Scottish Natural Heritage

Hydroelectric schemes and the natural heritage

December 2015

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1. Purpose

The purpose of this guidance is to:

- help developers and competent authorities identify, assess, and where necessary, mitigate against impacts on the natural heritage from hydroelectric developments. It is mainly aimed at run-of-river schemes, but refers to low head proposals too;

- help SNH staff formulate our advice on individual applications, particularly at the pre-application stage where we can influence the design of the development. It will help to ensure that our staff take a consistent approach to hydro casework.

2. Introduction

This guidance concentrates upon the natural heritage impacts associated with hydroelectric schemes, and complements the published guidance from the Scottish Environment Protection Agency (SEPA) that focuses on impacts upon the water environment only. Developers should refer to both of these guidance notes when developing a scheme.

At the early stage in the planning / Controlled Activities Regulations (CAR) licensing process and before we enter into discussions about a proposal, developers should apply the SEPA Guidance for developers of run-of-river hydropower schemes. This sets out how SEPA intends to achieve Scottish Ministers' policy objectives and contains guidance on the developments that are likely to be acceptable in the context of the Ministers' policy statement on renewable energy generation and the protection of the water environment. Emphasis will be placed on supporting hydropower developments which can make a significant contribution to Scotland's Renewable Energy targets while also minimising any adverse impacts on the water environment.

Should you have any difficulty in applying the guidance, you should contact your local SEPA office for advice. Should the proposal prove to be provisionally acceptable using the SEPA guidance, we would be happy to provide you with further advice on assessing the impacts on the Natural Heritage using this guidance.

Other aspects of development that are integral to the proposal and that should be considered where necessary include:

- a separate application for grid connection;
- an application for aggregate extraction;
- an application for forest clearance.

The Scottish Government's online advice on Hydro schemes is an additional source of background information on the processes behind each technology and can aid in identifying survey requirements at an early stage.

Sources of **Further Information** are provided in Annex 1.

Our role in the development process

Our role is to provide advice on the natural heritage impacts and to help the developer to identify solutions and / or mitigation to overcome these impacts. However, for some proposals in particularly sensitive sites, mitigation is not always feasible on a proposal. Where this is the case we should make this clear to the applicant at the earliest opportunity.

This guidance does not provide advice on when we should or should not object to an individual application – this is covered by our 'Identifying Natural Heritage Issues of National Interest in Development Proposals' guidance. This document is focused on design issues, and mitigating environmental effects where possible. Reference should be made to our Renewable Energy **Service Level Statement**, which sets out the level of involvement which we are able to offer at each stage of the consultation process.

Some of the information contained within this guidance relates to issues beyond the usual scope of our service statement and the advice that we will offer. It is important, however, that this information is available for the benefit of developers and planning officers in setting the wider context and allowing for consideration of natural heritage issues. For example, we are unlikely to offer advice on the detailed design of a tailrace structure (unless it is within or affecting a protected area), but the Planning Authority, or SEPA may seek further information on this.

Stream in a semi-natural upland environment, typical of those favoured for hydro schemes

Our operations teams will only advise on matters within the bounds of our service statement. In all cases our advice on the natural heritage needs to be balanced with the technical design involved in the project. It is for the applicant to design the project taking in to account technical, engineering, health and safety, and any other related considerations.

It is the role of the planning / competent authority to develop the wording of suitable conditions to accompany a planning permission or CAR licence. We will provide advice on the issues to be resolved by conditions through our written submission.

3. Potential natural heritage impacts from hydroelectric schemes and construction activities.

3.1 Requirement for environmental impact assessment

Under The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017, a developer will be required to undertake an Environmental Impact Assessment (EIA) and produce an Environmental Statement, if the proposal is likely to have significant effects on the environment. Planning Circular 1/2017 provides further guidance.

It is the responsibility of the planning authority and SEPA (for the water environment) to clearly set out the appropriate level of assessment required to determine the risk to the natural heritage.

We recommend consideration of the potential impacts on:

- Protected areas;
- Protected species;
- Landscape and visual amenity;
- Access and recreation

Specific considerations also apply to the construction stage and further information is provided in a Guide to hydropower construction best practice.

3.2 Protected areas

All developers of hydroelectric developments should undertake a basic desk study to ascertain if their proposal is likely to affect any protected area. These sites include:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs) (including candidate sites), and Ramsar sites;
- Sites of Special Scientific Interest (SSSIs);
- National Nature Reserves (NNRs);
- Geological Conservation Review sites;
- National Scenic Areas.

The planning authority may also wish to see consideration of potential impacts on any regional/ local natural heritage designations. Establishing whether or not a proposal is *within* a protected area is relatively straight forward using our SNHi information service.

Determining whether or not a proposal *out with* a protected site could affect the site requires further consideration. The key question is whether the proposal could affect the site through any ecological pathway, for example by:

- effects on species which use the protected area but move outside this area to feed or for other activities;
- noise during construction and operation;
- run-off or dust from construction works.

We will offer advice on the potential impacts of a development on the notified / qualifying features of a protected area, and will expect developers to follow good practice design and construction to mitigate and avoid the impacts.

We have a statutory duty to secure compliance with the requirements of the EU Birds & Habitats Directives. Of particular relevance is the need to advise on potential impacts of proposals within or affecting Special Areas of Conservation (SAC) and Special Protection Areas (SPA) as required by the Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007 (usually referred to as the 'Habitats Regulations'). SACs and SPAs are known collectively as 'Natura' sites.

Where Natura sites (their qualifying interests) may be affected by a proposal, the determining authority (known as the 'competent authority' in this context) is required to undertake a Habitats Regulations Appraisal. This may include an 'appropriate assessment' to ascertain that the integrity of the site and its conservation objectives will not be adversely affected by proposal. Applications some distance away from a designated area may also affect its interests (by connectivity), e.g. by changing river flow regimes, and advice should be sought from SNH.

Owners and occupiers of land within a SSSI must apply to SNH for consent to carry out certain operations that have been notified to them.

For further information on the requirements of the Habitats Regulations for Natura sites, and for information on National natural heritage designations such as a Sites of Special Scientific Interest (SSSI) or National Scenic Areas please visit our website. Details about these sites, including qualifying interests, conservation objectives and site boundaries, can also be accessed on sitelink.

