#

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**Intakes and outfalls**

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Contents

[1 Purpose 3](#_Toc198205868)

[2 Introduction 3](#_Toc198205869)

[3 Intakes and outfalls 3](#_Toc198205870)

[3.1 What are intakes and outfalls 3](#_Toc198205871)

[3.2 Key parts of a watercourse and loch 3](#_Toc198205872)

[3.3 What are the potential issues with intakes and outfalls 5](#_Toc198205873)

[3.3.1 Activity specific issues 5](#_Toc198205874)

[3.3.2 Sediment at intakes 5](#_Toc198205875)

[3.3.3 Erosion around outfalls 6](#_Toc198205876)

[3.3.4 Trapping of sediment 7](#_Toc198205877)

[3.3.5 Entrapment of fish 7](#_Toc198205878)

[3.3.6 Impact to the riparian zone 8](#_Toc198205879)

[3.3.7 Risks to the Water Environment 8](#_Toc198205880)

[4 Good Practice 10](#_Toc198205881)

[4.1 Demonstrate need 11](#_Toc198205882)

[4.1.1 Reasons for carrying out the activity 12](#_Toc198205883)

[4.2 Identify and appraise options 13](#_Toc198205884)

[4.3 Justify the selected option 23](#_Toc198205885)

[4.4 Use all reasonable mitigation 24](#_Toc198205886)

[4.4.1 Location 24](#_Toc198205887)

[4.4.2 Alignment and design of Intakes 25](#_Toc198205888)

[4.4.3 Alignment of Outfalls 27](#_Toc198205889)

[4.4.4 Other Mitigation 27](#_Toc198205890)

[Disclaimer 32](#_Toc198205891)

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# 1 Purpose

This document provides information and guidance for outfalls and intakes connected to activities which are subject to authorisation by SEPA under the Environmental Authorisations (Scotland) Regulations 2018, (EASR).

# 2 Introduction

This activity guide aims to demonstrate Good Practice requirements and to help select sustainable engineering solutions that minimise harm to the water environment. This focuses on the environmental aspects that should be considered when undertaking a project. Using this document will help with the process of obtaining an authorisation for works. It is not intended as a technical design manual, and it is important to recognise that any engineering works must be designed to suit site specific conditions.

# 3 Intakes and outfalls

## 3.1 What are intakes and outfalls

Intakes and outfalls are the structures through which discharges or water passes to or from the water environment. Intakes and outfalls can be located on the bank or bed of a watercourse or loch.

The installation of both intakes and outfalls can include a number of dependant activities linked to the outfall or intake pipe opening. For example, bank reinforcement (including headwalls and wingwalls), bed reinforcement (including any apron, cascades and energy dissipation structures), and other associated infrastructure including screens etc.

For further information on other activities please see WAT-G-022 EASR Guidance: Engineering: Activity Guide: Bank Works and WAT-G-025 EASR Guidance: Engineering: Instream and In-loch structures.

## 3.2 Key parts of a watercourse and loch

Key parts and terms of a watercourse and loch are shown in Figures 1 and 2 below and explained in the Glossary.



**Figure 1** Keys parts of a watercourse



**Figure 2** Key parts of a loch

## 3.3 What are the potential issues with intakes and outfalls

### 3.3.1 Activity specific issues

#### Main impacts of intakes

* Deposition of sediment and a reduction in sediment supply to downstream reaches.
* Deposition can lead to the need for dredging.
* Entrapment of fish.
* Direct loss of bank-side (riparian) habitat.

#### Main impacts of outfalls

* Outfalls can increase erosion and lead to an increase in sediment supply to downstream reaches of rivers and lochs.
* Trapping (accumulation) of sediment.
* Entrapment of fish.
* Direct loss of bank side/riparian habitat.

### 3.3.2 Sediment at intakes

As water is abstracted through the intake, sediment is typically drawn towards the intake structure or point of diversion. Sediment may either be drawn into the intake structure or may be trapped behind it. This reduces the amount of sediment that is supplied to downstream reaches. If sediment is drawn into the intake, there is the risk of damage to the intake facility and end operation machinery (e.g. turbines, gates and valves).

As water is abstracted at the intake, the amount of water in the river is reduced. This reduces the amount of sediment that the river can carry downstream. It causes the sediment to be deposited at the intake structure and leads to a decrease in the amount of sediment that is supplied to downstream reaches.

Large amounts of sediment deposition at the intake structure can require regular removal to stop sediment being drawn into the intake and to maintain the efficiency of the abstraction. This dredging disrupts and damages habitat and can risk causing pollution by releasing finer sediment downstream.

