Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

For the future of our environment

WAT-G-XXX

EASR Guidance: Guide for developers of storage and pump storage hydropower schemes

<Report date here (month, year)>

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Contents

1. Purpose

This document provides information and guidance for anyone planning to build a new or modify an existing hydropower scheme in Scotland that involves more than 24 hours' worth of water storage for conventional or pump storage hydropower which are subject to authorisation by SEPA under the Environmental Authorisation Scotland Regulations 2018 (EASR).

2. Introduction

Serious environmental harm could result from the operation of hydropower schemes, especially in the case of large-scale pump storage schemes. All hydropower schemes will have to demonstrate appropriate mitigation to ensure that these impacts are reduced to an acceptable level. If you are planning a storage hydropower scheme, it is essential you assess your proposal against the criteria in this document to ensure it is capable of being consented by us. You are recommended to use this screening guidance at an early stage in the planning of a potential scheme and thereafter to contact us to as soon as possible to verify its likely acceptability.

3. Background

Scottish Ministers set out their objectives with respect to striking the right balance between the protection of the water environment and renewable energy generation in a policy statement issued in January 2010.

Developers of hydropower schemes require a water activity permit from us[1]. Before granting such a permit, we must take account of a scheme's likely adverse impacts on the water environment as well as its potential benefits, including its contribution to renewable energy generation. This guidance has been produced in part to help you understand how, in carrying out our permitting role, we will help deliver ministers' policy objectives.

[1] Under the Environmental Authorisation Scotland Regulations 2018 (EASR).

4. Overview of approach

SEPA is required to operate under a general presumption against authorising proposals likely to result in significant adverse impacts. However, SEPA is responsible for controlling alterations to the water environment that serve a wide range of beneficial purposes, including public water supply, flood alleviation, hydropower generation and navigation.

SEPA will consider authorising such proposals if they:

- satisfy the criteria described in the checklists in Annex A;
- incorporate the mitigation described in the relevant section of Annex B;
    - the proposal's benefits to human health, human safety or sustainable development outweigh the benefits of protecting the water environment and cannot be provided using a significantly better environmental option; and
    - compliance with the requirements of legislation relevant to the protection of the water environment (including the *Water Framework Directive*[2] and other EU legislation, such as the legislation governing Protected Areas[3]) will not be compromised.

As part of our balancing test SEPA will follow the method in the guidance document WAT-G-047: EASR Guidance: Assessing the significance of Impacts - social, economic, and environmental when assessing the significance of positive and negative impacts associated with a proposal. This includes consideration of the impacts of proposals on the interests of third parties in so far as those impacts result from alterations to the water environment[4].

To help obtain the necessary information to make appropriately balanced judgements, SEPA will:

- require all proposals likely to have significant adverse impacts on the water environment to be advertised; and

[2] Including the requirements are set out in paragraphs 7, 8 and 9 of Article 4 and in Article 7 of the Directive
[3] Protected Areas under the Water Framework Directive include Natura 2000 sites dependent on the status of surface water or groundwater, Bathing Waters, Shellfish Waters and Freshwater Fish Waters
[4] For example, there may be several environmental, social or economic impacts associated with the construction of roads intended to serve a new development. SEPA will only consider those impacts which result from changes to the water environment caused by such works

- seek, and have regard to, the advice of Responsible Authorities[5] and other public bodies with relevant knowledge and expertise on the positive or negative impacts of a proposal.

Pre-application public engagement is normally required for pump storage hydro schemes and hydro schemes with more than 24 hours storage. Before submitting your application, you must engage with the local community to find out the views of those likely to be affected by the proposed activity and to gather relevant information about the potential impacts of the proposed activity. You will be asked to demonstrate that you have engaged and share the feedback received as part of the permit application process.

SEPA will also encourage prospective applicants to enter into pre-application discussions with SEPA at an early stage in the development of their proposals.

Further information and guidance for anyone undertaking an abstraction activity can be found in WAT-G-040 EASR Guidance: Permit application guide for abstractions and impoundments

5. Screening process – identifying acceptable hydropower schemes

To avoid individual and cumulative adverse impacts on the water environment, storage for conventional or pump storage hydropower schemes need to be sited and designed appropriately.

Hydropower that uses conventional and pump storage can reduce its impact through:

- Early consideration of designs which deliver good practice
- Locating schemes away from sensitive areas

[5] See The Water Environment and Water Services (Scotland) Act 2003 (Designation of Responsible Authorities and Functions) Order 2006. The Responsible Authorities are: local authorities, Scottish Natural Heritage, Scottish Water, District Salmon Fisheries Boards, National Park Authorities, British Waterways, Forestry Commission and the Fisheries Committee.