3.3 Protected species and habitats

Hydroelectric schemes may also affect species that are protected under domestic or international legislation. We advise that the developer collates relevant information on protected species, and presents a preliminary assessment of the potential impacts (including any proposed further survey requirements and/or mitigation) to the planning authority. This should include a desk study and a reconnaissance visit to the development site by a competent consultant. A basic assessment will require:

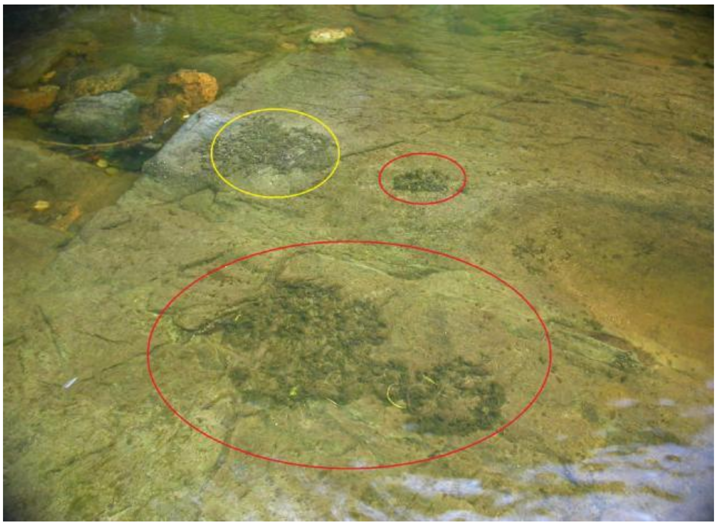
- a brief description of the site, its context, and the habitats and species present;
- identification of the presence of any protected species, description of any potential impacts and any required mitigation.

The need for further assessment should be determined by the planning authority following the submission of the initial appraisal. Advice on survey effort should be sought well in advance of the planned submission of any application to ensure that sufficient time remains available to carry out any surveys that are necessary.

Surveys at both the pre-application and pre-construction stages should rule out the presence of protected species, or inform a mitigation plan put in place before construction begins. Surveys should be done at the appropriate time of year for the species concerned and may need to follow particular methodologies. Also, a licence may be needed by those carrying out the survey. The survey report should include ways to mitigate unavoidable damage or disturbance and suggest ideas to compensate for any losses. The report should also identify any licensing requirements which might enable the work to be done in spite of the presence of protected species.

The species that are most likely to be encountered are Atlantic salmon, lamprey, otter, freshwater pearl mussel, water vole, river jelly lichen, breeding and ground nesting birds and, where there are structures or old trees that are likely to be affected, red squirrels, bryophytes, lichens, bats and birds. In some upland situations consideration should also be given to the possibility of the presence of wildcats.

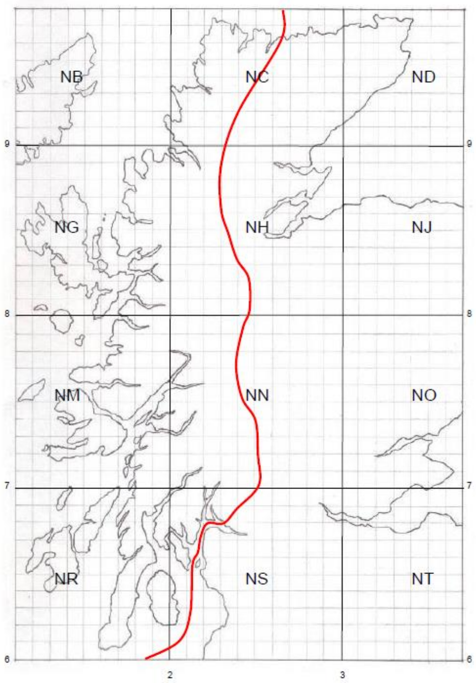
Maintaining the heterogeneity, or mix, of habitats is important for



River Jelly-lichen (Collema dichotomum) furthering species diversity, and ecological function. For most species protection extends to places used for shelter, resting or breeding. Several species, including otter, wildcat and bats are given strict protection under the Habitats Regulations. These species, known as European Protected Species (EPS), are protected from intentional or reckless disturbance and their breeding sites and resting places are protected from all types of damage or destruction wherever they occur.

Note that where EPS are present as a qualifying feature of a Natura site they will have to be considered a qualifying interest of the site as well as an EPS. Further guidance on protected species is available on our website.

A number of fish species, such as Atlantic salmon, brook lamprey, river lamprey, sea lamprey and Arctic charr are provided with strict protection within sites designated for nature conservation, such as SSSIs. Out-with these sites, the impact of new hydroelectric developments on other vulnerable fish species, such as the European eel and trout, should also be considered with appropriate mitigation e.g. screening, provided to ensure minimal impacts on species and habitats. These species are important components of a functioning, and healthy, aquatic ecosystem. The ability for fish species to complete their lifecycle is the key.



The red line marks the approximate eastern limit of the area richest in oceanic bryophytes. Consult the map in the online mapping tool to identify the category of a watercourse.

In wooded ravines, the impact on a range of bryophytes (mosses and liverworts) and lichens that depend on sheltered humid conditions will also require consideration. Bryophytes are one of the main species groups of concern in relation to hydroelectric schemes. The West Highlands (including the Hebrides) are home to some of the richest sites for oceanic bryophytes in Europe, and the general richness in these plants is higher than elsewhere in Great Britain. For watercourses flagged as category B or D on SNH's online planning tool, a survey of the 29 oceanic ravine indicator species outlined in SNH Commissioned Report 449b is required. The survey should focus on the burn itself (between the intake and return points), including rocks, banks and trees along the watercourse. Where the bryophyte flora is found to be of national importance (category A) within the abstracted reaches, additional survey should be carried out above and below the proposed scheme to help put the findings into context. It is helpful to illustrate findings in table and map format. There may be a minority of cases where additional survey of category A watercourses will provide context that allows a scheme to be developed without compromising the important bryophyte flora.

The impacts of hydroelectric schemes tend to be fairly localised in wooded landscapes, but could require some woodland removal to accommodate both the infrastructure and access to the site. Any proposed woodland management, including tree removal, should be discussed with the Forestry Commission in accordance with the Scottish Government's policy on the control of woodland removal and sustainable forest management principles.

3.4 Landscape and visual amenity

Most hydroelectric schemes will require a proportionate level of landscape and visual impact assessment, with the level of assessment required varying depending on the sensitivity of the location of the proposal. Infrastructure, particularly tracks, has the potential to have significant impacts and will require careful consideration (further information in Section 4.6).

Landscape and scenic value is recognised at national and local levels through development plan policies and designations such as National Parks, National Scenic Area (NSA), or local landscape designations. Designations are usually supported by legislation and / or specific planning policies at a national and local level. The lack of any designation does not imply that a landscape has no value.

