WFD111 (2a) Coarse resolution rapid-assessment methodology to assess obstacles to fish migration

Field manual
level A assessment

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Foreword

The method has been developed to help prioritise the removal or mitigation of man-made in-river structures that impede the migration of fish populations. It has been designed to provide a procedure for rapidly assessing at a coarse level the likely passability of obstacles; the procedure is consistently applicable, it gives results that are easily auditable, and it does not rely heavily on expert judgement, which can be highly subjective and of varying accuracy depending on the degrees of experience of the surveyors. Where expert judgment is utilised, it is clearly recorded. The method is appropriate for the full range of obstacles and species encountered in the UK, and can be used to assess natural obstacles as well as man-made structures.

The criteria for determining passability scores are based on published data describing the swimming and leaping abilities of different fish species. The method has been tested as far as possible against real fish population data. However, data at the required spatial and temporal resolution do not generally exist at present, particularly for non-salmonid species, and so extensive validation of the method has not been possible. Thus the scores produced by the method should be taken as indicative, rather than as a definitive statement of the passability of an obstacle.

Where the use of the method suggests that an obstacle is of particular concern or its impact on fish migration is uncertain but potentially significant, it may be necessary to perform more detailed investigations (such as hydraulic modelling, targeted electro-fishing surveys or telemetry studies) in order to help further decision-making and to predict the effects of barrier removal or mitigation.

A number of individuals have provided advice to SNIFFER during the development of the method, but the method and other project outputs do not necessarily reflect the final or policy positions of these individuals or their organisations.

Glossary of terms used

Bankfull conditions: the level of flow in a channel where the water is just about to overtop the banks.

Climbing substrate: applicable to juvenile eels. Any wetted roughened substrate such as mosses, rough rock or vegetation that can be used by eels to climb up vertical or near vertical surfaces.

Current conditions: the water flow conditions at the time of the survey.

Downstream migration (DS): The passive movement downstream of fish dictated by flow conditions in the channel, as opposed to active swimming abilities.

Effective pool depth: the depth of the water at the location in the downstream pool from which ascending fish are considered most likely to launch from, if attempting to cross the obstacle.

Effective resting locations: areas in the downstream vicinity of the obstacle where reduced water velocity and low turbulence, combined with increased water depth, provide refuge for fish from the channel flow. This enables fish time to recover between passage attempts.

High flows: refers to a time when flows are elevated from the current conditions. Surveyors are required to estimate if the high flow situation would lead to an improvement or reduction in passability for fish species.

Hydraulic head: the difference in water level between the crest and the foot of the obstacle structure. Measured from water surface to water surface.

Inlet/crest of structure: the highest submerged point of a riverine obstacle where the majority of the water flow is focused. Often associated with a notch or localised area of increased water depth at man-made structures.

Lip: these are distinguishable additional features on an obstacle < 0.10m in height that clearly deflect water off the main surface of the structure. Lips are often placed at the crest or foot of a riverine obstacle that acts to divert water off a surface. Lips can cause difficulties for fish passage by de-watering sections of otherwise passable sloping surfaces.

Mid-point of structure: the position midway between the structure crest and foot, with measurements only applicable for structures that present a slope or steps.

Outlet/foot of structure: the downstream edge of the riverine structure, usually at the point immediately before the downstream pool begins. Where man-made structures are "perched" on bedrock, the point should be taken where bedrock enters the downstream pool. Measurements here are only applicable for structures that present a slope or steps.

Passive migration: movement conducted passively using the water flow to displace and transport in a downstream direction. Often considered to be the predominant mode of downstream migration for many riverine fish species.

Passability: the extent that fish passage is possible across the obstacle. Scored from 1.0 = no obstacle, partial low impact obstacle = 0.6, partial high impact obstacle = 0.3 and complete obstacle = 0.0.

Standing wave: a free-standing wave feature associated with the return of water to the surface after being forced down by increased flow or a height change. Waves can take many forms and sizes but all exhibit a noticeable localised increase in water surface height. Standing waves can create problems for fish passage by causing them to become disoriented and water velocities can exceed swimming capacity.