Annex A includes a series of checklists that can be used to assess whether your proposed site and scheme design would avoid or reduce significant adverse impacts on the water environment.

These are high-level initial guidelines which developers can use to select less sensitive locations which are less complex to develop. The checklists embody the criteria we will subsequently use in determining applications for such schemes. Proposals meeting the criteria will be able to obtain a water use licence, subject to consideration by us of any adverse impacts on the interests of other users of the water environment.

Likely acceptable schemes include those:

- situated in areas that do not affect internationally important SPAs, SAC or RAMSAR sites or any other protected areas. More information on protected areas can be found on our website and in WAT-G-082 EASR Guidance: Permit Activity: Hydropower: Information on protected species.
- situated in degraded parts of the water environment (other than those planned to be improved).

Proposals not satisfying the criteria in the checklists may still be able to obtain authorisation if they would deliver additional and significant social or environmental benefits. Where you believe this to be the case you should contact us before proceeding further.

Table 1 below summarises the principal tests we will apply in determining a proposal, assuming the proposal includes the relevant mitigation set out in Part B of this guidance.

Table 1: Principal tests applied when determining a proposal

Row	Criteria	Yes	No
1	Does the proposal satisfy the checklist in Annex A?	Go to row 2.	Proposal unacceptable.

Row	Criteria	Yes	No
2	Would there be any significant adverse impact on the interests of other users of the water environment?	Go to row 3.	Proposal acceptable.
2	Would the proposal cause a deterioration of ecological status?	Got to row 4	Got to row 5
4	Would the proposal provide other significant environmental or social benefits?	Go to row 5.	Proposal unacceptable.
5	In SEPA's judgment would the benefits of the proposal outweigh the adverse impacts?	Go to row 6.	Proposal unacceptable.
6	If the proposal would cause a deterioration of ecological status, is there a better practicable environmental option?	Proposal unacceptable	Proposal acceptable.

Note:

Information on the status of water bodies is available via the water classification hub on the SEPA website. This information is updated from time to time and should be treated as indicative only. Developers may wish to contact us to check whether more recent assessments are available.

Annex A - Checklists

You should go to the relevant checklist for each type of water body affected as guided.

Table 2: Checklist 1: Proposals sited in degraded parts of the environment

Row	Criteria	Yes	No
1	Are the proposed storage reservoirs part of an existing heavily modified water body (HMWB)?	Go to row 2	Go to checklist 2
2	Is the existing purpose for the HMWB designation adversely affected by the proposed modifications?	Consult with existing users and assess the impacts	Got to row 3
3	Are the rivers upstream and downstream of the reservoir significantly adversely impacted e.g. the condition of the beds and banks is poor or bad because of: i) extensive stands of conifers or invasive non-native plant species on the banks; ii) (ii) extensive engineering modifications, including channel straightening, bank revetment, dredging, culverting etc; iii) (iii) does not contain any ecologically significant areas of good fish habitat?	Go to row 4	Got to checklist 3
4	Are the stretches of river upstream and downstream of the existing reservoir planned to be improved through the River Basin Management Plan?	Go to row 5	Go to checklist 3 row 6
5	Does the proposal include modifications that will enable delivery of River Basin Management improvements?	Proposal provisionally acceptable	Proposal provisionally unacceptable

Table 3: Checklist 2: Proposals sited in an area with no existing water body

Row	Criteria	Yes	No
1	Is this a proposed new reservoir on land where there are no streams, rivers lochs or ponds?	Go to row 2	Go to checklist 3
2	Does the proposal have more than one reservoir?	Go to row 3	Go to row 5

Row	Criteria	Yes	No
3	Is the other reservoir an existing heavily modified water body?	Go to checklist 1	Go to row 4
4	Is the other reservoir a natural water body?	Got to checklist 4	Go to row 5
5	Does the proposal result in deterioration of wetlands that are dependent on groundwater, rivers or lochs, including areas beyond the development boundary?	Go to checklist 3	Go to row 6
6	Does the proposal affect a wetland that is a peatland such as blanket bog?	Seek advice from NatureScot	Go to row 7
7	Does the proposal affect a site protected for its biodiversity or geological features?	Seek advice from NatureScot	Go to row 8
8	Does the proposal affect an area that is already degraded due to human activity such as a quarry?	Proposal provisionally acceptable	Proposal provisionally unacceptable