The key test applied in relation to NSAs, but employed for other valued landscapes too, is whether impacts would affect the integrity / special qualities of the valued landscape. It is important to consider the effects of hydroelectric schemes located just outside areas identified for their special qualities, as these have the potential to affect the setting, and potentially the integrity, of that designation.

The first step in the Landscape and visual impact assessment (LVIA) is to assess the landscape character of the study area and to identify the key characteristics relevant to the hydroelectric development. Different places have different 'landscape character', comprised of distinct and recognisable patterns of elements. These relate to underlying geology, landform, soils, vegetation, land use and settlement. Taken together these qualities contribute to regional distinctiveness and 'sense of place'.

Should the construction of a proposed hydroelectric scheme and associated infrastructure require the removal of existing areas of woodland, the landscape and visual consequences of creating new areas of open ground to accommodate the development should be assessed. Guidance on how the forest landscape context should be considered can be found in the UK Forestry Standard (2011) and associated Forests and Landscape UKFS Guideline, and FC Practice Guide: 'Design techniques for forest management planning'.

Further guidance on the assessment of impacts on landscape character is given in the Guidelines on Landscape and Visual Impact Assessment (GLVIA). In order to properly assess the landscape and visual impacts of a hydroelectric scheme it will be necessary to have firm details (plans and visualisations) of the scale and location of the components of the scheme e.g. the intake, the penstock, pipeline or canal, the turbine house, the tailrace, associated tracks and ancillary infrastructure. Understanding a landscape's key characteristics and features is vital in considering how new development would affect it or, with appropriate design, could contribute to it. More detail on this is explained below in Section 4.

Wild land

Paragraph 200 of the Scottish Planning Policy (2014) states that:

> *'Wild land character is displayed in some of Scotland's remoter upland, mountain and coastal areas, which are very sensitive to any form of intrusive human activity and have little or no capacity to accept new development. Plans should identify and safeguard*

the character of areas of wild land as identified on the 2014 SNH map of wild land areas.'

The map of Wild Land Areas can be found on our website. It is important to note that Scotland's wild land areas are not redundant and unused, but subject to some land management and activity that provides a range of social, economic and environmental benefits. Reflecting this understanding, it is important to emphasise our view that wild land does not denote 'no human management or development'. As a result, it is possible that well designed and suitably located small scale hydro schemes may be appropriate in Wild Land Areas.

A clear and robust method for the assessment of impacts on wild land is required due to increasing pressure on this diminishing resource. Whilst landscape assessment may record wildness as a characteristic of some landscapes, there is no definitive method for assessing impacts upon wildness which, for certain landscapes, may be the defining characteristic. It is important to recognise the more subjective nature, individual values and range of perceptions held for defining wildness or identifying wild land. Therefore, an assessment additional to, but sitting alongside, the GLVIA method is required.

The assessment of impacts on wild land comprises two stages: first, establishing a baseline of the condition and extent of the wild land resource; and secondly, assessing the magnitude and significance of the impact upon it. More detailed advice can be found via the link above.

The assessment should be carried out by a competent professional with appropriate experience. In setting out a method of assessment, we recognise that assessment requirements will vary from site to site and depend on the nature and size of the development. Applicants and their consultants should tailor their assessment method accordingly. In all cases the applicant should make early contact with SNH for advice on the approach for an individual site. A full assessment of a site may not be a requirement for every development.

3.5 Requirements under Land Reform (Scotland) Act

Everyone has access rights established by the Land Reform (Scotland) Act 2003 and there is a corresponding onus on land managers to manage their land and operations responsibly with regard to access. Access rights must be exercised responsibly. Prior to the commencement of works, a detailed plan for public access across the site (during construction, upon completion, and for any proposed site restoration / decommissioning) should be provided to the satisfaction of the determining authority.

Taking access along the route of a river.

In addition to their obligations under the Land Reform Act, developers have obligations relating to the safety of the public under the Health and Safety at Work etc. Act 1974, and the Construction (Design and Management) Regulation 2007 (CDM). Access rights become suspended on land where construction work is being carried out, except for routes that are core paths or rights of way.

This suspension applies to areas where building operations are active, rather than the whole area under the developer’s control, and the Scottish Outdoor Access Code underlines that restrictions should be kept to the **minimum area** and the **minimum duration** that is reasonable and practicable. This ensures that limitations on access are seen to be proportionate and credible by the public, and is therefore likely to encourage greater compliance and better meet health & safety needs. The importance of this approach and its consistency with CDM requirements have been underlined by discussion with HSE.

Local Authority and National Park Authority access officers can provide advice on the access implications of development opportunities. Contact details can be found here.

3.6 Sediment continuity

A river’s shape will naturally adjust in response to the amount of water and sediment moving through it. The shape of a river – its channel cross-section and position within its floodplain – is largely created during periods of high flow as sediment is eroded, transported and deposited downstream. In undisturbed rivers, these processes create a channel that accommodates the typical range of high flows and the amount of sediment available. Interfering with these natural processes by, for example, removing sediment or obstructing its passage, upsets what is termed a river’s *dynamic equilibrium*. Doing so can have serious consequences for the stability of a river and may, for example, lead to increased rates of erosion or habitat loss. The response to interfering with a river is often seen in unexpected locations.

By removing or obstructing sediment at a location, the amount of it available to be transported downstream in a river or along a loch shore is reduced; this can lead to sediment ‘starvation’. Reducing the amount of sediment available downstream or along a loch shore can lead to the increased erosion of the bed and banks of a river or the shore of a loch. This may turn depositional areas into erosional ones or increase the rate of erosion where it already occurs. These changes may lead to the reduction or loss of habitat such as riffles and pools and may cause scour around and damage to structures in or adjacent to a river. Even the regular removal of small amounts of sediment at a location can lead to a large reduction in sediment supply to downstream areas.

In many Scottish gravel bed rivers a surface layer of larger gravel protects underlying finer and more easily eroded material; this protective upper surface is termed the *armour layer*. The armour layer impedes the entrainment and movement of the underlying finer substrate. Disturbing or removing it exposes the finer sediment which requires less energy to be picked-up and transported and so is more easily eroded during lower flows. Interfering with the armour layer may lead to a gradual increase in erosion. Alternatively it may trigger sudden, significant erosion and instability and lead to the development of a step or *knick point* in the river bed. This break in slope in the long profile of the channel moves upstream as material is eroded and transported downstream. The drop in river bed level in the eroded channel leads to the undercutting and collapse of banks and so more sediment available to be transported downstream. The development of a knick point can have serious, often unpredictable, long-term or permanent consequences such as damage to habitat, the loss of land, or the undermining of structures such as bridges.