The reduction in sediment transported downstream can lead to erosion of the bed and banks at downstream reaches. This may lead to the failure of bank-side and in-stream structures (e.g. bridges, culverts, outfalls and hard bank protection structures), and a change in flood risk.

The reduction in sediment downstream and increased erosion can damage important habitats (e.g. bank-side habitat) and habitats that depend on a supply of sediment from upstream reaches (e.g. spawning gravels, gravel bars and islands).

The quality of habitats in rivers and lochs is controlled by relationships between flow and sediment. Disturbing one can have a range of impacts on the other. It is therefore important to consider all potential impacts when choosing the best design solution for intakes.

### 3.3.3 Erosion around outfalls

Increased flows due to discharges can cause erosion or scour of the bed and bank below an outfall which increases the supply of sediment to downstream reaches of rivers and lochs.

The outfall structure itself can extend into the channel and create localised turbulent flows, leading to localised erosion or scour of the bed and bank of the river. This increased erosion also increases the supply of sediment to downstream reaches of rivers and lochs.

Rivers may also attempt to adjust to an increase in flow and sediment supply. This may lead to increased bank erosion and channel widening downstream of the outfall. The increased bank erosion can lead to more sediment being supplied to the system, leading to still further channel adjustments, thereby exacerbating the problem.

Increased amounts of sediment in rivers and lochs can smother habitats important for fish spawning, aquatic invertebrates and macrophytes.

Localised erosion around the outfall structure itself, can lead to the structure being damaged.

### 3.3.4 Trapping of sediment

Sediment may be trapped behind or in front of outfall structures, such as erosion aprons (if extending into the channel) and outfall pipes (for example pipes leading to outfalls submerged under the water), leading to localised accumulations.

Larger accumulations of sediment can affect flood risk by reducing the flood conveyance capacity of the channel and resulting in partial or full blockages of culverts and bridges.

A significant build-up of sediment around a submerged outfall may result in a partial blockage of the outlet pipe. This can result in the back up of effluent, e.g. sewage, and the inefficient operation of the outfall system.

### 3.3.5 Entrapment of fish

If appropriate screens are not in place fish can be drawn into intakes and submerged outfalls, especially small and juvenile fish. This can have a significant effect on fish migrations. In lochs, fish often follow currents to guide migration and can be attracted to intakes and outfalls instead of the loch outlet. This can also have a significant effect on fish movement and migration.

Intakes and their associated infrastructure (e.g. impoundments) may also cause a physical barrier to fish migrating upstream. Consideration of fish passage for impoundments is beyond the scope of this Guide, but this is essential for any new intake structure where impoundments are required.

Migration throughout the river catchment is essential to the survival of many species of fish. For example, salmon travel as adults from the sea up the river to spawn and then, as juveniles, migrate back downstream to the sea. Other fish such as brown trout use the whole river catchment throughout their life cycle, migrating upstream to smaller headwaters to spawn and moving downstream to feed and grow in the larger rivers where more food may be available. Other fish species that make significant migrations are sea trout, eels, sea lamprey and river lamprey.

### 3.3.6 Impact to the riparian zone

Bank-side or riparian habitat can also be lost, either through the direct removal of vegetation by the construction of an intake or outfall structure, or indirectly by exacerbating bank side erosion and resulting in bank collapse.

Riparian habitat is crucial for the proper functioning of aquatic ecosystems and provides an important habitat for many aquatic and terrestrial species. It is also an important source of food for many aquatic invertebrates.

### 3.3.7 Risks to the Water Environment

The main risks to the water environment from carrying out this activity can be grouped as follows:

#### Harm to fish

This including impacts on fish migration, spawning and fry development, loss of habitat and direct impacts such as stranding or physical damage.

Scheduling the timing of works to avoid fish spawning times and fish emergence times. Key fish species to consider include salmon and trout (normally October to May), lamprey species (normally March to July). However, these times can vary and you should contact [Fisheries Management Scotland](https://fms.scot/) if you are unsure what fish species are present or what times should be avoided.

Temporary works such as crossings, channel isolation or diversions, blasting, vibration or pile driving, sheet pilling or using artificial lighting at night can affect fish or migrating fish. You should carefully manage these works to minimise any impact and carry out fish rescues, where appropriate.

For more information see WAT-G-032 EASR Guidance: Fish Protection.

#### Physical Impacts and Pollution

Physical impacts to the bed and banks of the channel which can lead to instability resulting in increased erosion or deposition, loss of habitats and increased flood risk.

