Environment Agency

Guidance for run-of-river hydropower

December 2013

Screening requirements

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

What are the issues?

The turbines in hydropower schemes may harm fish that pass through them. If this is considered to be a risk in your scheme, you will need to fit fish screens and an appropriate bywash. Screens may be needed to protect fish moving both downstream and upstream.

In most cases the screens used will form a physical barrier. These screens are known as 'positive exclusion screens'. However, the screens themselves may harm fish if they are poorly designed or if water is flowing too quickly where the fish approach the screen. When designing your scheme, you will need to make sure this 'approach velocity' is appropriate for the species of fish that need to be protected.

Poorly designed screens and bywashes can also delay downstream fish migration, so that it may be more difficult to meet the environmental objectives for the species to be protected.

Key aspects of fish screen design

This section sets out our standard, default requirements for fish screens for run-of-river hydropower schemes. You need to adhere to these requirements or justify your decision to vary the design. If you don't do this, we will not approve your scheme proposals.

The design requirements for different parts of England and Wales can vary. This reflects regional variations in climate and geology that affect fish growth. In particular, salmonid smolts tend to be smaller in colder areas and in places with low levels of nutrients. Table S1 sets out our default requirements that will be appropriate for most hydropower schemes.

In some cases it may be necessary for you to choose a screen with a different size of gap ('aperture') or design. Your decision should be based on the shape and size ('morphology') of the fish which require additional protection. If you consider the default screen size to be inappropriate, you will need to provide evidence to support both your view and your proposed alternative.

A good design for downstream passage, which should not delay migrating fish, will combine:

- effective screening and diversion and
- a safe bywash route

When choosing the right screen for your scheme, you must take account of the criteria for approach velocities (also known as 'escape velocities') and for bywash provision.

Where fish will pass through the turbines in your scheme, you must ensure that the design of any downstream screens allow fish to pass downstream while creating a barrier to fish migrating upstream.

Intake screening

The type of turbine used will determine the level of impact on the fish passing through. Table S1 sets out our default screening apertures. Generally, the smaller the turbine size, the more damaging the effect is likely to be.

Table S1 - Summary of intake screens

Situation	**At intake – fish screening requirements**		
Traditional waterwheel Most Archimedes screw designs	Trash screen (100mm) - **see also detailed guidance in Tables S6, S7 and S8** as in some cases smaller aperture screens will be needed to provide protection for larger fish.		
Impulse turbines,such as Pelton and Turgo	Drop through screens ≤ 3.0 mm (for example Coanda style)		
All cross-flow turbines and other turbines with a maximum turbine flow < 1.5 m^3 per second	Migratory salmonids	Y & NE, NW, SW (D&C) & Wales	≤10.0 mm
		Mid, Ang, SE, SW (Wessex)	≤12.5 mm
	Other species, including eels	≤ 12.5 mm (see notes)	
	Where protection of salmonid parr or young of year coarse fish (O+) is required.	Default is 6.0mm Such screening can be used for part of the year when parr or young of the year fish require protection.	
Any other turbine with a maximum turbine flow ≥1.5 m^3 per second (excluding cross-flow turbines)		Region	Screen aperture
	Migratory salmonids	Y & NE, NW, SW (D&C) & Wales[1]	≤10.0mm
		Mid, Ang, SE, SW (Wessex) [1]	≤12.5 mm
	Other species, including eels	≤ 12.5 mm (see notes)	

1 Environment Agency Regions: Y & NE –Yorkshire and North East; NW – North West; SW (D&C) – South West (Devon & Cornwall); Mid – Midlands; Ang – Anglia; SE – South East;

SW (Wessex) – South West (North and South Wessex); Wales – Environment Agency Wales.

Notes:

Further information can be found in our guide:
- Screening for intake and outfalls: A best practice guide

The screen aperture necessary to protect eels is dependent upon the size of eels and the orientation of the screen (its angle to the flow). Screen apertures for adult eels can range from 9 mm to 20mm. For further guidance, please refer to tables S2 to S8 and our eel screening guidance, Screening at intakes and outfalls: measures to protect eels.

Further protection may be required for species protected under specific legislation – such as lampreys, shad and bullhead where they are designated features of Habitats Directive sites.

If there are no eels or salmonid smolts present, a default screen aperture size of 12.5 mm is recommended. Where protection of young of year fish is needed, smaller screen apertures may be required depending upon the type of turbine used.