Table 4: Checklist 3: Proposals which impound natural rivers to create storage

Row	Criteria	Yes	No
1	Does the proposal inundate the surrounding land beyond the natural channel of a river?	Go to row 2	Go to checklist 4
2	Is the proposal located on a minor tributary of a water body i.e. a tributary with a catchment area <10km^2?	Proposal is provisionally acceptable	Go to row 3
3	Is the water body at good or high status?	Got to row 4	Got to row 7
4	Is the river designated for the conservation of aquatic plants or animals e.g. a SSSI, SAC or SPA?	Got to row 5	Go to row 8
5	Is it likely to result in a downgrade in classification to less than good status?	Go to row 6	Proposal is provisionally acceptable

Row	Criteria	Yes	No
6	Is length of water body affected > 5km, or extent of habitat affected >10%?	Proposal is provisionally unacceptable	Go to row 7
7	Is the water body affected less than good status and there are measures planned to improve status through the River Basin Management Plan Water, that this proposal with impact?	Go to row 5 (see note 1)	Proposal is provisionally acceptable
8	Is it likely to result in a downgrade in condition to less than good?	Go to row 9	Proposal is provisionally acceptable
9	Is the length of the watercourse affected <20km?	Proposal is provisionally acceptable	Proposal is provisionally unacceptable

Note 1

If there are measures planned on a waterbody it should be treated as if it is already restored to good status

Table 5: Checklist 4: Proposals sited on natural lochs

Row	Criteria	Yes	No
1	Are the proposed reservoirs existing natural lochs?	Go to row 4	Go to row 2
2	Is it an artificial reservoir that is fully contained as part of a closed loop system	Proposal provisionally acceptable	Go to row 3
3	Is it a heavily modified waterbody	Go to checklist 1	
4	Is the loch designated for the conservation of aquatic plants or animals e.g. a SSSI, SAC or SPA?	Go to row 5	Go to row 7
5	Is the loch at good or high status?	Go to row 7	Proposal provisionally acceptable
6	Is it likely to result in a downgrade in classification to less than good status	Go to row 7	Proposal is provisionally acceptable

Row	Criteria	Yes	No
7	Is the area of loch affected < 7.5 ha or the length of shore affected <1.5km?	Proposal provisionally acceptable	Proposal is provisionally unacceptable

Annex B – Supporting Information and Practicable Mitigation

SEPA expects supporting information and mitigation to be provided for all hydropower storage schemes.

Our guidance for applicants on supporting information requirements for hydropower applications will help you gather the appropriate information. Information is available in the links below:

Hydrological information for storage and pumped storage hydropower
Fish and fish habitats
Protected areas and species

Additional supporting information requirements can also be found in this section along with practicable mitigation to reduce the impacts on the water environment posed by storage and pumped storage hydropower schemes. The list of mitigation measures is not exhaustive and any site specific mitigation should be discussed with SEPA at an early stage in terms of fish passage, fish habitat, downstream flows, loch levels, hydromorphology, invasive non-native species (INNS), habitat mitigation and natural heritage requirements.

Any proposal involving a water transfer between unconnected or already connected catchments should follow the guidance in EASR-G-001 EASR Guidance: Invasive Non-Native Species (INNS).

Cumulative impacts of the development alongside other pressures on the water body may mean that the additional impact of the development is unacceptable. Therefore, you should also consider the cumulative impact of your development, using available information on pressures from other users including existing abstractions and storage developments.

Impact of proposals on river flows and loch levels

Potential Impacts	Prevention/Mitigation
Hydropeaking in lower reservoir outlet river –	1. The scheme is a contained system using water circulated between an artificial upper and lower reservoir, with the latter not driving flows in any river. 2. Cumulative volume of water movement into and out of the lower reservoir is such that it does not produce significant changes in loch levels and, hence, river flows 3. The lower reservoir is an impoundment, and the impounding works will be used to manage river flows. 4. The outlet river is steep and does not support significant fish populations. 5. Water abstraction from the lower reservoir is gradual to reduce risk of stranding of fish.
Reservoir water levels – rapid and frequent changes (limits ecological value)	1. Cumulative volume of water movement into and out of the reservoirs is small in proportion to the size of the reservoirs and does not produce significant water level variation. 2. The reservoir is already used for mass storage, and its shore zone is already significantly impacted e.g. an existing Heavily Modified Water Body. 3. The reservoir is a specially built artificial water body. 4. Hands off levels are required to limit the environmental impact and impact of other users?
Change to flow regime	1. Maintaining natural flow regime from impounded reservoir(s) (would only be available option to pumped storage hydro) 2. Providing appropriate compensation flows and freshet regimes to support downstream ecology