Carefully managing construction works is essential to prevent and minimise pollution from sedimentation, leaking oil from machinery and the entry of potentially polluting materials into water such as unset concrete.

Sites should be restored following works to management impacts from disturbance.

Further information on construction works and mitigation can be found in WAT-G-034 EASR Guidance: Construction works and silt/pollution mitigation.

#### Invasive Non-Native Species

Any Invasive Non-Native Species (INNS) present in or adjacent to site could have the potential to spread. You should identify and plan works with adequate biosecurity measures in place to prevent any spread of INNS. Further guidance can be found in EASR-G-001 EASR Guidance: Invasive non-native species (INNS).

#### Protected areas and species

You should identify any Protected areas (eg SSSI, SAC, SPA) in or adjacent to site and consider any impacts from the works onProtected species such as freshwater pearl mussels and otter. You should contact [NatureScot](https://www.nature.scot/) where your activity is in a Protected area or may impact protected species. For further information see WAT-G-008 EASR Guidance: Assessment of impact on Protected areas from inland water activities.

#### Impacts to other users of the water environment

There could be potential impacts on other water users such as water supplies, fishing, water sports.

These risks to the water environment will vary according to:

* The type and design of the engineering activity.
* The timing of the works.
* The working methods and mitigation.
* The reinstatement methods.

# 4 Good Practice

All intakes and outfalls should follow the principles of good practice to ensure sustainable design and limit environmental harm to our rivers and lochs.

Good Practice is achieved when the chosen option serves a demonstrated need, while minimising ecological harm, at a cost that is proportionate. It ensures that any negative environmental impacts are proportionate to the environmental, social and economic benefits the activity may bring.

We will carry out a ‘Good Practice Test’ on all Engineering Permit applications to assess whether the activities proposed in any Permit application will meet Good Practice. All such applications must meet Good Practice to be granted. To meet Good Practice you should follow the steps outlined in the Good practice summary below and in the subsequent sections.

For further information please see WAT-G-030 EASR Guidance: Good Practice test for Engineering permits.

**Good Practice Summary**

To meet Good Practice you must:

1. [**Demonstrate need**](#_2._Demonstrate_Need)
* State the reasons for carrying out the activity and the benefits it will bring.
* Identify and understand the problem or need.
1. [**Identify and appraise options**](#_Identify_and_Appraise)

Use sustainable river management principles to:

* Identify a number of options (minimum of three, including do nothing).
* Carry out an options appraisal.
1. [**Justify the selected option**](#_Justify_your_selected)
* State why it represents the best practical environmental option.
1. [**Use all reasonable mitigation**](#_Use_all_reasonable)
* State the mitigation measures you propose to minimise impacts.
* Submit method statement(s) detailing how the works will be carried out.

## 4.1 Demonstrate need

Before undertaking engineering works there should be a clear and justifiable reason or need. You should also have a good understanding of the causes (including the underlying cause), and scale of the problem being addressed.

You must:

* Specify the reasons for carrying out the activity and the benefits it will bring.
* Identify and understand the problem or need.

### 4.1.1 Reasons for carrying out the activity

You must provide us with:

* Clear reasons why you wish to carry out the activity.
* The underlying nature or cause of the problem (where relevant) or need being addressed.

In general, a new abstraction or discharge will require a new intake or outfall structure, so demonstrating a need for a new structure is relatively straightforward. However, options for using existing intakes and outfalls should always be explored and discussed with SEPA.

After 1 April 2007, surface water drainage systems for new developments must be treated by a sustainable drainage (SUD) system. A discharge from a SUD system to a river or loch may not always need a new outfall structure, particularly if the discharge is via a constructed channel/swale and replicates a natural drainage system. The objective of a fully sustainable drainage system for surface water should be to dispense with an outfall structure altogether.

The following questions should be considered before deciding if a new intake is necessary:

* **Am I using my water efficiently?**

Ensure that existing water is used efficiently before increasing volumes abstracted or creating new sources/intake structures. Contact SEPA for more information on the efficient use of water.

* **Can I use an existing abstraction point?**

It may be possible to take water from an existing abstraction point. But before increasing abstraction volumes, contact SEPA to discuss potential impacts on the water environment and implications for existing abstraction authorisations.

## 4.2 Identify and appraise options

It is a basic principle of good practice that when addressing any watercourse engineering problem, or need, that several options are identified and evaluated (considering the advantages and disadvantages) to determine the best solution. Each option should be fully evaluated in an options appraisal to determine the best practical environmental option for the situation.

This guide identifies five generic types of intake and four generic types of outfall, which are examined in more detail below.