Transect: a straight line drawn perpendicular to the direction of water flow from waters edge to waters edge across a riverine obstacle structure, along which measurement of water velocity and depth are taken.

Transversal section: a portion of a riverine structure used in the assessment of passability at riverine obstacles. When viewed from downstream, a transversal section is distinguished as having water velocity and depth conditions remaining similar across its' width. A transversal section can consist of several features longitudinally (i.e. a vertical jump and then a swim feature for fish), but generally provides a possible direct route for fish passage across the structure.

Turbulence: entrained air and chaotic flows associated with high water velocities and plunging flows at riverine obstacles. Turbulence can create difficulties for fish due to disorientation and impeding swimming ability.

Upstream migration (US): the active movement upstream of fish moving against the direction of water flow.

List of abbreviations

AE	Adult eel
AG	Adult grayling
AL	Adult lamprey species
AS	Adult Atlantic salmon
AT	Adult trout (brown and sea trout)
C	Cyprinid species
DS	Downstream
H/M/L	High, medium or low
JE	Juvenile eel
JL	Juvenile lamprey species
JS	Juvenile salmonid species
s	Second
m/s	Metres per second
US	Upstream
TS	Transversal section
WFD	Water Framework Directive

Section 1 Survey site details

This section provides the basic location information for the obstacle and should be completed for every survey, even if the flow conditions at the time the survey is taken prevent any further information being collected.

Site reference number

Enter a unique site number. Use codes for catchment, river, tributary, and number obstacles, starting from the location closest to the head of tide.

For example: Muckle Burn, tributary of the Allan Water, tributary of the River Forth in Central Scotland. The first obstacle encountered upstream from the confluence would be coded as FOR/ALL/MUC/01. The second obstacle upstream would be FOR/ALL/MUC/02.

WB ID and name

WFD water body identification and name. Leave blank if unknown.

Date/time

Date and time of survey. Use standard nomenclature, e.g. 15/03/2010 for 15th March 2010, and 24hr clock.

Surveyor name

Surveys must be conducted in pairs for health and safety reasons. Enter the full name of field operatives and the organisation they work for.

River/stream name

Local name of watercourse within which the structure is located.

Tributary to

The name of the main river to which the surveyed river/stream is a tributary.

GPS co-ordinates

Use a hand-held GPS to obtain National Grid 10 figure reference. If use of a GPS is not possible (e.g. due to tree cover) then use a map to provide a six figure grid reference for the location. It is important to ensure that the GPS unit being used is correctly calibrated. Surveyors should note the co-ordinates recorded as either UK, NI grid or as X,Y.

Photos

Digital photographic reference is required to aid interpretation of the data. Take a minimum of three photos of each obstacle from a safe position downstream looking upstream to the obstacle (photo 1), from side elevation (photo 2), and from a safe position upstream looking downstream to the obstacle (photo 3).

IMPORTANT: Before surveyors enter the channel to take photographs and undertake measurement, all footwear and equipment must be properly disinfected to minimize the risk of transfer of pathogens between catchments. Basic biosecurity precautions must be carried out to protect freshwater resources. For further information on biosecurity precautions contact Marine Scotland or the relevant local fisheries organisation.



Plate 1: (1) Looking upstream (2) Side elevation (3) Looking downstream

Ensure that a ranging pole or alternative standard scaling instrument is clearly visible in each photograph to enable the size of individual features to be considered and compared. Additional photos of specific features of interest should be taken, e.g. if there is a fish pass facility, or areas of significant erosion and structural damage.

Each photograph taken must be given a unique reference number corresponding to your site code. Record this from the digital camera.

IMPORTANT: It is essential for the assessment that a minimum of three photos are recorded for each site and that at least one is taken from a position downstream.

Ownership

Who is responsible for the structure (if this is known)?