Sediment management conditions will be included in any SEPA issued licence. Exactly what is specified will depend on the location and size of an impoundment. During the determination of an application a developer may be required to carry out further survey work if a site is considered to be *high risk*. A sediment management plan may be required. We recommend early engagement with us and SEPA to determine the level of assessment required.

3.7 Cumulative Impacts

The development of multiple hydroelectric schemes in close proximity to one another i.e. within one or more neighbouring catchments, presents a challenge in managing potential cumulative effects. These effects could be on the habitats (through changing sediment regimes), and species in and around watercourses. There may also be cumulative landscape effects from multiple access tracks, development infrastructure and power lines. The increasing number of smaller-scale hydroelectric developments has increased the potential for cumulative effects. Care should be taken in the planning of hydroelectric proposals, to account for nearby schemes.

Cumulative impacts should be treated as a material consideration by the determining authority. Cumulatively, the impact of related infrastructure (such as grid connections) - and neighbouring hydroelectric proposals - may be significant, and the most effective means of identifying impacts on the natural heritage is to have all applications available at the same time and addressed by a single EIA. Although there is no statutory requirement for the applicant to prepare and provide all applications simultaneously, we consider this to be best practice.

3.8 Reinstatement and restoration

Proactive management and restoration of habitats affected by a hydro development is often required and consultation with a specialist consultant and contractors is recommended.

The aim of restoration is to restore the original function (e.g. carbon store and sequestration, or ecological processes) of the habitat. This is to prevent or minimise impacts on vegetation and soils – or species dependent on them - during the construction and operational phases of the scheme. Habitat management and restoration measures should not have an adverse impact on sites of known archaeological or geo-diversity interest.

Key points:

- All reinstatement should be carried out in accordance with the associated planning consent conditions.

- Suitable material for reinstatement must be stored and managed appropriately, with suitable buffers from watercourses and other sensitive receptors.

- Restoration of a peatland can take from 5 to 30 years depending on the initial condition. Raising the water table to, or near to, the surface is critical to successful restoration. See our peatland restoration video for more detail.

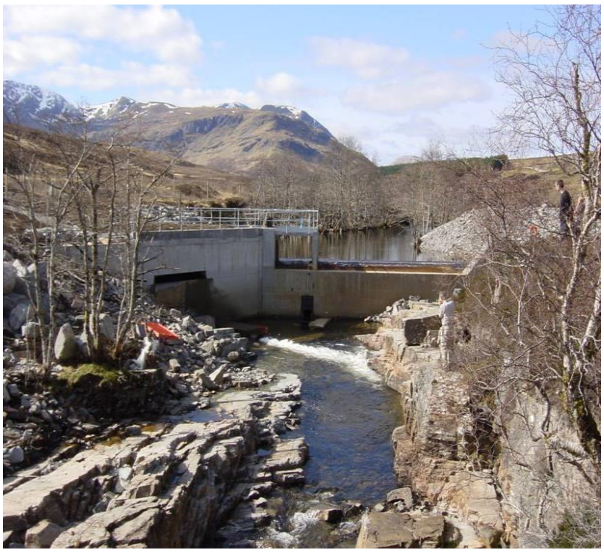
- Long-term monitoring is essential to ensure successful restoration. Monitoring can also help to develop cost-effective techniques and methods by reducing wasted effort and allowing measures to be targeted at the right habitats / locations.

The area affected by tracks and penstock routes should be limited to as narrow a corridor as possible, although there may be some benefit in widening the corridor where this allows engineered slopes to be blended into the surrounding landform. A narrow corridor may need steep cut slopes and embankments that would contrast with surrounding areas of hillside and could prove difficult to re-vegetate successfully. There must be a balance between the sensitivity of the site, the steepness of the slope and visibility. By grading out the areas of cut and fill it should be possible to blend them into surrounding slopes, achieve more successful re-vegetation and reduce the risk of erosion. This will significantly improve the appearance of the track, though it could result in more extensive areas of habitat disturbance. Relevant guidance on reinstatement techniques should be consulted.

4. Hydro components

4.1 Weirs, dams and intakes

The intake generally consists of a structure (a dam or weir) behind which water accumulates to a depth sufficient to ensure a flow into the pipeline. In some instances it may be possible to construct an intake without a dam or weir – e.g. by using an existing pool – which could reduce the natural heritage impacts.



Dam and intake structure

Potential impacts on habitats & species

Construction of an intake structure can have both direct and indirect impacts on habitats and species. Such a structure can have serious implications for species that may be present within, or on the banks of, rivers. Species like; otters, fish, lichens, freshwater pearl mussels, can all be affected by a restriction of access to previous feeding areas, increased silt run-off, the shading of vegetation, and disturbance.

An intake for a hydroelectric scheme can also isolate important fish and invertebrate populations, especially if their free upstream and downstream passage to important habitats is not maintained. New fish passes can also facilitate migration that wasn't previously possible, and this could have its own detrimental impacts. A clear understanding of the benefits of improving fish passage is essential.

Possible indirect effects can include reduced sediment supply downstream, and the pooling of the watercourse upstream of the new structure. Pooling can have temperature implications, and can change predator prey interactions. Increase in water depth above intakes can affect habitat suitability for aquatic lichens such as the protected river jelly lichens.

The risk to habitats and species from a changing sediment regime may vary depending on:

- Size/composition of sediment i.e. gravel vs. silt or other fine material

- Scale of works i.e. volumes restricted and lengths affected
- Submerged vs. exposed areas being manipulated
- Ecological sensitivity of the watercourse e.g. existing physical pressures, conservation status, suitability for fish spawning
- Management methods e.g. physical distribution of sediment
- Previous/historic engineering of the watercourse

Downstream, reductions in water depth and flow can affect the availability and distribution of fish spawning and holding habitats. It can also affect the suitability of some streams to host invertebrate species such as freshwater pearl mussel.

The intake can also damage fish if it is not properly positioned or screened. Good intake design and careful screening should mean that the local fish and mammal (e.g. otter) populations are not adversely affected at any stage in their life-cycle.

The impact of low-head hydroelectric schemes on fish and mammal species is poorly understood. Some low-head turbine designs, such as Archimedes Screws, are often considered to be less damaging to fish than conventional turbine types. This has yet to be fully demonstrated and it is likely that some species may be more vulnerable than others, either during migration or at other stages of their life-history. Some of the impacts of low-head schemes may be mitigated by careful design of the intakes and discharge points, and screening. Further information should be provided in support of an application.