The type of intake or outfall will largely depend on the abstraction properties or type of discharge and site conditions. Many different designs will fall into the generic types of intake and outfall identified. This document attempts to guide you through some of the key points that should be considered for each type of structure.

### 4.2.1 Types of intake

#### Bank-side with no in-stream structure

Intake structure built into the bank with no flow deflection or fore bay structures.

LOW IMPACT– please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any water abstracted.

Suitable for:

* Abstraction of relatively low volumes of water.
* Lowland environments.

Not suitable for:

* Environments where there are large fluctuations in water level as is often the case in upland environments.

Key points:

* No or limited in-stream works required for construction, thus reducing impacts.
* Choosing a location where the water is deepest will allow greater submergence of the intake

Considerations:

* Abstraction is dependant upon the water level; very low water levels can be a problem.

#### Bank-side with in-stream structure

Intake structure built into the bank with a flow deflection structure or fore bay used to divert flow towards the intake and/or used to trap sediment.

MINIMAL/MODERATE IMPACT– please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any water abstracted.

Suitable for:

* Situations where sediment ingress may be a concern.
* Straight sections of a river to help sweep flow past the intake.

Not suitable for:

* Streams with a large fluctuation in flow, e.g. upland environments;
* High energy environments (i.e. most upland streams). Placing in-stream structures in such an environment can lead to significant erosion and scour of the bed and banks. The structure itself also risks failure in such a high energy environment.

Key points:

* Fore bays can be used to help trap sediment in front of the main inlet structure. The first sill into the fore bay will stop large bed load from entering the intake. The second sill at the end of the fore bay will stop finer sediment from entering the head race and conveyance system.
* Flow deflectors placed in straight channels can be used to sweep the flow towards the intake and carry bed load away from the intake. The angle to the main channel flow and position of the deflector are crucial as they determine the direction and strength of flow past the intake.

Considerations:

* Any deflector structure must be positioned correctly as there is a risk it could lead to erosion of the bed and bank downstream of the intake. The position and angle of the deflector is likely to be site-specific and specialist advice from hydrologists and geomorphologists should be sought during the design stage.
* If flow is diverted towards the intake, the increased flow can reduce the efficiency of the fish screens.

#### Bank-side with weir

Intake structure built into the bank drawing water from a storage area behind a weir.

HIGH IMPACT– please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any water abstracted.

Suitable for:

* Most stream types.
* Streams with variable flow regime or where a substantial portion of the flow is to be diverted.

Not suitable for:

* Rivers with high sediment loads – the storage area in front of the weir can fill up well before the design life is reached if used in rivers with a high sediment load, and result in high maintenance costs (need for regular sediment removal).

Key points:

* Suitable for wide variety of stream types.

Considerations:

* High risk of sediment accumulation behind weir and may require removal.
* May be a barrier to fish passage. Will need to consider fish passes and screens (see [section 4.4.4.2](#_4.4.4.2_Screens)).

#### Bed intake

Intake structure is buried within the bed or sunk within a small weir and spans the width of the channel. Inlet feature is flush with the substrate or raised to form a small weir.

There are two generic types:

* Bed intake – sometimes called ‘Tyrolean’ type. Can be built directly into the bed. Bars across the top of the structure stop boulders, though not fine sediment, from entering the intake chamber.
* Coanda screen intake built into a small weir that spans the channel. Employs the ‘Coanda screen affect’ allowing water to be abstracted efficiently without the ingress of sediment. Can exclude fine sediment.

The ‘Coanda’ type intake has a screen with a wedge wire panel installed on the sloping downstream face of a weir. This screen allows water to pass through while allowing fine sediment, larger sediment, debris and fish and excess water to flow safely downstream. Water flows through the wire mesh screen to the collection system at the base.

MODERATE/HIGH IMPACT(where impoundment involved) – please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any water abstracted.

Suitable for:

* Upland streams.
* Straight stream sections.
* Streams with high coarse bed load (e.g. boulders and cobbles). ‘Coanda’ types can exclude finer sediments.

Not suitable for:

* Streams with high suspended load or fine bed load component (e.g. silt and sand).
* Lochs and lowland rivers.

Key points:

* The design of bed intakes allows larger sediments (boulders/cobbles/gravel) to be carried downstream of the obstruction when flows are sufficient.
* The ‘Coanda’ type also allows finer sediments to be carried downstream excluding them from the intake.
* Can operate in highly variable flow regimes.
* Limited maintenance required.
* Low maintenance, self-cleaning screen – no moving parts and no power required to remove debris and sediment.