Access notes

It is important to record any access issues relating to the site, e.g. if it is only accessible from the left bank or any other information pertinent to safe access. This should be offered for use as advisory notes for future surveyors.

Antecedent conditions

For surveyors to be able to assess the flow conditions at the obstacle on the day of survey, it is important to consider the weather conditions in the days preceding the survey. Surveyors should estimate the precipitation in the following way:

The antecedent conditions are assessed on a scale of 1 – 5, where:

1 = Heavy rainfall for past week;
2 = Heavy rainfall within past two to three days;
3 = Light rain/drizzle within past two to three days;
4 = No rain within past two to three days;
5 = No rain within past week.

Flow conditions

Estimate the present state of the waterway. Record flow conditions as:

Bankfull = water level at point where banks are about to be overtopped.
Elevated = water flows appear to be elevated but within normal limits for the specific water channel.
Summer low levels = flow level is minimal (typical of extended dry periods in summer, but can occur at any time of year). Exposed mid-channel bars and significant portions of the streambed are dry.

Flow conditions can significantly influence obstacle passability to fish movement. Flow influences water depth over the obstacle, the velocity, depth in any pool downstream, the turbulence, and is related to changes in water temperature and chemistry. All of these can affect fish behaviour and success of a passage attempt. The actual flow conditions that favour the passage of one species/guild may provide unfavourable conditions for another.

The recommendation is to conduct the initial assessment of the structure under low flow conditions. Surveying at low flow conditions will enable the surveyors to assess the structure under the most severe conditions for fish passage and will encourage comparability between the recorded scores. Low flows are not restricted to the summer months and may also occur during the normal spawning migration periods for certain species of interest, and consequently restrict fish access. Low flows will also maximise the chance that most of the data can be collected by measurement and not estimation.

It is recognised that assessments carried out at low flows may not accurately reflect the conditions under which passage of certain species may preferentially be attempted (i.e. many adult salmonids). Therefore, the assumption is that the resulting passability scores for adult salmonids will be an underestimate of overall passability of the obstacle. This limitation is accepted, as the benefits of conducting the initial survey at low summer level are considered to outweigh this disadvantage. The migrations of other species and guilds such as juvenile salmonids, eels and lampreys can and do occur at low flows, so scores taken at low level may provide a truer reflection of the current status of the obstacle for these species/guilds. Further assessment may be advised at certain locations under a range of flow conditions.

It is recognised that it may be difficult to avoid surveying at times when conditions are sub-optimal. Under these circumstances the field survey form should be completed where possible and estimations entered where necessary, without compromising surveyors' health and safety.

IMPORTANT: For the purposes of obtaining useful and comparable information across a range of fish species/guilds, it is recommended that the Level A assessment is (in the first instance) carried out at or very close to the SUMMER LOW LEVEL. This will maximise the opportunity for surveyors to safely collect measurements at the locations.

Adverse conditions affecting site survey

Record adverse conditions that may impact the accuracy of the measurements or estimates recorded (e.g. high winds creating a rippled surface, or turbid water obscuring view).

Section 2 Structure of concern

Fish passage efficiency across an obstacle is influenced by a number of physical attributes that in turn influence the depth and velocity of water. The vertical height, the length of the structure, the gradient and material all influence the type of obstacle that is formed. On the basis of the challenges presented to fish, obstacles can broadly be classified into **jump, swim or depth** obstacles, relating to the limit placed on fish swimming ability by vertical height, high velocity or reduced water depth.

It is recognised that reductions in water flow resulting from upstream abstraction can create an obstacle to fish movement across an area, or areas of natural channel bed. However, the methodology cannot be used to assess the cumulative impacts of multiple upstream activities on water flow conditions and fish passage in sections of natural channel. The methodology should be limited in application to the list of man-made and natural riverine structures where an obstruction to fish passage may result from conditions at the location itself.