Potential Impacts	Prevention/Mitigation
Disruption of thermal stratification of reservoirs by mixing proportionally large volumes of cold water into the surface layers	1. Use artificial reservoirs 2. Ensure proportion of water moved into reservoir is small compared to volume of stratified photic zone of reservoir 3. Water added to reservoirs at depth to avoid disrupting thermocline
Access to previously inaccessible habitat (extending native range)	1. Ensure increased storage does not result in naturally impassable barriers to fish migration becoming passable due to raised water levels. 2. Provision of appropriate screening to avoid transferring fish between upper and lower reservoirs.
Stranding of spawning habitat left dry when loch levels drop again	

River flow mitigation

The impact of a storage hydropower scheme is measured against the Environmental Flow Standards and Loch Level Standards set in the Schedule 2 Part B and Schedule 4 of The Scotland River Basin District Standards Directions 2014.

Flow requirements for habitat protection are outlined in the sections below.
Requirements for mitigation of impact on flow standards depend on the scale of impact and options relating to the type of scheme. As a baseline the following mitigation measures would apply:

Type of Storage Scheme	Required outflow mitigation measures(s)
Pumped Storage Hydro: No overall consumption of water between reservoirs*	Mimic natural flow at upper- and lower- impoundments. If flow in the downstream water body is already impacted this may not be required but options to improve flow standards should be explored.
Conventional Storage Hydro: Impacted reach between storage and turbine outflow	Compensation arrangements – a minimum base level of Q95 would be required varying to Q80 at top water level. Additional requirements (e.g. enhanced baseflow or freshet releases) may be required at times depending on ecological requirements.
Attenuation Storage: Retention of high flows to provide prolonged turbine flow downstream	HOF (only high flows are attenuated to enhance generation. Low flows are unaffected).

*During the construction and reservoir filling phase of pumped storage scheme development, which will likely take place on a years-long timescale, the operation will be consumptive and there will be a need to reduce flow to the downstream catchment. Temporarily, the scheme will operate as a conventional storage hydro scheme and current guidance for mitigation and impact assessment will apply.

Information requirements: hydrology

River flow and mitigation

To help determine the impact of the scheme and set appropriate mitigation flow, SEPA will require detail on natural, current, and proposed changes to the flow regime at relevant locations:

- Where there is no existing storage, the natural flow regime of the proposed impoundment location(s) must be established. If there are existing pressures on the river flow the current flow regime must also be established.

- Where the proposed scheme utilises an existing loch, the applicant should provide both modelled inflow and outflow timeseries as part of the reservoir modelling process (see below).
- Supporting flow monitoring should be carried out over at least one year to capture a full range of flow conditions, following existing SEPA guidance for minimum supporting data requirements (see: annex-a of Guidance for applicants on supporting information requirements for hydropower applications).
- Details of the proposed method of mitigating impact on the flow regime downstream of the loch(s)/reservoir(s) must be provided and agreed with SEPA. Discussions at an early stage will help incorporate this into operational modelling. Where required, natural flow patterns can be mimicked through monitoring background flow condition in some form. This can be done with reference to a suitable, established flow gauging station, through catchment rainfall recording or by recording level change in the reservoir.
- The modelled outflow should be provided to show that the operational flow regime reflects the natural flow duration curve and is timed to compliment surrounding catchment conditions.

Loch modelling requirements

Loch modelling for all storage hydropower activities utilising existing lochs should establish the natural inflow, loch level change and outflow from the system. Where artificial influences already exist, these details must also be detailed in a ‘current operation’ modelled scenario. A timeseries of at least 30 years should be modelled to determine the natural and current flow/level statistics.

Comparable timeseries under the proposed operation should also be modelled. Where storage has been created through impounding a river the proposed operational regime, inflow, loch level change and outflow from the system should be provided.

Such loch-routing modelling will most likely be carried out using a suitable modelling software package to accurately detail loch parameters.

If the scale of impact is such that the baseline loch habitat is entirely lost (i.e. this will be the case with significant impoundment and level raising), Loch Water Level Standards will fail regardless, and detailed level modelling is not necessarily required. Details of the natural/current outflow and proposed loch-level and outflow regime should still be provided.