Considerations:

* ‘Tyrolean’ type may require a removal system for fine sediments.
* ‘Coanda’ type intakes need a weir of sufficient height for the screen to operate properly.
* Need to consider fish passage with a ‘Coanda’ weir.

#### Submerged

Intake structure on the bottom of the bed submerged under the water. Structure does not span the river. Submerged intakes differ from a bed intake in that they abstract water from a single point within a river or loch, as opposed to water abstraction across the entire width of the channel. The intake structure may:

* Rest on top of the river or loch bed, submerged under the water, with the inlet feature raised into the water column; be buried under the bed of the river or loch, with the inlet feature raised into the water column.
* Be associated with a tower structure raised into the water column with multiple inlets.

MODERATE IMPACT– please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any water abstracted.

Suitable for:

* Submerged intakes may be suitable for both lochs and rivers.
* Deep environments (e.g. lochs and deep rivers) with high amounts of mobile sediment.

Key points:

* Tower intakes allow water to be withdrawn from various depths, improving the quality of water abstracted and minimising the prospect of sediment intake if sediment builds up around the base.
* Operate within a large variation of water level.
* Can locate the structure off-shore to minimise the exposure of juvenile fish to the intake.
* Low impact on the bank and riparian zone.

Considerations:

* Adequate depth required.
* May lead to localised erosion.
* The structure should not be located in areas that are likely to leave the inlet exposed during dry periods.

### **4.2.2 Types of outfall**

#### Submerged

Submerged outfalls are suitable for discharges that require initial dilution and also for high volume/velocity discharges, this includes:

* Sewage effluent.
* Industrial effluent.
* Cooling water.
* Hydro-scheme discharge.

LOW IMPACT- please note this is the impact on the physical habitat (morphology) of the river and doesnot take into account the impact of any discharge on water quality.

Key points:

* Outfall soffit should be below low water level.
* Outfall pipe should not protrude beyond the bank line.
* Pipe should be buried beneath the bank and native bank vegetation should be re-established.
* Safe access should be provided.
* Sample chamber should be provided (if necessary).

Considerations:

* Adequate river depth is required.
* Location and alignment should be carefully considered (see sections [4.4.1](#_4.4.1_Location) and [4.4.3](#_4.4.3_Alignment_of)).
* Type and extent of erosion protection required should be carefully considered (see [section 4.4.4.1](#_4.4.4.1_Erosion_Control)). Underwater erosion protection may be required and should be laid below natural bed level.
* Maintenance inspections should be planned.

#### Partially submerged

Partially submerged outfalls are suitable for clean water discharges often of high velocity such as:

* Hydro-scheme discharge.
* Water treatment works discharge.

LOW IMPACT- please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any discharge on water quality.

Key points:

* Outfall pipe should not protrude beyond the bank line.
* Pipe should be buried beneath the bank and native bank vegetation should be re-established.
* Safe access should be provided.
* Sample chamber should be provided (if necessary).

Considerations:

* Location and alignment should be carefully considered (see sections [4.4.1](#_4.4.1_Location) and [4.4.3](#_4.4.3_Alignment_of)).
* Type and extent of erosion protection required should be carefully considered (see [section 4.4.4.1](#_4.4.4.1_Erosion_Control)).
* Maintenance inspections should be planned.

#### Bank side

Bank side outfalls should only be used where there is inadequate water depth for a submerged outfall or set back outfall.

HIGH IMPACT- please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any discharge on water quality.

Key Points:

* Should only be used where there is inadequate water depth for a submerged outfall or set back outfall.
* Mitred headwall is flush with bank allowing for easy maintenance (e.g. mowing) and reducing trip hazard.
* No part of the outfall structure should protrude beyond the line of the bank, this includes headwalls, wingwalls and protection aprons.
* Should have silt apron to aid silt removal / raised inlet to avoid silt build up in pipe.
* Safe access should be provided.
* Sample chamber should be provided (if necessary).
* Native bank vegetation should be re-established after construction.

Considerations:

* Location and alignment should be carefully considered (see sections [4.4.1](#_4.4.1_Location) and [4.4.3](#_4.4.3_Alignment_of)).
* Type and extent of erosion protection required should be carefully considered (see [section 4.4.4.1](#_4.4.4.1_Erosion_Control)).
* Maintenance inspections should be planned.

#### Set back

Setback outfalls are suitable for low velocity clean water discharges such as discharges from a sustainable drainage (SUD) system. A SUD system mimics natural drainage systems that aim to reduce the impacts of flooding and pollution that were associated with some more traditional types of drainage systems. A SUD system aims to reduce impacts on water quantity, water quality, amenity and biodiversity.