Individual obstacles will often present multiple passage challenges to fish. These will often include certain features intended to reinforce a structure or re-direct water flow, or portions of disrepair/damage to the structure. Riverine obstacles are very varied and perform many different functions. For the purposes of assessment for passability to fish movement, it is more important to consider the functional aspects of their design rather than the specific categorisation of structure type or component.

The general characteristics of the structure are recorded in Section 2 of the field recording sheet. There are eight basic categories, with sub-divisions. Tick the appropriate description of the obstacle. Examples of each of the obstacle types are included in the Appendix.

Whilst it is useful to note the category of the obstacle and attempt to categorise to a sub-division, it is not as important in terms of the actual functional challenges that an obstacle presents to fish passage. It is also recognised that certain structures will not fall easily into a single category. This is often the case at bridge footings and large fords, where the downstream face often presents a jump/swim challenge from a vertical, stepped or sloping weir in addition to the constructed stream bed or apron either directly beneath the bridge or immediately downstream. Reinforced aprons are also often found extending downstream from large culverts, creating the need to categorise the structure as both a culvert and bridge apron. In these situations, where it is clear that there is more than one significant functional obstacle type at a single location, it is appropriate to categorise the structure in terms of its component parts, ticking multiple boxes in this section.

Materials

It is important to record the predominant construction material of the structure, as this may influence fish passage by increasing turbulence or providing resting areas. For example, corrugated materials used in a culvert will provide lower velocities and greater hydraulic heterogeneity than smooth pipes. Materials also play a role in determining the feasibility for modification or removal of the obstacle in the future. Record the materials from the following list:

- PCC = pre-cast concrete; material constructed off-site in sections and fitted
- CPC = cast-in-place concrete; material poured on site using shuttering
- CST = corrugated steel; sheets of steel used to face structures or for shuttering concrete
- SST = smooth steel; sheets of steel used to face structures
- CAL = corrugated aluminium; sheet aluminium used to face structures
- SPS = structural plate steel; sheets of steel used for structural support
- PVC = polyvinylchloride; man-made material often used in small gauging flumes
- TMB = timber; any wood used as facing or structural material
- MRY = masonry; any stonework used as facing or structural material
- OTH = other; any material that does not fit into other categories

Total width of the obstacle

Record the width of the physical obstacle to the nearest metre, measuring directly along the crest of the structure, from the extent of exposed material from one bank to the other. This can be done using a tape measure or digital range finder (Figure 1).

Total width of channel

Record the width of the channel to the nearest metre, measuring from a mid-point on the structure crest and perpendicular to the water> measure from the mid-point of a one bank to the other. This can be done using a tape measure or digital range finder (Figure 1).