Outputs required from loch routing modelling should therefore meet as a minimum:

- Detailed loch level: surface area relationship covering the reference/current and proposed level ranges. Existing bathymetric survey data may be used if this exists (e.g. Murray and Pullar records on the National Library of Scotland archive). Where collection of bathymetric detail is required this should be accurate to at least 1m in the littoral zone with values interpolated between this. A long-term (ideally 30-years covering the current standard Meteorological Office climate reference period 1991-2020) sub-daily (idealyhourly) timeseries of loch level and 'reference' surface area for the current loch level range. Levels should be detailed to at least 0.01m.
- A comparable timeseries with the proposed scheme operation modelled.
- Natural, current and proposed timeseries data for the outflow from the loch/ impoundment location(s).

Loch Water Level Standards give a general, loch-wide scale indication of condition. Where noted sensitive or protected loch shore habitat exists a detailed analysis at a sufficient resolution of the impact on the level change proposed must be made.

Dealing with existing pressures

All modelling and operation proposals should account for any existing pressures within the system. Details must be supplied showing how any other pressures have been accounted for within calculations.

Downstream impacts

The above analysis must be carried out for any other impacted water bodies further downstream in the catchment. Any key receptors, such as existing water users or designated areas, must be specifically covered in the assessment of impact.

Fish protection

Hydropower schemes should be designed and operated to minimise negative impacts on the existing fish populations. This can be achieved through a mix of structural measures (for example, fish passages/fish ladders, protection grids at intakes, low mortality turbines, fish diverters, and the enhancement or creation of instream habitats) and operational measures (minimum environmental flow, limitation of flow variations, river works or sediments flushing during spawning season, fish stocking programmes). Regardless of the mitigation measures applied, each project should be designed based on a robust aquatic biodiversity baseline, an assessment of the hydraulic and hydrological changes resulting from the hydropower development and an understanding of the fish ecology.

Information requirements fish

To help determine the impacts, SEPA will require information on the extent and distribution of fish habitat available, fish populations currently present, and the operating design of the scheme. The level of survey information required will be proportionate to the environmental risk.

- Where stream channels are being inundated, what length of channel will be inundated at high water level (for Hydromorphology environmental standards test).

- What lengths of each channel type and fish habitat are being lost (for rarity/ecological significance assessments during a derogation test). Hydro morphological assessment methods (HYMO) reconnaissance and fish habitat surveys may be the best way to provide this information

- If a natural loch is affected, habitat survey of whole loch shore zone and possibly deeper parts of the loch may be required to identify if there are sensitive habitats that will be lost (for rarity/ecological significance assessments during a derogation test)

- Fish survey to identify which fish (and any other relevant species) are present in the water body. This needs identified as early as possible in the development of the scheme to identify any further evidential requirements, risks, and appropriate, well-evidenced mitigation

- If migratory salmonids are able to access the water body, migration routes, habitat loss and risk to spawning must be considered for these species in addition to resident fish

    - Fish and Fish habitats survey
    - Protected species survey
    - Details of the proposed operational water level regime
    - Baseline spawning habitat potential
    - Baseline accessibility of tributaries to fish species
    - NGR of the future reservoir high water level point on all inflowing streams
    - Representative photos of the stream channel upstream and downstream of the section of stream to be drowned out of this point
    - Gradient for each of these streams upstream and downstream of the given NGR
    - Draw down range and details of the proposed loch level regime (including cumulative impact with other water users). Loch modelling should establish the natural inflow, loch level change and outflow from the system
    - Determination of rare fish species / species of conservation concern presence in the loch (such as Arctic charr, powan, vendace) and which areas / depths / habitats they use for spawning
    - Identification of areas of the reservoir margins where strandings may be a possibility, and the risks associated with these
    - Presence of aquatic and terrestrial protected species and habitats that may be affected
    - Elevations of the maximum and minimum surface water area (inputs to Loch MiMAS environmental standards assessment)

- Full details, including drawings, of the intake screening arrangements including gap sizes, through-screen velocities, cleaning devices and oversizing of the screen area to allow for partial blinding, are required
- Detailed assessment of the likely routes taken by downstream migrating fish as they pass the intake / outfall structure, including the likely effects of the scheme in isolation and any potential in-combination effects
- Any other means of reducing the attraction of upstream migrating fish to the discharge area

Mitigation fish

- Fish pass using best practice in IFM Fish Pass Manual
- Appropriate screen design, following all relevant guidance
- Additional behavioural deterrents may be desirable, but these should be considered only in addition to appropriate physical screening. Such deterrents may include acoustic, strobe or bubble screens, and these should be considered and targeted at species that may not be excluded by any physical screening.
- Mitigation options will depend on the relative sizes of the waterbodies, their bathymetry and the anticipated variations in lake levels.
- Condition to require reservoir level to be maintained at high / crest level during spawning period e.g. October and November to prevent fish spawning in areas likely to be inundated

Protection of flows for fish spawning and migration

The scheme must be operated to provide suitable flows for fish migration and spawning activity during the periods of the year in which that activity would naturally occur. These periods will depend on:

- the fish species and fish populations;
- the location of the scheme.

