



Hydropower Guidance Note: HGN 10 Geomorphology

This Guidance Note has been prepared by Natural Resources Wales (NRW) to provide applicants for abstraction and impoundment licences for the purposes of hydropower schemes developers with information on geomorphology. Its contents may be updated periodically and developers should ensure they read the most recent version, which is available on the NRW website.

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Introduction

The physical form of the water environment, adjoining banks and floodplains, and the processes of sediment erosion, transport and deposition are collectively known as fluvial geomorphology. These processes and features are a determining factor for the habitat of a river reach- e.g. the abundance and character of shallow riffles and deep pools, the distribution of areas with boulders and cobbles or sand and silt. The distribution and character of these different habitats influences the types and abundance of fish, invertebrates and plants that live in a river reach. Because hydropower schemes typically alter flow regimes and the movement of sediment, they can impact geomorphological processes and habitats, and thus affect fish, macrophyte and invertebrate populations. It is therefore important for NRW to consider geomorphology when assessing applications connected with hydropower development.

At the end of this Guidance Note, '*Annex 1: hydropower and geomorphology*' provides more information on how hydropower schemes can affect geomorphological processes and stream habitat and ecology.

What do you need to do?

As part of your application, you need to provide information that will allow NRW to assess the risk your proposed scheme poses to river geomorphology and ecology. For the majority of applications we will be able to assess risk using basic information about the site and scheme, along with photos and maps. We call this the Stage 1 Survey. All applications for hydropower schemes will need to include a Stage 1 Survey.

If your Stage 1 Survey suggests your proposed scheme poses a potentially higher risk, and we cannot mitigate this risk through working together to adapt the design of your scheme, we will ask you to conduct a more detailed Geomorphology Assessment. These assessments will be more technical and will typically require hiring a qualified geomorphologist.

Stage 1 Survey

The 'Stage 1 Survey' is designed to be simple, fast and inexpensive. If you have any questions about how to prepare your Stage 1 Survey, ask your Account Manager and they can help.

Stage 1 Surveys need to include the following:

- photographs showing planned locations of all structures to be sited in or near water, including access tracks, the impounding intake weir, pipelines, turbine house, and outflow. The photos for the intake should include one with the crest level and the extent and level of the impoundment clearly marked. This can either be done on site with survey staffs or afterwards with Photoshop. Include an original photo and then below a copy of the same photo with the impoundment drawing superimposed on top. Do the same to show level and spatial extent of the proposed impoundment pool behind the weir.
- photographs of the depleted reach (a minimum of 10 photos evenly spaced throughout the depleted reach BUT no fewer than one per 250m)
- photographs of the reach upstream of the planned abstraction point (one per 100m for 500m)
- photographs of the reach downstream of the outfall (one per 100m for 500m)

- photographs of the surrounding environment (e.g. riparian zones, flood plains) and any key channel features (waterfalls, etc.) in the depleted, upstream and downstream reaches
- photographs of significant features within the depleted reach such as crossing points, culverts, waterfalls areas of erosion or deposition and tributaries
- photographs of the sediment types, banks and bed throughout the reach. These three additional photos (one looking down at the substrate, one left bank, one right bank) should be taken at each 'reach photos'

IMPORTANT:

- **EVERY photograph must be numbered, grid referenced, given a descriptive heading and located on the accompanying map of the site (a numbered dot of where the photograph was taken with an arrow showing the direction of photograph).**
- **Include an object for scale in EVERY photograph. Metre sticks are useful to indicate channel width and depth or the height of waterfalls. Rulers, notebooks and pens placed on emergent substrate are useful for pictures of sediment.**

In addition to the photographs, the following standard information is required:

- annotated site map
- grid reference and elevation (m OD) of the proposed weir site
- grid reference and elevation (m OD) of the proposed outfall site
- length of the depleted reach (as measured down the channel) AND slope of the depleted reach
- plan or map showing the location, type and extent of any proposed instream or bank-side modifications and structures, both temporary and permanent
- a short description (with map location and/or grid references) of any proposed maintenance activities and access points

Geomorphology Assessment

If your Stage 1 Survey demonstrates there are risks to geomorphology and habitat that cannot be resolved through adapting the design of your scheme, we will ask you to conduct a Geomorphology Assessment. The content of this Assessment will vary

depending on the details of the proposed scheme. We provide general descriptions of the Scope, Style and Detail, and General Information of a Geomorphology Assessment.