The use of other screen aperture sizes must be based on evidence and linked to the size of fish which need to be prevented from passing through the screen.

The values provided in Table S1 assume that screening best practice is followed (e.g. screens are angled to the flow where appropriate).

Screen design and orientation

The main design requirements for fish exclusion screening are:

1. Select the mesh size to ensure exclusion of the minimum target fish size, based on preventing penetration of the fish's head;
2. The screen should be flush with the river bank for a lateral river intake or, when placed across a channel, angled (in plan view) relative to the channel to guide fish into a bywash. An angle of 30 degrees or less provides the best screening properties. The angle is calculated such that the flow vector normal to the screen face is below the required escape velocity for the target fish species and sizes
3. Screens may be also be angled horizontally, as viewed from the side, but may require smaller screen apertures. A bywash is still required, and this should be located towards the top of the screen.
4. Provide a suitable bywash if the screen is placed across the channel.
5. Ensure the water velocities ahead of the screen are low enough to allow fish to escape without injury.
6. Drop-through screens, typically used for high head schemes, can have different arrangements (see Screenings for intakes and outfalls: a best practice guide).
7. Ensure that there is a suitable depth of water below a drop-through screen where fish are present.

The figures in the tables S2 - S8, with the exception of those for impulse turbines, are based on what is appropriate for screens constructed with either vertical or horizontal bars or a mesh-type arrangement.

If you use small screens – for example screens that are up to two metres across – you may align them at right angles to the flow. However, if you do this, there must be a bywash right next to the screen and the bywash flow must be at the upper end of the acceptable range.

Where screens are positioned at right angles to the flow they offer no behavioural advantages to the screening process and have an increased risk of blinding. You will need to ensure that the screen apertures can prevent the relevant size species of fish from passing through or being trapped on the screens. These are likely to be smaller for those presented in Table S1 (excluding drop through screens)

Rectangular section bars or perforated plates are preferable to round-section bars. The latter are likely to trap fish by their gills and if used a smaller aperture between bars would be required. Bars need to be sufficiently stiff to maintain the design spacing right across the screen, you may need to fix horizontal tie-bars across the back of the screen.

Screen orientation and design should comply with our screening guidance:

- Screening for intake and outfalls: a best practice guide.
- Screening at intakes and outfalls: measures to protect eels

Behavioural barriers and guidance methods

Fish deterrent systems are commonly known as 'behavioural barriers' or 'behavioural screens'. In some cases these can be used as a substitute for, or supplement to, more conventional positive exclusion or physical fish screens. Some positive exclusion screens, when operated and maintained correctly, can keep all sizes of fish out: behavioural screens cannot achieve this.

Fish have a number of well-developed senses. They can detect and react to light, sound and vibration, temperature, taste and odour, pressure change, touch, hydraulic shear, acceleration, electrical and possibly magnetic fields. Fish deterrent methods use one or more of these stimuli to divert fish from the immediate area of the water intake. In some cases it will also guide them past the intake into a bywash or to a point downstream.

A risk assessment will be required for this type of screen or combination of screen types (see below).

There is further information on this in Screening for Intake and Outfalls: a best practice guide.

Tailrace screens

Fish that are migrating upstream may be attracted into tailrace channels. This may delay or stop their migration and must therefore be prevented, unless there is a co-located fish pass. You may also have to install tailrace screens to direct fish away from a long tail race, prevent fish from entering a turbine or direct fish towards a fish pass.

Physical or electric barriers are acceptable as tailrace screens for salmonid or coarse fish, although electric barriers should not be used where fish are allowed to pass through the turbine. We recommend physical barriers if there is a risk that fish could enter the turbine from the tailrace.

In general, tailrace screens should be upright, placed close to the edge of the river bank at the point where the water from the turbine discharges back into the river and be designed to guide fish to a fish pass entrance where appropriate.

Base your decision on the need for a tailrace screen on:

- the layout of the scheme, and
- the migratory fish species present.

Many turbine channels will require a screen at the downstream exit to ensure that upstream migrating fish do not try and ascend the flow coming through the turbines. In cases where downstream migrating fish are allowed to pass through the turbine you must ensure that screens to prevent upstream migration do not prevent downstream migrants from re-joining the river downstream of the structure.

Further details of tailrace screens are shown in Table S9.

