs/flow duration curves and temporary works
- a description of any proposed mitigation or enhancement measures

Impact assessment: An assessment of likely geomorphological and associated ecological impacts of the scheme within the water body and adjacent water bodies, if applicable:

- Considered at the short term (including construction phase), medium term (geomorphological adjustment following construction) and long term (including operational and decommissioning phase).
- Including the ecological consequences of any predicted geomorphological impacts at the site, along the depleted reach, and at the weir outlet.
- Including the geomorphological or ecological mitigation measures you will put in place to manage any predicted impacts. You should also describe any additional enhancements you propose that will contribute to WFD objectives.

Concluding statement: Your geomorphological assessment should clearly demonstrate that your proposed hydropower scheme will not:

- contribute to a deterioration in the current status or potential of the water body or water bodies affected by your scheme
- prevent the achievement of objectives set for the water body or water bodies affected by your scheme
- compromise the achievement of designated site conservation objectives

You must submit a summary of the evidence you have used and justify the level of confidence in your judgement.

Weir pools

A weir pool is an area of water below a weir (or similar impounding structure) that is influenced by the flow of water over the weir. They form as a consequence of geomorphological processes (scour and deposition) and are therefore important features to consider as part of your geomorphological assessment.

Weir pools can be important habitats for plants, invertebrates and fish. They are used for spawning and fry development of several river-based species, such as trout, barbel, dace, chub, bullhead and stone loach. They can provide valuable and popular recreational fisheries.

The weir pool habitat may contribute to the status of the fish population, wider ecology and recreational fisheries for a distance downstream. It may also contribute significantly to the WFD status of the river water body.

What do you need to do?

If there's a weir pool associated with your scheme you need to understand how it affects the local ecology and design your scheme to take account of this. Factors that could affect a weir pool include:

- the location of the turbine tailrace
- the management of flows across the scheme, including turbine flow, flow over the weir and fish pass flow where relevant
- the local bed and bank material and structure, and changes in sediment supply

It's important to avoid changes to a weir pool that might adversely affect compliance with the relevant environmental legislation or the rights of existing users. Examples of unacceptable adverse change include:

- a deterioration in the WFD status of the associated water body
- preventing the water body from achieving its environmental objectives under the WFD
- a harmful change for existing users of the river, including riverside ('riparian') use such as a fishery, rights of navigation and legitimate amenity use

How can you assess the weir pool habitat?

For each weir pool, you must consider the following elements:

- which ecologically important features are contained within the weir pool
- the contribution these features make to the ecological status of the river
- whether there is a fishery (or other existing use) associated with, or affected by, the weir pool

Ecologically important features

Before you undertake detailed ecological and geomorphological survey, try to establish what is already known about the nature of the weir pool. If possible, we will try to make decisions on the basis of existing data and information you supply, together with expert judgement. Where this isn't possible, we may require you to carry out surveys and modelling to provide the necessary information.

To understand the ecological significance of a weir pool, it's necessary to understand both the type of habitat associated with the weir pool and the species that use it. In relation to the WFD, where a weir pool contributes to the ecological status of a water body, we need to consider any potential changes to the flow and geomorphology within it that would be caused by the introduction of a hydropower scheme. Table 3 highlights some of the key areas to consider.

Table 3 Important ecological features in weir pools

Feature	Considerations
Substrate	<p>Fish use gravels for spawning. Gravels are typically found at the tail of the weir pool. Presence and distribution of gravels are maintained by flows through the weir pools:</p> <ul style="list-style-type: none"> • large flows can significantly alter their distribution • low flows can result in sediments being deposited • medium flows help maintain spawning gravels by keeping them clean and well oxygenated
Fish and other biological interests	<p>Many species can utilise weir pool habitats for a range of purposes.</p> <p>The biology found in weir pools can contribute to the assessment of ecological status under the WFD.</p> <p>Fish and other biological interests can be designated features of protected areas and may require additional protection.</p>
Ecologically significant habitat	<p>Habitats change depending on location and flow regime. Not all weir pools will have the same ecological value.</p> <p>Large, deep weir pools with large boulders are unlikely to contribute to the wider ecology of the river. Changes to flow are less likely to affect the overall status of the stretch of river.</p> <p>Flow of water over the weir creates increased oxygen levels.</p> <p>Water-borne food can be channelled through the tail of a pool and so provide an attractive habitat for fish.</p>
Lawful uses, such as a fishery	<p>Weir pools are often the site of recreational fisheries.</p> <p>Changes to the design and management of flows within such habitats might alter the distribution of fish within the weir pool, to either worsening or improving the fishery. Where a fishery exists, we need to consider the likely effect of the revised flow regime through the site.</p>