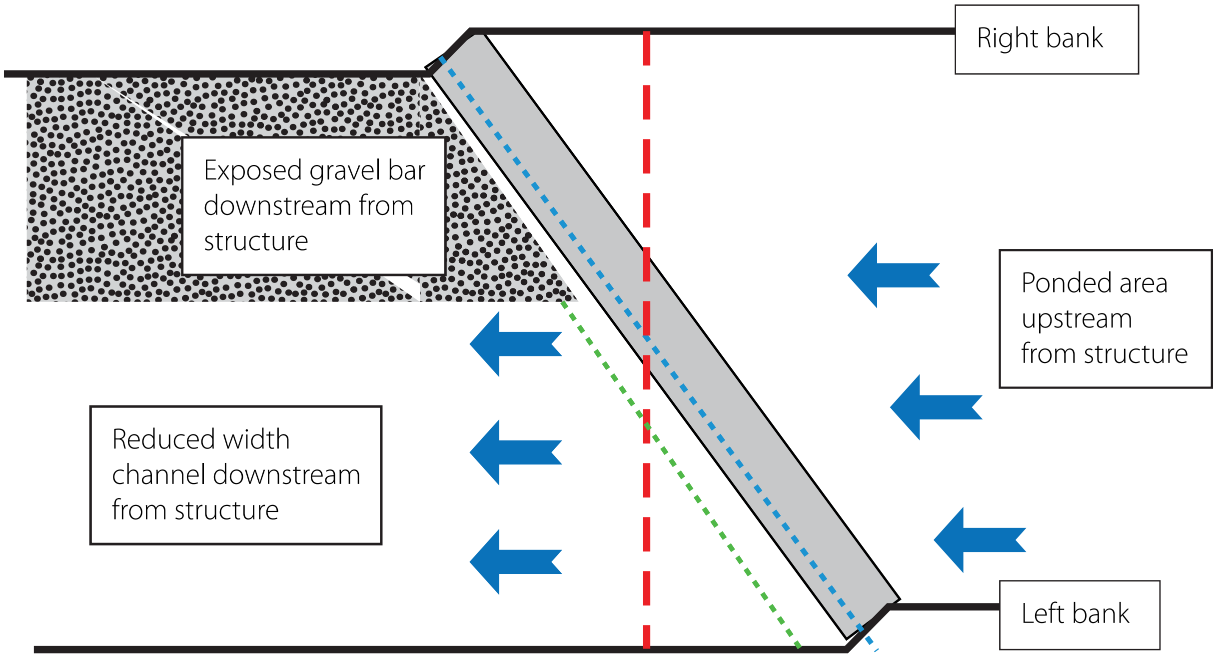


Figure 1: Width measurements at a diagonal obstacle structure. Water flow is from right to left and the crest of the structure is indicated by a grey rectangle across the flow. Right and left bank are labelled. Blue hatched line indicates where the total obstacle width measurement should be taken, along the crest of the structure. Red hatched line indicates where the total width of the channel is taken from the midpoint of the crest, perpendicular to the flow. Structures with diagonal or crescent-shaped crests may result in total width measurements exceeding that recorded as total width of channel. Green hatched line indicates where the wetted width measurement should be taken along the structure crest.

Total wetted width of channel

Record the width of the wetted channel to the nearest metre, measuring across the crest of the structure and only including areas of water. This will provide information about the proportion of the crest that is currently wetted and therefore potentially passable for fish. Measure from waters edge to waters edge and sum the distances across the crest. This can be done using a tape measure or digital range finder.

The comparison of these measurements provides information on whether the obstacle spans the entire channel width and whether it may be possible for fish to by-pass the obstacle under higher flows, utilising an area of crest that is currently dry. Where total obstacle width exceeds total width of the channel, water flow and depth across the crest may be reduced when compared to shorter crest lengths that are more similar to the total width of channel.

Is structure presently drowned?

A 'drowned' structure is one that is being overtopped by elevated flows that elevate the water level downstream and effectively lessen any vertical water height difference across the structure. The pictures below show examples of 'drowned' weirs, with the crests indicated by a red line. Under these drowned conditions the water height difference between upstream and downstream is significantly reduced, and features of the structure are obscured. If a structure is drowned at the time of the survey then the surveyor should not attempt to collect measurements.

Plate 2: A drowned small vertical weir and sloping weir. Red lines indicate position of structure crests.

Structure currently dry?

If the obstacle structure is currently completely dry then circle YES. In this situation it is not possible to take a further measurement of flow or water depth and the obstacle will be assumed to be a complete obstacle to fish movement. The physical characteristics of the structure should still be measured to provide information about the severity of the structure under increase flow conditions.

Transversal sections

Often riverine constructions are complex in form, with a number of component parts that can each present challenges for fish passage. These components can occur either transversally, where a single structure has different characteristics across its width, or longitudinally, where multiple obstacles are in a sequence along a section of the channel.

Within one obstacle location, multiple passage routes open and close for fish at different points across the structure, depending upon conditions of water flow and temperature. In order to adequately assess the passability of a riverine structure for fish passage, it is important to start the process by considering each obstacle in terms of its potential passage routes for fish (i.e. from the point of view of the fish attempting to cross the structure). This process is started by considering the challenges presented by an obstacle to actively upstream migrating fish. Downstream fish migration is generally considered to be much more passive, i.e. determined less by the swimming performance of the fish, and more by the force and direction of the water flow.