Weir and fish pass

Detailed assessment has not been undertaken to assess the potential impacts of otters interacting with Archimedes screw developments. We therefore advise that in order to ensure compliance with regulations relating to protected species, all effort should be made to restrict access to these devices by otters. If no mitigation is incorporated into the development there is a risk that an offence may be committed.

We advise screening the intake of the device using a maximum 100mm (preferably 85mm) spaced vertical bars, as well covering the length of the device with a ‘roof’, of appropriate spacing (weld mesh or plastic type cover), to reduce the likelihood of access. Any further gaps that may exist in the structure between the intake screen and the screw, larger than 85mm need to be either filled in or covered in mesh.

<u>Potential landscape and visual impacts</u>

The impact of a structure will depend on its design and “fit” with the surrounding landscape and its height, form and materials. This will also be influenced by the degree to which the intake is visible. If a structure restricts or traverses a water body it may appear obstructive and create a strong artificial edge or horizontal element which appears very dominant as an element preventing natural flow of both water and views. Debris and sediments may collect where there is restriction of surface flow, highlighting the presence of an obstruction and creating a negative visual image.

To minimise adverse effects, the design of the whole structure should be kept as simple as possible with the form of the weir relating to prevailing landforms and the finish being of a texture and colour that relates to local ground cover, e.g. outcropping rock/vegetation. Wing walls should also tie sensitively into natural rock prominences at the edge of the channel, i.e. with no hard linear edges and constructed of a material sympathetic to the character of the surrounding landscape.

Both rock armouring and gabions (rock-filled wire baskets) tend to increase the clutter and visual influence of infrastructure and built material. Green engineering should be a first consideration before considering 'harder' options. Measuring devices, gauges, handrails and protrusive pipework should be kept as low in profile as practical, sensitive in colour to the surroundings, and avoided if possible.

Careful design and preparation of the construction area can minimise landscape and visual impacts (eg. vegetation management, levelling, grading, bunding). Its use will have landscape and visual impacts in addition to those of the weir itself through increased activity and clutter. Effective and timely reinstatement of habitats (re-shaping, replacing vegetation, etc.), and the prevention of excess material remaining beyond the construction phase is key to mitigating impacts. This is particularly important in sensitive landscape areas such as National Scenic Areas, National Parks and Local Landscape designations.

The landscape and visual impacts of reduced / changing flows in rivers and burns should be assessed as part of the wider LVIA, e.g. effects on waterfalls, inundating or drying out boulder areas and pool stretches. Locations where there are open, or otherwise important, close-up or popular views of the river are particularly important.

Low head schemes, for instance Archimedes screws, will have their own potential landscape and visual impacts. Although the need for lengthy penstocks and tracks is often not required, the turbine infrastructure and housing itself can sit vertically above the watercourse, out of the water. The turbine house (containing gearing and electrical equipment) may also sit over the water course. Consideration should be given to the colour of turbines, turbine covers, fencing and screening style and colour, as well as building design, height and layout.

Rivers and adjacent land are often the focus of multiple recreational uses

Potential impacts on recreation & access

The landscape and visual impacts described above can all affect the quality of recreational experience. Hydroelectric developments can also physically affect the recreational use of an area. The Scottish Outdoor Access Code states that dams are *'regarded as structures and in these cases access rights do not apply'*. However, the Code does encourage owners to support access across dams where there are no safety issues (*refer to Sections 4.23, 4.24 and 4.25 of the Access Code for further guidance*), and this may help to mitigate any adverse effects of the development on public access.

Depending on the design and structure of the dam, it may also be adapted to create recreational opportunities for canoeists. Conversely, negative impacts can also arise, especially if a previously navigable river will be obstructed and there is a need for canoeists to portage around the dam. In the case of small weirs, if the watercourse is used by canoeists, a means by which to allow continued water-borne travel may need to be considered in a similar way to fish ladders (refer to the Scottish Canoe Association for further information). The use and value of burns and rivers for water-borne recreation should be assessed for all schemes which entail the construction of weirs and dams.

4.2 Impoundment

Impoundment structure on an upland stream.

Wherever a weir is constructed and water levels are raised upstream, it is likely that some level of water impoundment will result.

Potential impacts on habitats and species

Key impacts of this water storage regime include the loss of terrestrial, wetland and riverine habitat through upstream inundation. There can also be changes in downstream bankside plant populations as a result of less frequent and reduced downstream flooding and spray/humidity. This can affect plant species requiring moist conditions, notably bryophytes. Disruptions to overall geomorphology, flow regimes and wider habitats are typically much greater when a proposed development includes an impoundment for water storage.

Impoundments may damage spawning areas for Atlantic salmon, trout, and lamprey through inundation, or may result in the loss of valuable holding areas for juvenile fish. Species such as Arctic charr, which spawn in lochs, may be affected if drawdown occurs when eggs have been laid in littoral (bank / loch shore) habitats. It is important to recognise the need to maintain access from these standing waters to inflowing and outflowing streams for fish which may use these as spawning habitats.

Downstream of run-of-river developments, spawning reaches may remain, provided compensation flows are sufficiently generous to allow adult fish easy access and they remain wetted throughout the entire egg incubation period. More detail on spawning times can be found on our website.

Depending on the nature of the impoundment or the level of compensation flow, changes in surface and hyporheic (the region beneath and lateral to a stream bed) water temperature may also be an important consideration.

Where flood flows are considered important, particularly in rivers with migratory fish, artificial flood flows known as 'freshets' may be released. At appropriate times, freshets help to encourage movement of fish upstream and mitigate ecological damage caused by artificially prolonged low flows, such as drying out of spawning grounds.

Reservoirs can act as major sediment traps which interrupt the natural transport of sediment. On smaller scale impoundments sedimentation can lead to a loss of reservoir storage capacity, and will have to be purged. As a result of sediments being trapped in the reservoir, sediment-free water can be released downstream of the dam at high velocity. This leads to altered patterns of local and downstream erosion and sedimentation and, in time, the habitats and species that the river supports. Scouring of fine sediments from the river beds and banks is intensified in the reach immediately below a dam, and high discharge releases can lead to armouring of the stream bed. For species such as freshwater pearl mussel that obtain their nutrients from filtering water, impoundments can have a less obvious, but still negative, impact on their growth and survival.

Where impoundments are large and add to existing lochs, species which are already present may be affected by either the inundation of littoral habitats (marginal shallow water where light can penetrate to the bed) and/or increased drawdown during periods of peak production. Where the drawdown zone is wide, aquatic plant species and invertebrates may be unable to colonise these areas. This has consequences for species which predate on those supported by these habitats. Rapid changes in water level can also directly affect breeding birds such as black-throated divers and can have significant impacts on riparian mammals such as otters and water voles.