During periods in which migration or spawning would be expected to occur, schemes will be expected to operate so that the rate of abstraction or range of draw down is no greater than that permitted by the river flow standards or loch level standards for good across the range of flows providing the flow depths and velocities needed by fish for migration and spawning. This may be achieved by one of the following:

- reducing abstraction rates accordingly;
- ceasing generation during the relevant period of the year;
- Limiting level range
- Considering the creation of escape routes to allow fish to retreat to deeper refuges during generation periods
- Reduce speed of level lowering to minimise strandings
- Establish safe ‘lagoons’ in existing shore zones that need protection
- Reduce risk of delay at intake and outfall by minimising water velocities during pumping and generation
- Seasonal reduction or cessation of pumping / generation

The most appropriate option for providing the required flows and optimising the electricity output of the scheme will depend on the site-specific circumstances.

Impact of proposal on river continuity for fish

Potential Impacts	Prevention/mitigation
River inundation (i.e. through creation of upper reservoir that floods a river)	1. An artificial upper reservoir is used that does not flood an existing river. 2. The upper reservoir is already a HMWB storage reservoir and will not be enlarged by the scheme. 3. The catchment area of the part of the river that is affected is small (e.g. < 5 km2) and does not provide important fish spawning habitat.
Disruption of thermal stratification of reservoirs by mixing proportionally large	1. Use artificial reservoirs

Potential Impacts	Prevention/mitigation
volumes of cold water into the surface layers	2. Ensure proportion of water moved into reservoir is small compared to volume of stratified photic zone of reservoir 3. Water added to reservoirs at depth to avoid disrupting thermocline
Impoundment creating an artificial barrier to migration	1. Could then include fish pass mitigation.

The fish related issues which SEPA will generally consider when assessing storage and pump storage hydro-schemes include:

- How will the impoundment affect flows in the outflow stream (i.e. what are the proposed compensation flow arrangements)?
- Is the loch or catchment of ecological or commercial importance in terms of its fish species? For example, are migratory fish present, do significant fisheries exist, or are high conservation value fish species present?
- Is the impoundment likely to impact on fish recruitment by causing inundation or loss of connection with important spawning and nursery habitat in the inflowing and outflowing streams, and / or in the loch.?
- Attraction to intakes or outfalls and the potential for impingement on screens.

Provision for upstream fish passage

Fish Passes and Screens Guidance

The Environmental Authorisation (Scotland) Regulations 2018, gives power to SEPA to control the design and operation of abstractions and impoundments which includes the provision of fish passes and screens. To ensure compliance with the Water Framework Directive and other relevant legislation,

Disruption or delay to fish migration can have significant adverse impacts on the distribution and/or abundance of fish populations. Hydropower schemes can pose significant risks to fish migration, and the impacts can extend far beyond the site of the hydropower scheme. Unless such risks can be avoided, authorisation will generally be refused.

Developers are advised to consider:

- sites that are upstream of natural[6] barriers to fish migration.
- sites where fish habitat upstream is only very poor quality, or very limited, and not important for maintaining the distribution or abundance of fish populations.
- utilising existing weirs that are currently acting as a significant barrier to fish migration.

The development of such sites must aim to improve fish passage.

We will only consider applications to develop other sites where the developer provides evidence that the fish passage provisions proposed (including the accompanying management regime) will be effective in safeguarding fish migration.

Most fish passes are likely to cause some delay or increase fish stress or energy use. It is not possible to predict the efficiency of any design with 100% confidence. We will take account of this uncertainty in deciding whether or not the benefits of the scheme justify the risk. Even with a well-designed fish pass, a development may be unacceptable if located on an important fish migration route or if it would contribute (together with existing obstacles) to a significant cumulative risk to fish migration.

Where there is a significant extent of good fish habitat upstream of a proposed scheme, we are likely to require effective operation of the fish pass to be demonstrated as a condition of continued authorisation. This may involve electric fishing, redd counts or fish pass surveillance using TV or automatic fish counters. For this purpose, camera systems, light boxes and counter housings may need to be incorporated into the initial design of the fish pass.