The quantityof water released is restricted to the rate at which water would leave the site before development took place. This is the ‘greenfield rate’ of run-off.

The quality of run-off from SUDS systems is managed by removing silt and pollution ‘at source’ and designing a ‘management train’ too improve the quality of water in stages depending on the risk of pollution. The ‘management train’ is usually expressed as a design sequence: prevention – source control – site control – regional control with a series of ‘treatment stages’ or SUDS features used to ensure pollution is adequately controlled.

The amenity and biodiversityaspect of drainage is provided by maximising visual, social, environmental and wildlife opportunities.

For further information on SUDS please see [Susdrain - The community for sustainable drainage](https://www.susdrain.org/).

* Wherever possible the outfall from a SUDS system should be an open low flow route e.g. swale, open channel, or linear wetland. Where water flows directly from this type of route then it is unlikely to block – but consideration should be made to making the outfall location visible for any future maintenance requirements.
* Where the outlet from a SUDS system is through a pipe it should finish some distance from the entry to the watercourse to provide a surface discharge route and semi-natural entry e.g. it should discharge to a set back channel or wetland. Where water is discharged through a grille or pipe then consideration should be given to blockage by debris. Where the end of the pipe is open then consider risk of blockage e.g. by children, debris or vegetation (see section [4.4.4.2](#_4.4.4.2_Screens) other mitigation: screens).

LOW IMPACT- please note this is the impact on the physical habitat (morphology) of the river and does not take into account the impact of any discharge on water quality.

Key Points:

* Outfall is setback from bank side and water edge.
* Erosion protection should be minimal as low velocities involved.
* Bank side (riparian) and wetland can be planted with local native species so reducing the impact and maximising biodiversity.
* Swale / constructed channel bank profile should have a maximum slope of 1 in 3 for management and health and safety considerations.
* Safe access should be provided.
* Sample chamber should be provided (if necessary).

Considerations:

* Location and alignment of swale / constructed cannel should be carefully considered (see sections [4.4.1](#_4.4.1_Location) and [4.4.3](#_4.4.3_Alignment_of)).
* Need to ensure outfall location is kept clear of vegetation to ensure easy inspection.
* Outfall and wetland / channel maintenance should be planned.

## 4.3 Justify the selected option

After evaluating all the alternatives, the best practical and environmental option, with proportionate costs, should be chosen and justification provided. This does not always mean adopting a lowest impact engineering approach or adopting the cheapest solution. The best practical environmental option means choosing the approach that effectively addresses the problem or need and minimises negative environmental impact as far as practical. Proportionate costs are those that correspond to the level of environmental harm being minimised or the environmental benefits that the option provides. Large absolute cost in itself does not constitute disproportionate cost.

For example, incurring significant costs to prevent significant environmental harm or achieve significant environmental benefits e.g. safeguarding protected species and designated sites, is likely to be considered proportionate. But incurring significant costs for minor environmental benefits would likely to be considered disproportionate.

## 4.4 Use all reasonable mitigation

Successful adoption of good practice requires selection of a suitable option followed by appropriate design and implementation. This section will provide guidance on design and implementation considerations and at gives general principles that can be applied to all types of intake and outfall.

### 4.4.1 Location

Choosing an appropriate location for the intake or outfall is the first step in reducing the risk of sediment deposition or erosion and scour. This will help reduce the risk of damage to the structure, helps reduce the amount of erosion protection that may be required, and reduce the need for dredging. The location of intake and outfall structures should:

* Be on a stable bank with no evident signs of erosion or undercutting.
* Not be located in areas of sediment deposition.

#### Location in rivers

Structures should be located on straight sections of rivers where there is less risk of erosion. The outside of meander bends where erosion naturally occurs should be avoided. The inside of bends, where sediment tends to accumulate, should also be avoided.

There are several different types of bank erosion, for further information on the different types of bank erosion and different management solutions see WAT-G-022 EASR Guidance: Engineering: Activity Guide: Bank Works.

#### Location in Lochs

* Do not locate intakes and outfalls in areas where sediment is depositing.
* Locate intakes and outfalls on a stable bank where there are no evident signs of erosion.
* Pipe soffit should be below loch low water level.
* Avoid important habitats.

Erosion occurs on the banks of lochs as well rivers. Areas where erosion is evident in lochs, such as wave washed shores should be avoided. Pipe soffit (top of pipe) should be located below low summer water levels so it is not exposed during dry periods.