Potential landscape and visual impacts

Impoundments can result in variable water levels causing a drawdown scar, which is likely to have increased visibility from a distance, creating a new visual focus in the landscape. An unnatural mix of aggregates can also add to visual impacts. All of these can produce a visual barrier between the reservoir and surroundings. Impacts can arise from the direct visual effect of this new feature, or from the perceived effects on wild land quality. Assessment of the landscape and visual impact of the likely drawdown maximum and minimum levels (natural and managed) and the duration of the maximum and minimum levels and the timing (season) should be considered.

Close up views of the reservoir edge may be affected by the aggregates making up the drawdown beach – care should be taken to avoid an unnatural mix, attempting to match any aggregate in with the surrounding rock or scree type colour and texture. These often seem incongruous as they may represent unnatural patterns of deposition or erosion, and create a visual barrier between the reservoir and its surroundings.

Measuring devices, gauges, handrails and protrusive pipework should be kept as low in profile as practical, sensitive in colour to the surroundings, and avoided if possible.

Potential impacts on recreation & access

The landscape and visual impacts noted above can all affect the quality of the recreational experience, and the impoundment may physically affect access if it blocks existing paths or other recreational routes. These effects can sometimes be mitigated by providing suitable alternatives. Reservoirs may also create opportunities for positive access provision, for example for sailing, canoeing or fishing.

4.3 Penstock

A penstock or pipeline links the flow of water between the head and the turbine building. Penstock pipes may be laid above ground or be buried underground.

Potential impacts on habitats & species

During the construction of tracks or pipelines, loss of riparian vegetation e.g. mature trees, must be minimised. Removal can reduce shading and ambient humidity, creating impacts on internationally important bryophyte communities. Terrestrial habitats along any pipeline route will also be disturbed during construction and, unless reinstatement is sufficient, in the long term too. A good understanding of the drainage (surface and ground) is essential along the length of the route in order to minimise direct and indirect impacts from the alteration of watercourses.

Restoration work should be undertaken as quickly as possible following the construction phase, including appropriate soil and subsoil reinstatement and cut turves replaced. This is to ensure that existing vegetation and soil structure are utilised in as natural a pre-worked state as possible. Discussions with our Operations teams is recommended when planning reinstatement strategies. Further guidance is available in the Guide to hydropower construction best practice (2014).

Pipeline routes should avoid areas of woodland, particularly native woodland and where the woodland has not previously experienced disturbance, as is the case in many wooded ravines. Any trees that are felled should be left in-situ where possible to supplement the local deadwood habitat.

Unburied pipeline section. Even a small section can produce a negative visual impact in the landscape in some settings.

Large boulders / boulder fields are an important habitat for some species of bryophyte and lichen. To minimise the impact on these species, these areas / boulders should be avoided where possible, be returned to their original position and orientation or relocated in similar nearby habitat.

It is important that construction of the penstock, particularly when it crosses steep ground, does not give rise to pollution via erosion and run-off. A robust pollution control plan will be important. A geotechnical survey of local ground conditions, to ensure there is adequate slope stability to support penstock construction, should be considered where slope failure could give rise to serious pollution, particularly above protected habitats and watercourses.

Penstocks should avoid passing over areas of peat, where management of excavated material and subsequent reinstatement may prove difficult, particularly in the uplands. It may be preferable for a penstock to detour around, or lie above the surface to minimise disturbance.

Where a proposal involves the transfer of water between two previously unconnected catchments (or water bodies) there is the potential for effects on species and habitats in the receiving water body because of potential changes in the water chemistry. Generally, inter-catchment transfers should be avoided. The transfer of water between catchments may also result in the unintentional transfer of invasive non-native species.

Potential landscape and visual impacts

Above ground penstocks will create a strong linear feature within the landscape, which can be accentuated by concrete block anchors at bends. Associated settlement / silt ponds should also be considered as visual components. Penstocks tend to be most noticeable in areas of grassland or moorland; here, a penstock will create a dominant visual edge or divide the landscape. In contrast, a penstock may appear more rational in a landscape which possesses existing linear features, for example following the route of a road, dyke or watercourse. Consideration of the effect of adding further infrastructure alongside existing features is recommended.

The colour of a penstock pipe will affect its visibility and the nature of the image it creates. It is very difficult to choose a colour of pipe that blends in with the surrounding landscape at all times of the year to limit visibility. It is generally more successful to colour the pipe so that it relates to the shades and hues of the surrounding land through all seasons. Plastic pipes fade over time in sunlight and a lighter colour will be likely to be more visible in the landscape. In terms of texture, pipes tend to appear less prominent and contrasting to their surroundings where they are of a matt surface, avoiding light reflection.

The location of penstock pipes underground will result in minimal visual impact once surface vegetation has adequately re-established; however, this may take considerable time within certain parts of Scotland where recovery rates for vegetation and peatland are extremely slow. In some locations, particularly montane or blanket bog environments, disturbed vegetation may never recover without significant intervention. This will obviously be affected by the methods of construction and operation, but also drainage and grazing if a cleared surface encourages run-off or if sheep or deer favour the newly established vegetation upon the buried pipe. Restoration using whole turves is the preferred method.

The use of an open channel, similar to that of a canal structure, is not common within most upland landscapes. These engineered routes may seem incongruous as they often link two points in the shortest distance, rather than following the ‘lie of the land’ like a natural watercourse. Careful siting and design is required, respecting contours and landscape features and considering the potential for screening using landform or vegetation.

4.4 Turbine buildings

Potential impacts on habitats & species

There can be direct habitat loss associated with the land the building is located on, and disturbance to the immediate surroundings, though if well located these should be minimal. There can also be disturbance to some species such as bats and birds, especially in remote areas, through construction and general access to the buildings.

There may be disturbance associated with noise, lighting and regular servicing of the turbine itself. However, there could also be some positive outcomes from the construction of a turbine building through the creation of new habitats, e.g. for bats, and this could be encouraged at the initial design stage. Opportunities such as green rooves should be considered to provide new habitat.

Sympathetic construction material, partial burial and appropriate screening can minimise visual impacts of turbine buildings.

<u>Potential landscape and visual impacts</u>

It is important to respect the rural character of the environment when siting and designing turbine houses. They should, if possible reflect the character of existing buildings in the area. The use of formal or urban style road design and edging, decorative vegetation, lighting, excessive signage, handrails and fencing surrounding a turbine building is generally inappropriate. Screen planting, if appropriate, could be used in some locations as long as it is in character with the surroundings.