[6] Rivers and streams upstream of man-made barriers to upstream migration may support local brown trout populations that could be adversely affected by new obstacles to fish movement in those rivers and streams.

The most appropriate fish pass design to use will depend on a range of factors including:

- the fish species present (e.g. Atlantic salmon, sea/brown trout, eel, lamprey, etc.).
- the characteristics of the intake structure, including the head difference.
- the characteristics of the river or stream.
- the type of management regime it is feasible to put in place to ensure the fish pass is maintained in working order.

The fish pass need only operate during the period of the year used for migration by the fish species and populations that are present. Early discussions with us are recommended.

Fish pass design - salmon and trout

The mitigation in this section does not apply to schemes located on rivers lacking populations of salmon and trout (e.g. schemes located above the upstream limit to migratory fish in steeply sloping channels through which upstream movement of brown trout is unlikely).

Purpose

Mitigation must be designed to ensure that salmon and trout are provided with a means of ascending past the weir at times during which they would naturally move upstream.

Requirements

Passage must be provided by one of the following fish passes outlined below. In all cases, there must be an appropriate flow attracting fish to the pass entrance. To achieve this, the fish pass discharge must be able to out-compete other flows in its attraction to fish. Where a turbine is on a weir, the turbine outflow should be adjacent to the fish pass so that it augments attraction rather than competing with it.

All passes must be maintained free of any debris that could impair their effective operation. This will require suitable design characteristics (e.g. incorporation of an upstream debris boom) and a maintenance programme.

Natural design passes

Low-gradient, by-pass channels

These can accommodate all fish species and provide additional fish habitat.

Rock-ramps

These are built into the river channel and lead up to the weir crest. They must be engineered with strategically placed rocks (boulders) designed to provide natural refuge pools and reduced water velocities. They must also be able to withstand flood flows. The appropriate gradients and boulders for a rock ramp depend on the fish species that are present. Table A2 provides indicative design criteria for ramps suitable for salmon and trout. Adjustments may need to be made (e.g. to boulder placements etc) to optimise the performance of the rock-ramp.

Artificial design passes

Pool and traverse passes

These break down the head-difference at main weir into a series of small steps that can be ascended by fish. The pass should be designed to ensure that:

- the drop in water levels between adjacent pools does not exceed 30 centimetres if trout are present or 45 centimetres if only salmon are present.
- the pools have minimum dimensions of 3 metres long, 2 metres wide and 1.2 metres deep.
- the downstream edge of the notch and traverse is curved to reduce turbulence and ensure water flows down the face of the wall (i.e. has an adherent nappe) rather than forming a free-spurting jet.
- most of the baseline flow regime passes through the fish pass.
- the pass is positioned at the most upstream section below the weir where fish naturally accumulate.
- the pass is still effective when flow in the river upstream of the intake structure rises to Qn10.

Baffled fish passes.

These consist of rectangular channels/troughs containing various shaped, closely spaced baffles set at an angle to the axis of the channel. The baffles form secondary channels whilst leaving a proportion of the channel/trough to take the main flow. The gradient and length (between resting pools) of baffled fish passes must be designed to suit the swim speeds and endurance of the fish present. Baffled passes can be constructed off-site and bolted together *in situ*, or the baffles inserted into a pre-formed channel. Examples of baffled passes include:

- the Alaskan ‘A’ baffled pass. This can operate at steeper gradients than other baffled passes. A maximum slope of 25% and maximum length of 12 metres (i.e. a 3 metre head difference) can be used for salmon. A less steep gradient and shorter length is required for smaller fish. These passes operate with relatively low flows, give the most lift before requiring a resting pool, and accommodate about a 1 metre change in upstream water level. Their complicated baffle geometry and narrow free gap make them very prone to blockage by debris. An effective means of preventing blockage by debris (e.g. an upstream debris boom) must be incorporated into the design and operation of the pass.

- the plane baffle or Denil fish pass. This uses a less complicated baffle design than the Alaskan A and can operate up to a maximum slope of 20% and maximum length of 12 metres (i.e. a 2.4 metre head difference) before a resting pool is required. An effective means of preventing blockage by debris (e.g. an upstream debris boom) must be incorporated into the design and operation of the pass.