Proposing a different screening regime

You may wish to propose different screen spacings to the default settings given here. This would be based on the specifics of your scheme design, the local environment and associated ecology. If you do, you must complete a risk assessment which will be assessed by the Environment Agency.

Risk assessment

This risk assessment should consider

- the species and size ranges of the fish that need protecting (including resident, migratory and recovering species)
- the deflection rates of the screens
- the mortality rates associated with the type of turbine to be deployed at the full range of scheme and river flow rates
- the overall effect that the proposed scheme may have on the fish population or on other animals that need to be protected.

Your risk assessment must show that your proposed screening arrangements would provide the same level of protection as the default screen requirements set out in Tables S1 to S8. If they do not, the proposal will be rejected.

The risk assessment should include:

- an assessment of how efficiently the screen deflects the fish species to be protected: you must also show how this 'deflection efficiency' may vary
- the mortality and /or injury rates for fish that pass through the turbine
- an assessment of how any additional mitigation measures, such as behavioural screens or cessation periods, would further increase the proportion of fish diverted to safety (the 'additional deflection efficiency'.

Other mitigation measures

A number of mitigation measures may be compatible with using an over-spaced screen. These mitigation measures include:

- Stopping the turbines at times when there is a risk of entrapment or entrainment.
- The use of behavioural barriers, such as bubble curtains or strobe lights. These have been shown to be effective deterrents when used with a physical screen.

Further advice on this subject can be found in our Screening for Intake and Outfalls: a best practice guide.

Screen Approach Velocity

The ability of a fish species to swim (its ‘swimming performance’) is strongly influenced by the length of the fish and by water temperature. Fish approaching an intake need to be able to swim fast enough and for long enough to ensure their escape through the bywash – or by any other route provided to return them to the main river flow.

If you place the fish exclusion screen at a diagonal angle to the flow (as viewed from above), fish can be guided to the lower end of the diagonal, where a bywash can allow their safe transit downstream. The angle of the screen can be set to ensure that the escape velocity is kept below required design value.

A fish exclusion screen which is set at a diagonal angle to the flow will be better at diverting the fish towards the bywash than one set at right angles to the flow. You will need a bywash where the screens (including trash racks) are not located in the normal course of the river. If you have this arrangement and don’t plan to have a bywash in these circumstances, you will have to submit evidence that the scheme provides an adequate downstream passage for fish in another way.

Figure 1 shows the relevant velocity components for an angled fish barrier. For the purposes of designing the screen, the approach velocity Ue (also known as the ‘escape velocity’) is defined as the velocity 10 cm upstream of the screen, at right angles to the screen face. Where screens are not angled to the flow, approach velocities may need to be reduced.

If the screen is installed in a headrace, angle the screen diagonally across the flow. This enables the approach velocity to remain low even when the axial channel velocity (Ua) in the headrace is high. This has the added benefit of guiding fish towards the bywash entrance. Note that where you need to protect more than one species of fish, the approach velocity must be low enough for all the species to be protected.

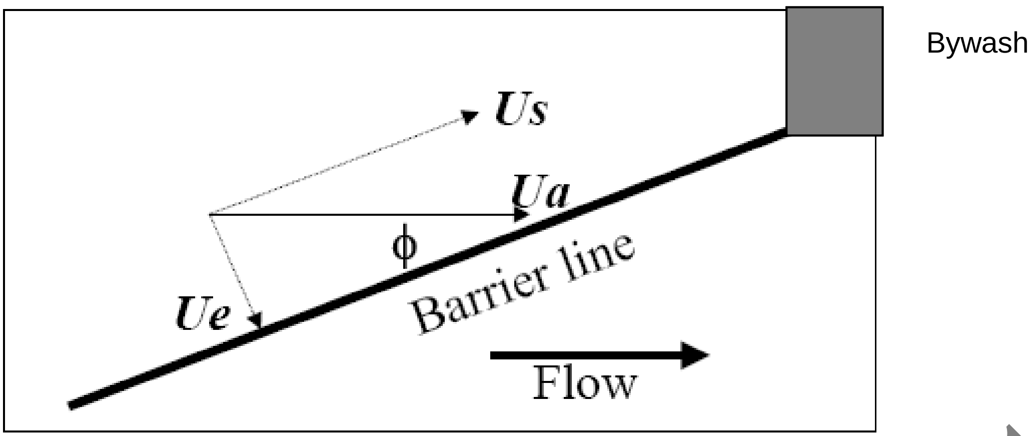


Figure 1 Flow velocity components in front of an angled fish barrier

Ua is the axial channel velocity; Ue (=UsinΦ) is the fish escape velocity; and Us (=UcosΦ) is the sweeping velocity along the face of the screen.