Scope

The table below highlights some of the key issues to consider in defining the scope of your geomorphology assessment. This list is not exhaustive and these considerations will not be relevant to all schemes.

Assessment	Considerations to help define your geomorphology assessment
Flow dynamics	What are the effects on water surface elevations, flow diversity and physical habitats (e.g. 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 (e.g. for fish spawning, invertebrates and macrophytes)?
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 (e.g. bank revetment, outfall pipe) lead to bed or bank erosion immediately upstream or downstream of the structures?
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.

Style and level of detail

You should present your assessment as a single report or as a separate chapter within an Environmental Report. A non-technical summary should also be included.

The level of detail in your assessment and report will reflect the complexity of your scheme and the characteristics or sensitivity of the site/catchment to potential environmental impacts.

Geomorphologically sensitive site selection and design from the outset can significantly reduce the complexity, detail and cost associated with a geomorphological assessment. For example; a small impoundment on a steep narrow bedrock reach, or a design that does not require a formal impoundment, is less likely to be geomorphologically damaging than a large impoundment on a shallow unconsolidated reach.

The table below provides examples of the different levels of assessment we may require.

Level of assessment	Example	Typical tasks
Light-touch review – desk-based	Minor amendment to existing hydropower scheme	<ul style="list-style-type: none"> • Collation and assessment of existing reports • Web-based map analysis • Discussions with NRW • Short report of assessment
Detailed review – desk-based with site visit where necessary	Turbine installation on or adjacent to existing weir, utilising former wheel pit.	<ul style="list-style-type: none"> • As above, plus: • Analysis of data (e.g. flow data, scheme evaluation, environmental impacts) • Expert interpretation • Geomorphological reconnaissance survey of the site if appropriate: basic habitat mapping and photographic assessment / review
Bespoke data collection and analysis	New high head hydropower scheme incorporating new weir and off-take	<ul style="list-style-type: none"> • As above, plus: • Site-based data collation and mapping (topo survey, sediment character, detailed physical mapping) • Bespoke sediment and geomorphology modelling

Standard information

Your Geomorphology Assessment will include the following information¹:

Geomorphology site overview: Site overview to describe and quantify the geomorphological characteristics (including geo-referenced photos of the bed, banks and sediment present). The nature of your proposals and site characteristics will inform the scale of assessment, but is likely to include an evaluation of:

¹ We have listed these requirements as suggested section headings for your report. The level of detail required in each section will depend on the proposed scheme design and site characteristics. Your Account Manager will help you defining to define the scope of your assessment.

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

WFD baseline data: A summary of the relevant WFD water body 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. Indicate the relative scale of potential impacts.

Scheme description

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 at a site scale and the WFD water body scale, which should:.

- consider the short term (including construction phase), medium term (geomorphological adjustment following construction) and long term (including operational and decommissioning phase)
- consider the ecological consequences of any predicted geomorphological impacts
- include 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: A concluding statement on the probability that the geomorphological impacts of the work (including mitigation where appropriate) will either:

- cause a non-temporary deterioration in the WFD water body quality elements and deterioration in the ecological status/potential of the water body, or adjacent water bodies
- compromise the achievement of WFD objectives for the water body or adjacent water bodies.

- A summary of the evidence used and a statement of the level of confidence in the judgement must accompany the statement.

Annex I: Hydropower and geomorphology

Hydropower schemes can affect river geomorphology in a number of ways. This section provides a summary of factors to consider in designing your proposed scheme.

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
- creating areas of deposition immediately upstream of a weir pool
- restricting the ability of the watercourse to move vertically and laterally

Weir pools are typical features that develop in response to bed scour below a weir. We have prepared a separate guidance note for assessing possible impacts to weir pools and their ecology.

Depleted reaches

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

The impact of a scheme on the geomorphology of the depleted reach can depend on: the geomorphological characteristics of the channel, the impact of the weir on sediment transport, the length of a depleted reach, the nature of the flow alteration, the presence and nature of tributaries entering the depleted reach.

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. Infrastructure such as pipeline stanchions and outfalls may also interfere with natural geomorphological processes.