The colouring on this turbine house can help it to 'blend in' to its surroundings.

It is increasingly common to face or construct these buildings in artificial, reconstituted materials which may detract from the vernacular architectural design unless they are carefully detailed and built. The use of local stone, slate or timber is likely to help integrate the building into its surroundings. Bright colours should be avoided in sensitive rural locations.

The location of most turbine buildings adjacent to water bodies or watercourses may result in severe weathering of the structure. This means that, in order to portray a positive image, such buildings need to be constructed of high quality materials and be appropriately maintained.

Some turbine buildings have exterior lighting. This increases their visual impact and appears inappropriate in rural areas, and particularly remote landscapes, where such lighting is rare. The use of external lighting should therefore be minimised where possible. External infrastructure, such as switchgear and transformers, should be minimised and carefully located to reduce visual impact, and thought given to their colour.

4.5 Tail race

After driving the turbine, water is returned to its natural course via the tailrace.

Potential impacts on habitats & species

The tail race may increase flow velocities within the receiving watercourse and this can result in an increased potential for erosion. An inappropriately designed or oriented tailrace can directly threaten species such as the freshwater pearl mussel by dislodging them or by removing the fine and coarse substrate that they require to survive. Displaced material may be deposited downstream, resulting in, for example, the creation of obstructions to migrating fish or the siltation of fish spawning or holding habitat. Further information is available in SEPA's 'Engineering in the Water Environment Good Practice Guide Intakes and outfalls'.

A screened outlet returning water to the river. In sensitive locations the use of fencing could be avoided by using a natural stone wall or even large boulders instead.

The tailrace should be carefully designed, orientated and screened to ensure that migratory species such as Atlantic salmon, trout, lamprey, eels and other fish, as well as otters, are not distracted by the higher flows and cannot reach the turbine. In low-head hydroelectric schemes the returning water from the tailrace will often make up a relatively high proportion of the total flow in the river. In such cases the potential to interfere with migratory fish movements is much greater and will need careful consideration.

Potential landscape and visual impacts

Visually, a tail race above ground links the turbine building to the outflow watercourse and thus indicates the rationale and function behind these structures. The impact of a tailrace structure will depend on its design and "fit" with the surrounding landscape and its height, form and materials.

To minimise adverse effects, the design of the whole structure should be kept as simple as possible, relating to existing landforms and the finish being of a texture and colour that relates to local ground cover, e.g. outcropping rock/vegetation. Measuring devices, gauges, and protrusive pipework should be kept as low in profile as practical, sensitive in colour with the surroundings, and fencing avoided if possible. Natural stone should be used where possible to tie the design into the local landscape, avoiding bare concrete surfaces where possible.

Effective and timely reinstatement (ground reprofiling, replacing vegetation, etc.) is key to mitigating impacts, particularly in sensitive landscape areas.

4.6 Access tracks - temporary or permanent

The initial question to be asked on any hydroelectric development is whether or not permanent tracks are required as part of the build and operation. In some cases temporary access tracks or indeed no track may be more appropriate.

If a permanent track is necessary, the requirements for post-construction access should be carefully considered to allow track widths be reduced to the minimum, for instance allowing 4x4 access.

For every hydroelectric proposal, a comprehensive assessment of the potential impact of access tracks will be necessary. Can other methods of access be utilised, for example, via boat or helicopter? Guidance on track development can be found in *Constructed tracks in the Scottish Uplands*. Track construction has the potential to have significant environmental impacts, particularly landscape and visual, and requires thorough assessment and appraisal.

Existing upland track. Note that a level of maintenance will be required to prevent ponding and erosion / run-off.

Ensuring that appropriate siting and design options are discussed at the earliest stage in the planning process is the key to minimising impacts, if a new track is required. The success of access track construction, its use and ongoing maintenance comes from the drafting of a detailed environmental / construction method statement. This should be exact and enforceable, preferably as a condition of planning permission, detailing step by step processes. It is recognised that some flexibility needs to be built into such a statement, however, as unpredictable issues may arise during the construction and operation phases and improved techniques may also be developed. It is essential that the measures set out in the environmental / construction method statement are clearly communicated to all relevant contractors on the site.

<u>Potential impacts on habitats & species</u>

Track construction can have considerable impacts in terms of loss of habitat and ongoing consequences from changes in drainage, erosion, and human activity and disturbance. There is also the risk of imported materials containing non-native species, or being chemically different from that of their intended location, being introduced as part of track construction. The creation of local borrow pits which then need to be reinstated and the habitat restored require careful consideration.

Geotechnical investigations should be undertaken to determine the level of risk associated with development in areas where the stability of rock or earth slopes may be of concern. The Scottish Government publication 'The Peat Hazard and Risk Assessment Guide' provides best practice methods to identify, mitigate and manage peat slide hazards.

The greatest risk of erosion is during construction and during the operational stage if tracks are left un-monitored. It is important that there is sufficient mitigation in place to treat potentially very large volumes of slit laden water before it can be allowed to flow into natural watercourses. Drains are normally constructed to transmit water off a track or divert it away before it reaches local water courses.

Potential erosion and run-off from neglected track edges

When a track is cut across a hillside, it is almost inevitable that there will be changes in the drainage pattern caused by the interception of surface water and ground water flow. Such changes can cause serious disruption and possibly destruction of the complex mosaic of plant communities which usually occur on upland sites. Careful planning for this is essential.

Temporary floating boards construction avoiding sensitive habitat beneath.

In terms of conserving the existing drainage patterns, floating tracks usually result in fewer adverse impacts as excavated tracks require fill to be applied to the sub-base beneath the peat. Serious problems associated with slumping and subsidence can also occur if the development of a track with associated drainage causes the surrounding peat to de-water.

New tracks should avoid valued areas of native woodland, particularly where the woodland has not previously experienced disturbance, as is the case in many wooded ravines. When widening an existing woodland track, care should be taken to avoid damaging old wayside trees. These trees often support important populations of bats, bryophytes, lichens, fungi and invertebrates, and should be surveyed before disturbed. If it is essential that trees are to be felled, they should be left in-situ where possible to supplement the local deadwood habitat.

Further information on managing forest residues can be found in 'Use of Trees Cleared to Facilitate Development on Afforested Land' on SEPA's website.

A survey for breeding and ground nesting birds may also be required along track routes, depending on timings of work. Disturbance should be considered when construction works are likely to have an impact on raptors or waders.

Landslide potential on un-vegetated land in an area of worked ground

Access tracks should avoid passing over areas of peat and it may be preferable for a track to detour around. If a track is to pass over peatland, further guidance is available in 'Floating roads on peat' a joint publication between SNH and FCS.