Fish species	The maximum acceptable approach velocity towards any part of a screen (in metres per second)
Salmonid	0.60 m/s
Coarse fish and shad	0.25 m/s
Eel	0.50 m/s
Lamprey	0.30 m/s

Accounting for debris

Screen apertures can become blocked by debris. When this happens, the speed of the water as it approaches the screen increases – particularly if the screen is at right angles to the flow. This reduces the ability of the screen to divert fish to safety. You need to make sure that the water hitting the screen is not flowing so fast that fish cannot escape – in technical terms it must not exceed the target 'approach velocity', also known as the 'escape velocity'.

There are three main approaches for tackling this problem:

- Automatic screen cleaning – the inclusion of an automatic screen cleaner will reduce the problem of debris. However, when deciding on the overall screen size, you will still need to assume that 10 per cent of the screen may be blocked.
- Manual clearance – if you plan to clear screens manually, you will need to be confident that the target approach velocity can be maintained even if up to 50 per cent of the screen is blocked.
- Self-cleaning drop-through screens

Screen bywash

The term ‘bywash’ describes the arrangement of flow that is needed to prevent fish becoming trapped by, or caught up in, the screening at a hydropower scheme and allow them to be safely delivered downstream.

Your hydropower scheme will need a screen bywash if the fish exclusion intake screen is not located in the normal course of the river – in other words if it is within the headrace.

Where your screen is angled, locate the bywash entrance at the downstream end of the screen. This takes advantage of the direction in which fish will be guided. Vertical screens would have the bywash at the top of the screen.

Make sure your bywash is designed to work effectively. Bywash flows should be in the range of 2-5 per cent of the scheme’s design flow, based on the effectiveness and efficiency of the scheme design.

This percentage may need to be higher if the design of the bywash is poor – for example if the screen is aligned at right angles to the flow, the bywash is located away from the end of the screen, or if the hydraulic conditions at the entry to the bywash are poor.

A good design for a screen and bywash will:

- have a sweeping velocity that increases smoothly into the bywash entrance
- have an adequate entrance size – at least 0.4 - 0.5 m wide and deep
- avoid the creation of sharp shadows, particularly at the entrance to the bypass
- provide a smooth and safe conduit that avoids damaging the fish in transit and delivers the fish safely downstream
- prevent fish from trying to ascend the bywash

We will accept some types of fish pass instead of a bywash – provided that they can be suitably positioned. Suitable types include Larinier, Vertical-slot, Pool and traverse, or nature-like fish passes. However, Denil, Alaskan A, or side-baffle passes might cause abrasion to the fish and are therefore not suitable for use as a bywash.

The point at which the bywash returns to the main channel (the ‘bywash return point’) should be sufficiently deep to prevent fish being stranded or damaged on impact. It should be at least 25 per cent of the difference between the height of the river up and downstream (the ‘differential head’) and no less than 0.3m deep.

Bywash entrances for adult eels should open at bed depth, preferably via a full-depth opening.

This section, apart from depth and delivery point, does not apply when drop-through screens are used (typically in high head schemes) since they should be designed to allow fish to safely pass over the screen.

The following tables provide additional detail on the screening requirements for specific turbine types

Table S2 - Pelton and turgo turbines

Where used – type of installation	Normally used on high-head systems.
Survival rate	Almost no fish survive if taken into turbine.
Notes	In most cases, operators use a 3mm (e.g. 3 mm Coanda-effect, wedge wire or perforated sheet) screening drop through a self-cleaning screen. This prevents the entry of debris that will damage the turbine.
Screens required for:	
Salmonid fry, under-yearling coarse fish, lamprey ammocoetes, salmonid parr, young of year coarse fish, or silver eels.	Max 3mm

Table S3 - Cross-flow turbines

Where used	Low-head schemes
Survival rate	The shape of the turbine and blades and the high rotation speed mean that very few of the fish taken into the turbine would survive.
Screens required for:	
Salmon and sea trout smolts, adult eels	10/12.5mm screens (based on size of smolts)
When salmonid parr or young of year coarse fish are present or occur at the site	Default is 6mm from May to September