- Larinier Super active baffled pass. This consists of 10 to 15 cm high chevron baffles that span the bottom of the fish pass channel and (unlike in the Alaskan A and Denil) do not extend up the sides. Channel widths can be very wide to accommodate large flows provided longitudinal webs are used to separate each set of chevron baffles. The design can achieve very low water velocities and so enable passage of small salmonids and large coarse fish. They are not as prone to blockage by debris as other baffled passes and so require less maintenance. The Larinier pass operates at a maximum gradient of 15% and a maximum length is 12 metres for large salmonids before a resting pool is required (i.e. a 1.8 metre head difference). This type of pass is less tolerant than other designs of large upstream head fluctuations. The maximum head over the top baffle is limited to about 0.7 metres.

Impact of proposal on morphology

Potential Impacts	Prevention/mitigation
Protection of downstream transport of sediment	Removal and return downstream (at appropriate times and locations) of sediment accumulation upstream of intake structure.
Protection of riverbanks and bed from erosion	Appropriate design of engineering structures and tailrace to ensure that erosion rates of the bed and banks is not increased
Reduction in diversity of shore zone habitats	

Sediment Management Physiochemical Measures	Has the developer provided information on sediment continuity? • Is the impoundment >25Ml, with a set compensation flow where that compensation flow is not delivered from the surface of the waterbody? • Are there downstream engineering structures to ensure adequate dissolved oxygen and temperature? • Could riparian woodland restoration of river channels upstream and downstream be used to optimise shading of the channel. • Creation or restoration of riparian woodland and vegetation in the upper catchment is recommended to address the climate change impact and could ensure

that the temperature change caused by the turbines remain within acceptable limits.

Impact on sediment transport and sediment discontinuity extends beyond individual hydrological units to impact habitats downstream, the level of impact will depend on whether a river or natural loch are being impacted and, if a natural loch, whether there are routes for sediment transport such as long-shore drift.

Pumping water (for example between the two reservoirs of pumped storage schemes), typically causes water temperatures to increase due to friction from movement through penstocks, pumps and turbines. This could result in an increase in water temperatures in the outflow. In addition, any disruption to thermal stratification and disturbance of sediments in reservoirs, has the potential to increase nutrients and suspended sediments in the outflow.

Reservoirs often have raised water levels, and these higher water levels will encroach into the tributaries flowing into the reservoir, abruptly slowing the flow in these streams. When flow is slowed, the stream loses its energy and releases its sediment load. This could potentially cause excessive sedimentation at the mouths of these tributaries, and in extreme cases, may block fish access to them.

Impoundments can trap sediment, disrupting its natural movement and causing erosion of the bed and banks downstream. This can lead to serious negative impacts and cause damage to or loss of ecologically important channel habitats (morphology). The effects can be long-lived and sometimes irreversible and can be detected several kilometres downstream of the impoundment.

Building power stations on or close to the shoreline can disrupt sediment transport along the shores of lochs, a process known as longshore drift. This is essential for maintaining shore and beach habitats such as spawning gravels or shallow zones where light can penetrate, where plants are able to grow and support food webs. When waves hit the shore, it is often at an oblique angle, and then gravity drains the water straight downslope (backwash). This process sets up a longshore current that moves sediment in a sawtooth motion along the shore. Building obstacles on the shore truncates this process, similar to dams preventing sediment transport down rivers.

Information requirements

- Proposed design and interaction with / effects on the shoreline

Mitigations

- Design power station minimising impact on the shoreline
- Avoid building on localised protected areas / habitats

Mitigation sediment management

- Appropriate sediment management such as dry skimming of newly developed gravel deposits and reintroduction of coarse sediments downstream of the upper reservoir.

- Appropriate sediment management measures could ensure that sediment continues to be transferred downstream

- Periodic draw down coinciding with high stream flows to balance erosion / deposition processes

For more information on sediment management see WAT-G-026 EASR Guidance: Engineering: Activity Guide: Sediment management.

For further mitigation for new impoundments see section 13.3. of WAT-G-040 Permit application guide for abstractions and impoundments.

Information requirements temperature

- Temperature environmental standards are defined for rivers to regulate discharges that change ambient water temperature refer to this guidance for information requirements see The Scotland River Basin District (Standards) Directions 2024.
- Temperature logging (baseline and operational)

- Baseline and post development monitoring of fine sediment content of spawning and nursery habitat
- Information on water quality and chemistry in all relevant waterbodies, and the effects the proposed scheme will have on this.

- Loch bathymetry, thermal regime and thermal stratification (and any other stratification) in all relevant waterbodies, and the effect the proposed scheme will have on this.

Information requirements

- Depth of intakes/outflows and position relative to substrates.

Mitigation temperature

- Locate inflows/outflows to minimise mixing of stratified zones and thermocline disruption

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