Features elsewhere within the river section

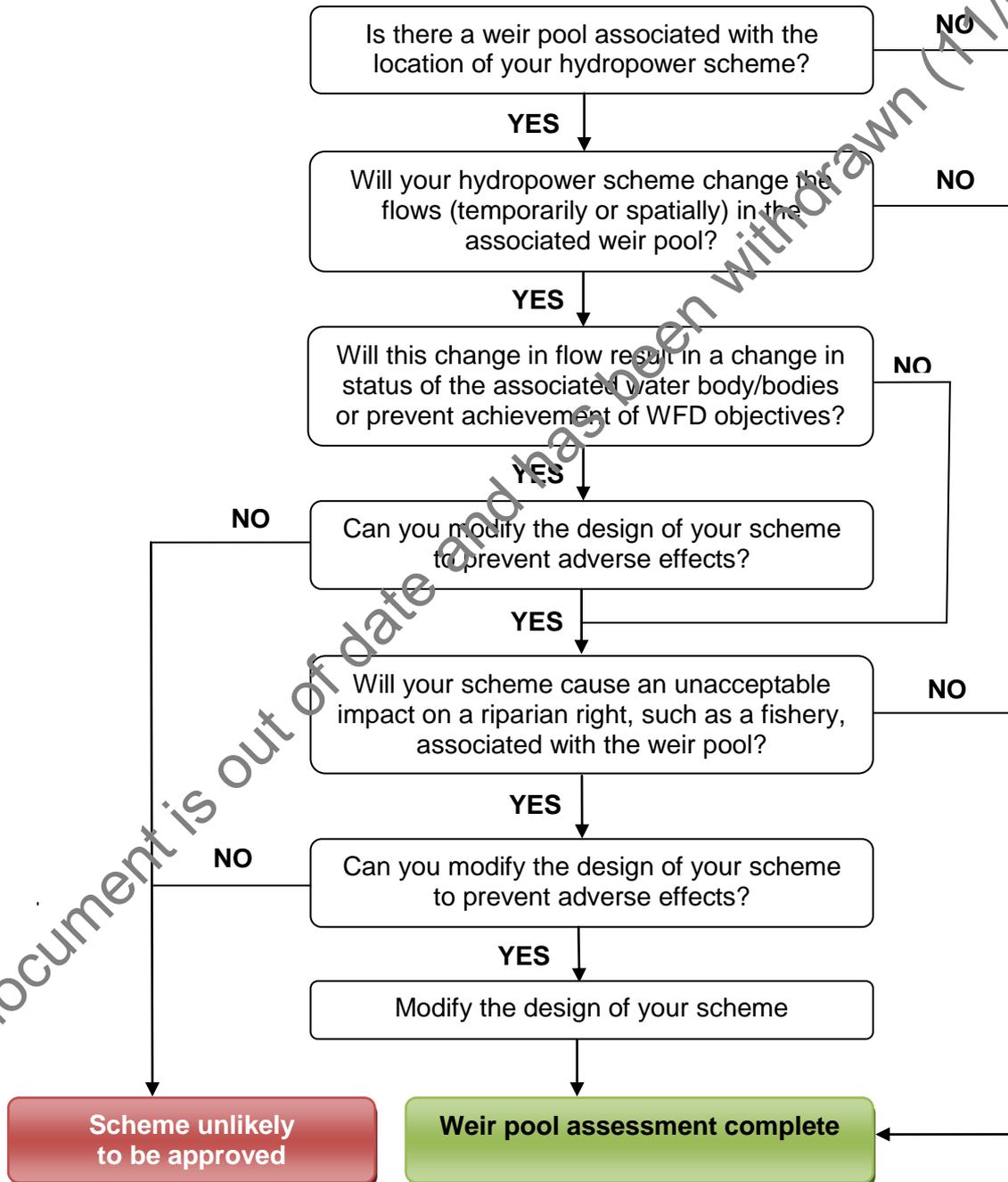
Where similar habitat features are prevalent throughout the stretch of river, the contribution from the weir pool may be relatively small. In these cases, changes to a weir pool are less likely to affect the ecology of the river section as a whole and would be unlikely to cause a deterioration in the status of the water body in which it's found or with which it's associated.

In other cases, for example in lowland impounded rivers, the important habitat associated with the weir pool may not be prevalent in the rest of the river. In these situations, the weir pool habitat is even more valuable. Changes that would damage this habitat are more likely to be unacceptable. Not all changes have the potential to cause an ecological impact, some may be beneficial.

How can you do this?

Figure 1 shows how to design your scheme to take account of the associated weir pool.

Figure 1 Decision tree to support weir pool assessment



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