Table S4 - Smaller reaction turbines – for example Kaplan, Francis and other propeller turbines

Where used	Kaplan – used in high-flow and low-head conditions. Francis – used in a wide variety of flow and head conditions.
Survival rate	The shape of the turbine and blades and the rotation speed mean that few of the fish taken into the turbine would survive.
Notes	If the turbine flow is less than $1.5m^3/sec^{-1}$, you will require screening to a similar specification to that required for cross-flow turbines – especially where there are autumn migrating smolts and juvenile trout. We will be able to help provide evidence for this need. For other propeller turbines, the risk to fish posed by the size and rotational speed of the turbine should be considered before appropriate screening is determined.
Screens required for:	
As default: Salmonid parr, young of year coarse fish Otherwise: Salmon and sea trout smolts	6mm (May to Sept) 10/12.5mm screens (based on size of smolts - see main Good Practice Guide for details)
Eels Full details on screening for eels can be found in our guidance Screening at intakes and outfalls: measures to protect eels	Small adult eels (>30cm and < 50cm in length) - 9mm screens (where screen angles are >20 degrees). These are likely to be found lower down in the catchment. Large adult eels (>= 50cm in length) - 15mm screens (where screen angles are > 20 degrees)

Table S5 - Larger reaction turbines – for example Kaplan, Francis and other propeller turbines

Where used	Kaplan – used in high-flow and low-head conditions. Francis – used in a wide variety of flow and head conditions.
Survival rate	These larger turbines are considered to be safer for fish passing through. The damage rate for fish passing through a propeller type of turbine depends on the size/capacity of the turbine and the length and species of the fish at risk.
Notes	If you plan to use large Kaplan turbines (turbine flow > = 1.5m3/s) with screens that differ from the default size below, you will need to carry out a risk assessment to demonstrate that the same degree of protection will be provided. The older type of low-head Francis turbine is less damaging to fish, but this type is no longer manufactured. Where refurbished ones are used, a 10/12.5mm screen is necessary – to exclude smolts, other similarly sized fish, and eels. For other propeller turbines, the risk to fish posed by the size and rotational speed of the turbine should be considered before appropriate screening is determined.
Screens required for:	
Salmon and sea trout smolts, adult eels	10/12.5mm screens (based on size of smolts)
Eels Full details on screening for eels can be found in our guidance Screening at intakes and outfalls: measures to protect eels.	Small adult eels (>30cm and < 50cm in length) - 9mm screens (where screen angles are >20 degrees). These are likely to be found lower down in the catchment. Large adult eels (>50cm in length) - 15mm screens (where screen angles are > 20 degrees). These are likely to be found in more upstream catchments.

Table S6 - Archimedean screw turbines (3, 4 and 5 blade)

Where used	These are suited to low-head sites.
Survival rate	Archimedean Screw Hydropower Turbines (ASHTs) have been shown to cause minimal damage to fish, as long as there is appropriate protection on the leading edge of the screw and they are designed within acceptable limits.

Notes

We will normally approve the use of ASHTs according to the table below. Schemes designed within these parameters are likely to require only trash screens. Protection to the leading edge of the blade will be necessary.

As the licences for hydropower schemes are based on site specific information and the risk assessment associated with those turbines, the diameter and maximum speed of the turbine will need to be specified in the licence.

Turbine diameter and rotational speed

Number of blades	Minimum diameter of turbine (m)	Maximum rotational speed of turbine (rpm)
5	3.0	24
4	2.2	30
3	1.4	32

Variable speed ASHTs are preferred to fixed speed as they pose lower risks to fish for much of the time when they are operating at less than maximum power.

Where the diameter of the turbine is less than that specified in the table or the rotational speed is greater than in the table we will require fish screens and appropriate by-wash to be included in the scheme design. Screen apertures will need to be sufficient to prevent passage of large fish at risk of being struck by turbine blades. An assessment will need to be undertaken to consider whether such species are present and require protection (e.g. eels or salmon and sea trout kelts or large rheophilic coarse species).

Screening will be specific to the fish requiring protection. Please note that fish of less than 60 cm in length are not considered to be at risk from damage through being struck by a turbine blade providing it is fitted with an appropriate compressible rubber bumper, see below.