Key habitats in lochs should also be avoided such as:

* Macrophyte beds.
* Shallow littoral areas and embayments (habitat for some juvenile fish species).
* Wave washed shores.
* Inlets and out lets (fish spawning areas).

### 4.4.2 Alignment and design of Intakes

Once you have mitigated impacts by locating the intake appropriately, the next step is to minimise impacts through careful alignment and design of the intake.

#### Alignment

The alignment of the intake can affect the localised scour and deposition of sediment around the intake structure. It may also affect the performance of fish screens and trash racks and affect the potential for ice blockages and subsequent damage in cold climates. Alignment issues are important for rivers, but less relevant to lochs. The alignment of an intake will also depend on the type of intake proposed, however some general principles are discussed here.

A good alignment can:

* Minimise the change in flow direction between the source body and diverted flow, thus helping to reduce sediment ingress, deposition and erosion around the intake.
* Allow for a sweeping and self-cleaning passage of sediment, trash and ice past the intake in the downstream direction.

In rivers, the intake should be aligned so that the diversion angle between the main flow in the river and the intake entrance is 10 to 45 degrees; the intake should not be aligned at an angle of 90 degrees. An angle of 10 to 45 degrees will help to minimise the change in flow direction between the source body and the diverted flow, thus helping in turn to:

* Reduce localised erosion and scouring of the bed and bank.
* Reduce sediment deposition near the front of the intake.
* Allow for a sweeping and self-cleaning passage of sediment, trash and ice past the intake.

#### Intake sill height

Locating the intake in deep water to allow for a high sill freeboard depth (height between the bed and the inlet pipe/feature) can reduce the risk of sediment entering the intake structure.

#### Flushing structures

Where sediment does accumulate in the intake structure or behind a weir, flushing structures can be built into the intake to periodically flush out sediment during high flows.

Sluices and flushing canals can be incorporated into the intake structure itself or be incorporated into a weir.

Careful consideration should be given to the time of year that flushing is carried out to avoid pollution of downstream reaches with fine sediments.

Flushing should not be carried out during fish spawning times or in the period between spawning and the emergence of juvenile fish. You should contact [Fisheries Management Scotland](https://fms.scot/) for more information on appropriate timing.

Flushing should be carried out under high flows to ensure that the sediments are carried downstream.

### 4.4.3 Alignment of Outfalls

Correct alignment and design of the outfall can also help reduce scour around the structure and erosion of the bed and banks of rivers and lochs. This will also help reduce the amount of erosion protection required. If incorrectly aligned, the outfall can cause turbulence in the water and exacerbate scouring of the bed and banks and could lead to the structure itself being damaged.

The discharge should be in line with the flow of the river as this helps to reduce turbulence and erosion.

No part of the outfall structure should protrude beyond the line of the bank, this includes headwalls, wingwalls and protection aprons. This helps to reduce turbulence and localised scour.

Outfall structures protruding beyond the bank can lead to increased erosion. The outfall structure can act as a flow deflector and deflect flow toward the bank downstream leading to increased erosion and the requirement for further erosion protection.

The height between the outfall pipe and the river or loch bed should be minimised to help reduce erosion. This can be achieved by:

* Laying the pipe as low as is practically possible.
* If the banks are particularly high, a properly designed drop pipe structure can be used to move the water to a lower height. They also have the advantage of acting as an energy dissipater (reducing the discharge velocity) if the lower outlet pipe is placed a few inches off the bottom of the drop structure.

### 4.4.4 Other Mitigation

After impacts have been minimised by selection of an appropriate location and careful consideration of the alignment and design of the intake or outfall, other mitigation measures can be considered that can be used to reduce the impact of intakes and outfalls on the morphology, hydrology and aquatic life of rivers and lochs.

#### 4.4.4.1 Erosion Control

The potential for localised erosion or scour around the intake or outfall structure should be minimised through careful consideration of the location and design of the structure as described above. Once this has been done then further requirements for erosion protection should be considered.

Low velocity discharges (such as discharges from SUDS) or abstractions in low energy environments are unlikely to require any erosion protection. Where erosion protection is necessary, softer techniques/measures may be appropriate. Whereas high velocity discharges, such as discharges from hydropower schemes or structures in high energy environments, have a high risk of erosion and are likely to require harder techniques to control erosion.

#### Soft/low impact Erosion Protection

Soft erosion protection has less impact on the bank side (riparian) habitat and biodiversity. In some urban areas it can also improve the riparian habitat and biodiversity. Soft erosion protection is most suited to low energy environments. In the case of small structures in low energy environments, no erosion protection may be necessary. In these cases it should be ensured that the bank is restored after the structure has been constructed and the vegetation is re-established with appropriate native species. A large range of options are possible including:

* Low maintenance tough grasses and herbs (use locally sourced native vegetation).
* Bio-degradable geo-textile matting and prefabricated planting pockets and vegetated plots. Geo-textile matting needs to be firmly secured to the bank to stop slippage and washout during high flows.