When considering batters and reinstatement of vegetation, tracks running below the tree line can experience rapid natural colonisation by a wide range of annual and perennial species, except where the soil or subsoil is very coarse or infertile, or where slopes are steep. There is usually an adequate supply of seed from surrounding ground already present in the soil for colonisation. However, stripped turves should also be incorporated, following appropriate managed storage. Above the tree line, re-colonisation becomes progressively slower with increasing altitude due to the generally infertile soils, lack of seed source and severe climate. Increased consideration, care and management of reinstatement in these areas is required.

Key factors affecting the successful reinstatement of vegetation along tracks are:

- steepness of cut batters;
- material composition of edges and cut batters;
- timing, in terms of how long the subsoil is exposed and top soil replaced;
- whether vegetation is replaced as turves or as seeded ground;
- the extent of excavation;
- ongoing management, for example grazing sheep may favour newly established vegetation so that this is never able to establish good cover and thus always stands out from its surroundings.

Potential landscape and visual impacts

Many access tracks to hydroelectric developments have considerable landscape and visual impacts in their own right and may be particularly visible where they cross moorland areas with few features, or steeper ground where cuttings and embankments are most obvious. Some upland tracks are visible from as far as 30-40 km away in certain conditions.

Upland tracks can be very prominent especially when the colour of material used does not match the surrounding landscape.

Tracks in particularly sensitive areas such as National Scenic Areas should be reinstated as soon as possible after the construction phase comes to an end. Running widths should be reduced, stored soils reinstated, and turves replaced upright to minimise scarring and prevent erosion of subsoil.

Lines which run along natural edges of a landscape and not against existing contours will tend to appear more appropriate on account of the obvious rationale for their route. The use of landform or existing vegetation to screen tracks should be maximised where possible.

The visibility of tracks can also be minimised where they are surfaced with an aggregate of similar tone, colour and texture to the surrounding vegetation. The use of temporary access provision, such as geotextiles or temporary road structures should be considered to minimise the need for permanent access tracks, although these may also need some reinstatement/restoration following removal.

4.7 Construction & infrastructure

Fencing

Fencing is generally not a large part of a hydroelectric development, although this may be introduced, with gates immediately around turbine buildings, dam walls and weirs for safety reasons. Fencing may occur for many reasons, including; greater control over grazing animals; defining land ownership boundaries; and to create or enhance habitats to mitigate against impacts of a development on species. Fencing must not result in unreasonable interference with access rights and should be minimised where possible.

Changes in habitat management delineated by fences may affect bird populations. The need for fencing requires careful consideration and suitable markers should be used where necessary.

Noticeable habitat variation either side of a fence line

Electricity connections & transmission

The impacts of power lines can include impacts on birds due to a potential for collision, and disturbance to species / habitats during construction. Impacts on birds are generally minimised where lines are routed underground, although attention needs to be paid to the method of these works and vegetation reinstatement.

If underground power lines are planned and these are to be placed under small rivers or streams, careful consideration should be given to the distribution of sensitive sedentary species, such as freshwater pearl mussel, and the impact that physical disturbance, changes in water quality and the possible modification of in-stream flows could have on them.

The landscape and visual impacts of power lines associated with a hydroelectric development may be considerable in some locations, especially in wild land. Careful route selection and design, as well as the consideration of alternatives, is required.

Substation
The impact of this, like any new building in the landscape, will depend largely on its siting and design. The location of a substation near a hydroelectric development may increase the visual complexity of the development, and thus a simple building form with the minimal amount of associated elements such as fence lines and access routes will tend to appear most appropriate. The requirement to assess the impacts of ancillary electrical equipment is important, as part of the wider development, at the earliest stages in the planning process.

5. CONTACT

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Acknowledgements
SNH would like to acknowledge Buchan Landscape Architecture, SEPA, Scottish Renewables, Inter Hydro Technology and Jamie Troughton of Ardchattan Estate for their kind permission in granting the use of their photographs.

ANNEX 1 Sources of further information

SNHi - The purpose of SNHi and Site Link is to provide easy access to data and information about sites of national and international importance across Scotland.

SEPA

- Hydropower
- SEPA Planning – How and when to contact SEPA; Energy; and Flood Risk.
- River Basin Planning Interactive Map

Scottish Government

- Scottish Planning Policy
- Renewables Routemap

Marine Scotland

Association of Salmon Fisheries Boards

National Biodiversity Network (NBN)

River Restoration Centre

Forestry Commission Scotland

Landscape Institute

Mammal Society

Plantlife

BAT Conservation Trust

The Royal Society for the Protection of Birds

Scottish Outdoor Access Code

Advice for Land Managers

British Hydro Association (mini hydro guide)

ANNEX 2 - Further information on Q values and flow duration curves

In a river, the amount of water that flows past point *x* in a day is recorded as the daily mean flow (DMF). It's the 'mean flow' as it's the average of the flow values collected at regular intervals throughout a day. This information is collected at a gauging station. 365 DMFs will be collected in a year. Q values, the amount of time as a percentage of a year that a particular quantity of water or greater flows past point *x*, are derived via the analysis of this DMF data:

- DMFs are ranked highest to lowest;
- the number of days (*n*) that a DMF of a particular magnitude occurred is calculated;
- *n* is summed cumulatively; and
- summed *n* is expressed as a percentage of the year over which data was collected for.

Example

Discharge (DMF) at point x (m^3/s)	n	$\sum n$	$\frac{\sum n}{365} \times 100(\%)$
10	2	2	1
9	21	23	6
8	44	67	18
7	58	125	34
6	26	151	41
5	46	197	54
4	65	262	72
3	13	275	75
2	50	325	89
1	40	365	100

Where:
n = number of days that discharge occurred during the year
$\sum n$ = cumulative number of days, so the number of days that a discharge of a particular magnitude or greater occurred
$\frac{\sum n}{365} \times 100(\%)$ = the percentage of a year that a discharge of a particular magnitude or greater occurred

In the example above a discharge of 6 m^3/s occurred on 26 days in a year. A discharge of 6 m^3/s or greater occurred on 151 days in that year or 41% of the time. So, the Q_{41} flow was 6 m^3/s. In the same year, a discharge of 1 m^3/s or greater occurred for 100% of the year i.e. there was always some flow in the example watercourse. Interpolation allows values of e.g. Q_{95} to be established.

Flow duration curves are a plot of discharge (m^3/s on the y axis) against the percentage of time that discharge of a particular magnitude was equalled or exceeded (x axis), and they also can be used to establish values of Q.

www.snh.gov.uk