Screw turbines with tip speeds at or above 3.5 m/s (approx. 2.5m diameter) should have compressible rubber bumpers fitted to the leading edges to safeguard the passage of large fish

Turbines with tip speeds below 3.5 m/s should have compressible rubber bumpers fitted although harder compounds may be acceptable. However, where there is a risk of large fish passing through the turbines, softer rubber bumpers will be required.

Maximum tip speeds

Tip speeds should not exceed a speed that would result in unacceptable impact forces. Based on current evidence turbines with a tip speed greater than 5m/s and/or a diameter exceeding 5.0 m will require additional protection for large fish, such as the inclusion of appropriate screening and by-wash facilities.

If you propose a scheme that falls outside these requirements, you will need to submit a risk assessment providing justification for any departure that shows equivalent levels of protection are provided.

Information required

Hydropower developers will need to provide information on various aspects of the ASHT design when submitting an application. These should include: the diameter, the number of blades, the rotational speed (rpm), the pitch of the screw, and whether it is fixed or variable speed. The type of compressible rubber bumper fitted and the gap between the blade and turbine housing will also need to be provided.

Installation and maintenance

It is essential that ASHTs are designed and maintained to specific standards. The following points should be addressed and where necessary appear as conditions within the licence.

- The leading edge must be at least 10mm within the perimeter of the trough before rubber bumpers are fitted
- The appropriate type of rubber bumper must be fitted correctly and must sweep within 5mm of the trough
- The gap between the turbine blade and the trough must be maintained to agreed tolerances throughout the length of the turbine (e.g. 5mm)
- The rubber bumpers fitted must be maintained in good condition
- To ensure these points are addressed it is recommended that they form part of the ongoing compliance assessment of schemes.

The clearance between the screw and the trough in which it runs must be checked at routine intervals and compared to permissible tolerance. An increase in the gap will increase the risk of injury to fish (and lead to a reduction in efficiency of the turbine).

Where checks indicate remedial action is required, operation must stop until remedial work has been completed. Remedial action can include the installation of screens and associated by-wash to prevent fish from entering the ASHT. The operator could choose to fit screens during the installation of the ASHT, in which case, the requirement to include rubber bumpers or regularly check design tolerances is removed.

Licence conditions

The abstraction or impoundment licence will specify:

- the diameter of the turbine
- the number of blades.
- the maximum rotation speed
- fixed or variable speed

- the magnitude and tolerance on the gap between screw and trough and the frequency of checks
- the type of compressible rubber bumper fitted to the leading edge of the blades

Screens required

Where the diameter of the turbine is less than that specified in the table or the rotational speed is greater than in the table, we will require the provision of fish screens and appropriate by-wash. We are also likely to require screening and by-wash if the diameter of the turbine exceeds 5.0m.

Screen apertures must be sufficient to prevent the passage of large fish at risk of being struck by turbine blades.

Screening will be specific to the fish requiring protection. An assessment will be required to consider whether such species are present and require protection (e.g. eels or salmon kelts).

You will need to submit evidence to confirm the size of fish present. We can then assess the need for fish screens and/or a bywash.

Fish of less than 60 cm in length are not likely to be damaged by impact with turbine blades, providing that appropriate compressible rubber bumpers are fitted, (see below).

Table S7 - Waterwheels – overshot, backshot and breastshot

Overshot, breastshot and backshot waterwheels typically use buckets to transfer the water. These usually pose little risk to fish, providing that suitable gaps exist between the buckets and the housing of the wheel.

We recommend 100 mm trash screens for traditional overshot, breastshot and backshot water wheels. However, where there is an insufficient gap to protect fish smaller aperture screens will be needed.

In all cases, take account of the species and size of fish that will have to pass the wheel and consider the risk of their being damaged and/or trapped. Where fish will be damaged or trapped, appropriate screening will be required.