#### Hard/high impact Erosion Protection

Protection may be required in high energy / active environments such as stone rip-rap. The extent of erosion protection should be minimised and based on site specific requirements.

Natural features such as bedrock lined channels / pools are common in high energy upland areas. As these environments are very stable and not prone to erosion then little or no erosion protection may be necessary. These features can be chosen as an appropriate location for an outfall to reduce the need for erosion protection.

Discharges with high velocities may require energy dissipaters such as stilling basins. Stilling basins must be appropriately designed to suit the discharge and site conditions.

For further information on bank protection techniques see WAT-G-022 EASR Guidance: Engineering: Activity Guide: Bank Works and WAT-G-029 Engineering: Sustainable Bank works.

#### 4.4.4.2 Screens

Screens maybe required to:

* Stop fish and mammals (e.g. otters) from entering the discharge or abstraction system.
* Stop debris from entering and blocking the discharge or abstraction system.
* Health and safety reasons e.g. stop vandalism and to stop children from entering pipes.

The design of the screen depends primarily on the purpose. For example, if it is to stop the migrating fish from entering the outfall system, then the mesh size or spacing between the bars has to be appropriate for the size and age of the target species. Screens to stop vandalism or the entry of children into outfall systems on the other hand need to be strong enough so as to ensure the bars cannot be bent or prised from the frame or mounting structure.

#### Fish Screens

Migrating fish are often attracted to the fast flowing and turbulent water from higher volume discharges or abstractions, significantly affecting upstream migrations. Screens are therefore required to stop fish entering the discharge system. The Local District Salmon Fishery Board should be contacted if this is a concern. Below are given some general principles on screens further information can be found in the Institute of Fisheries Management [Fish Pass Manual](https://ifm.org.uk/ifm-training/ifm-fishery-guidance/).

It is crucial to ensure that the appropriate type of fish screen is fitted to the structure. There are many different types, dependant primarily on the fish species targeted, its life stage (i.e. juvenile, adult etc) and the water velocity near the screen (commonly referred to as approach velocity).

Most fish screens require regular cleaning and maintenance to ensure that they operate at full efficiency.

#### Trash / Debris Screens

Screens to prevent debris from blocking the intake or outfall should be angled at 45 degrees. This reduces the risk of debris building up at the screens and causing a blockage itself.

#### Security/safety and mammal screens

Screens may be required on structure to prevent ingress by individuals. The design of these screens may mean that aperture or spacing between bars is restricted. This can have implication for fish and sediment movement through the structure and as such some further consideration may be required.

#### Dual apertures / Bypass facility

Screens could be fitted with dual apertures such that larger spacing is afforded below water level for fish and sediment movement passed screen and smaller spacing above water level for health and safety reasons. Bypass facilities could also be provided in locations sensitive to flooding where if screens become rapidly blocked there is an alternative route for flows to pass forward.

#### Maintenance

Screens should be maintained in order to ensure that they are operating effectively, this includes removal of debris caught up in screen apertures. Good housekeeping will ensure that screen and other surrounding infrastructure or banks are not damaged through build-up of debris and sediment which may result in scour or flooding due to restricted flows as well as ensuring fish passage through the structure.

#### 4.4.4.3 Flap Valves

Flap valves are primarily used on outfalls to prevent backflow, i.e. prevent water from backing up into the pipe network during periods of high flow.

There are many different types, sizes and strengths of flap valves, and it is important to choose the one that is most appropriate for the outfall system. They can, if not appropriate for the system, result in inefficient discharge of effluent from the outfall.

#### Key Points:

* Flap valves need to be robust to withstand damage during high flows.
* Require regular maintenance and checking, the valve should be kept clear of debris.
* Blockages increase the risk of damage and leave the outfall open to access from otters and fish, which can then become trapped within the outfall system.
* The flap valve should be positioned to allow for easy access for routine maintenance and checking.

#### 4.4.4.4 Anti Seepage Collar

An anti-seepage collar is required to stop water from tracking along the pipe and causing bank erosion at the point where the pipe emerges from the bank. It may be required where the soils are unstable and there is significant overland and sub-surface flow.

#### Key Points:

* A clay barrier can form a natural anti-seepage barrier.
* The anti-seepage collar should extend into solid ground.

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