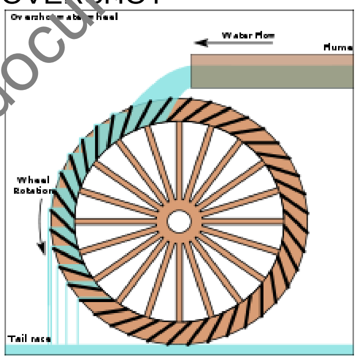
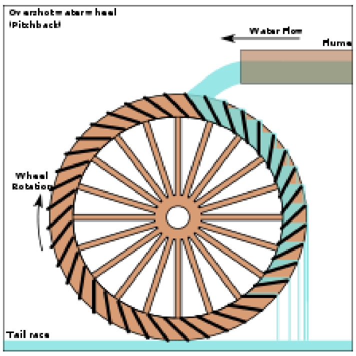
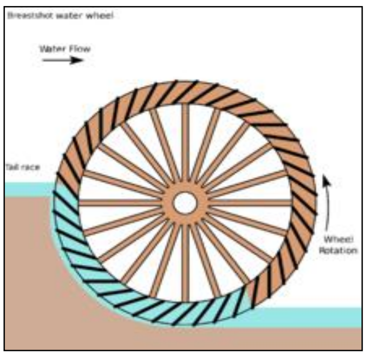
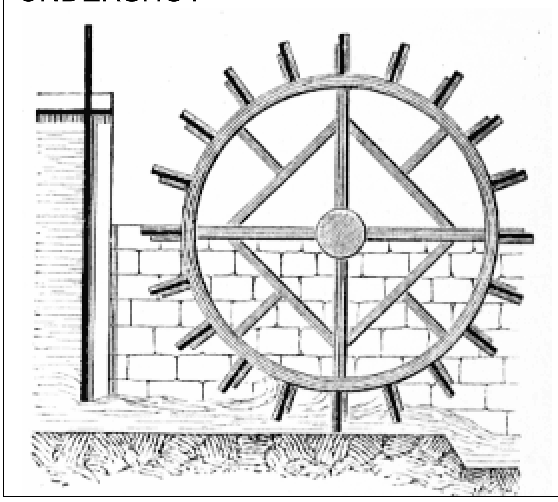
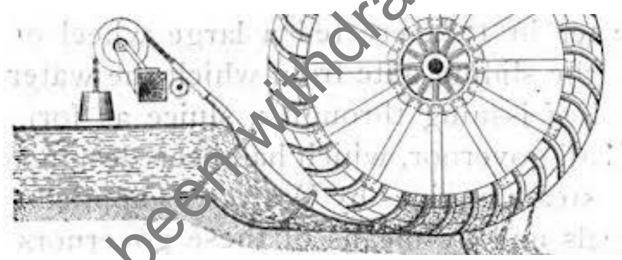
OVERSHOT	BACKSHOT	BREASTSHOT
		

Table S8 - Waterwheels – undershot and poncelet

Undershot and poncelet waterwheels are typically used where there is a very low head. The wheels (and paddles) in undershot and poncelet designs need to be a close fit in the channel to obtain good efficiency. The limited clearance around the wheels creates a significant risk of damage to fish. Screening will therefore be required. In all cases, take account of the species and size of fish that will have to pass the wheel and consider the risk of their being damaged and/or trapped. Where fish will be damaged or trapped, appropriate screening will be required.	
UNDERSHOT 	PONCELET 

Other turbine types

From time to time new technologies are proposed for hydropower generation. We will give regulatory guidance on the evidence we require before any new technology is deployed on rivers and watercourses in England and Wales. We may require the developer or promoter of the technology to carry out a risk assessment.

The risk assessment is a staged process and is designed to assess risks by building on the existing evidence base, rather than replicating previous work. Depending on the results of a desk-based assessment, we may require that further evidence is provided.

We will require the installation of fine screening if a risk assessment indicates unacceptable risk to the passage of fish.

Developers may choose to commission further evidence gathering without first carrying out a risk assessment.

We encourage developers to discuss plans with us at an early stage if considering development or use a turbine type or technology not outlined in the screening tables.

Summary of tailrace screens

Table S9 - Turbine type and default requirements for tailrace screens

Screen type	At outfall – fish screening requirements
Electric barrier	Only use these where fish cannot pass downstream through the turbines. Barriers with graduated field types are preferred. It is essential that these barriers are always in operation, even when the hydropower plant is not running. Otherwise fish may enter the turbines and be present when they re-start. There must be an externally visible indicator light, or other means of checking, so that the operator or regulator can confirm that barrier is switched on. Check the voltage field annually in the water using a suitable test device. Compare the reading to the specification, in order to ensure that electrodes are in good condition.
Physical bar screens	These should have a 40 mm spacing for salmon, or 30 mm where there are sea trout (exceptionally where many small sea trout are present 25mm screens may be required). The spacing required to protect other species should be determined on a site-by-site basis. Construct screens from wedge wire, square or oblong metal bars. Round or oval bars are more likely to gill fish.

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NA/EAD/1212/pdf/v2