Riverine obstacles are often non-uniform in structure across their width (i.e. transversally) and this can present multiple routes and challenges for fish passage (see Plate 4). These varied structural components, which provide alternative potential routes for fish passage, are termed **transversal sections (TS)**. Passage conditions for fish will be altered by water flow velocity and depth, as well as the length of a sloping face and height of any vertical surface that requires a jump. Conditions may change gradually across a structure from the shallow water at a bank to the deep water in mid-stream, but in many situations, the changes are marked by recognisable structural features such as a material or slope change, or a clear channel depth alteration. Surveyors should assess the obstacle and consider the range of passage options across the face from bank to bank. They should use discretion to choose a number of transversal sections that best represents the variation across the obstacle, whether the boundaries between each are clearly defined by a physical change in the structure or not. Often channel margins will provide potential passage routes for fish as they can be shallower, with reduced water velocity. It is left to the discretion of the surveyor whether to separate the channel margins and include as distinct transversal sections for evaluation, or include with a longer transversal section. Ultimately, the decision on the number of transversal sections assigned is left to the discretion of the surveyor, but it is important to ensure that the range of variation in physical characteristics, water flow conditions and water depth across the structure are fully captured within the sections.

At this point it is useful for surveyors to note the possibility for additional passage routes for fish to become active under elevated flow conditions i.e. currently dry sections or channels in the structure that may represent an option for fish passage with an increase in water level across the structure (see photo below). These dry channels should not be included as transversal sections or assessed further in the methodology, but their presence should be noted for inclusion into the final assessment of passage under elevated flow conditions. Notes on these dry channels should be added in the notes sections and an assessment of their potential to enable fish passage under elevated flows included in 7.

Plate 3: The currently dry channel eroded into the right hand bank of this sloping weir may provide a fish passage option under elevated flow conditions and should be noted for consideration in the final section of the methodology (Section 7).

Each TS can comprise a number of different features that a fish might have to surmount whilst travelling upstream across the obstacle (e.g. a vertical drop followed by a sloping surface), but it is important to recognise that each TS represents a separate possible direct upstream route for fish passage across the obstacle. Each TS at an obstacle has to be assessed separately for each of the species and guilds of fish. Measurements are taken from each TS and then an assessment for passability carried out independently, relating to the feasibility of each species/guild crossing the TS under the current conditions.

Plate 4: Examples of riverine obstacles where transversal variation in flow depth and velocity may lead to provision of alternative passage routes for ascending and descending fish. A number of possible routes for fish passage to consider for inclusion in the assessment are marked with red arrows. The routes vary depending upon the structure and are only indicative of possibilities for passage. The routes indicated are not an exhaustive list of the available passage options. In some instances the options presented may be varied and certain routes will be considered much more feasible for fish passage than others.

Enter the number of transversal sections for the obstacle. A single set of field recording sheets includes the ability to record **one** TS per obstacle. It is therefore important that the surveyors make and take additional copies of sections 3, 4, 5 and 6 to each obstacle site, to allow additional TS to be assessed. As a guide, during field trials of the method, the most commonly encountered number of TS at an obstacle was one, with more than four only encountered rarely.

Once each TS has been assessed, a final passability score for each species/guild can be determined. This approach allows several potential routes for fish passage to be included in a single overall assessment procedure for an obstacle, and allows representation of the fact that certain fish species may preferentially select different routes up the same obstacle.

IMPORTANT: To facilitate this assessment, wherever possible, obstacles should be viewed from a position downstream to enable the possible routes for fish passage to be clearly determined, and the obstacle split into transversal sections (TS) that display similar water velocity and depth conditions. Each TS should be clearly assigned a label (A, B, C etc.) and have their positions recorded on the field sketch on page 1 of the field recording sheets. Ultimately, the decision on the number of transversal sections assigned is left to the discretion of the surveyor, but it is important to ensure that the range of variation in physical characteristics, water flow conditions and water depth across the structure are fully captured within the sections.

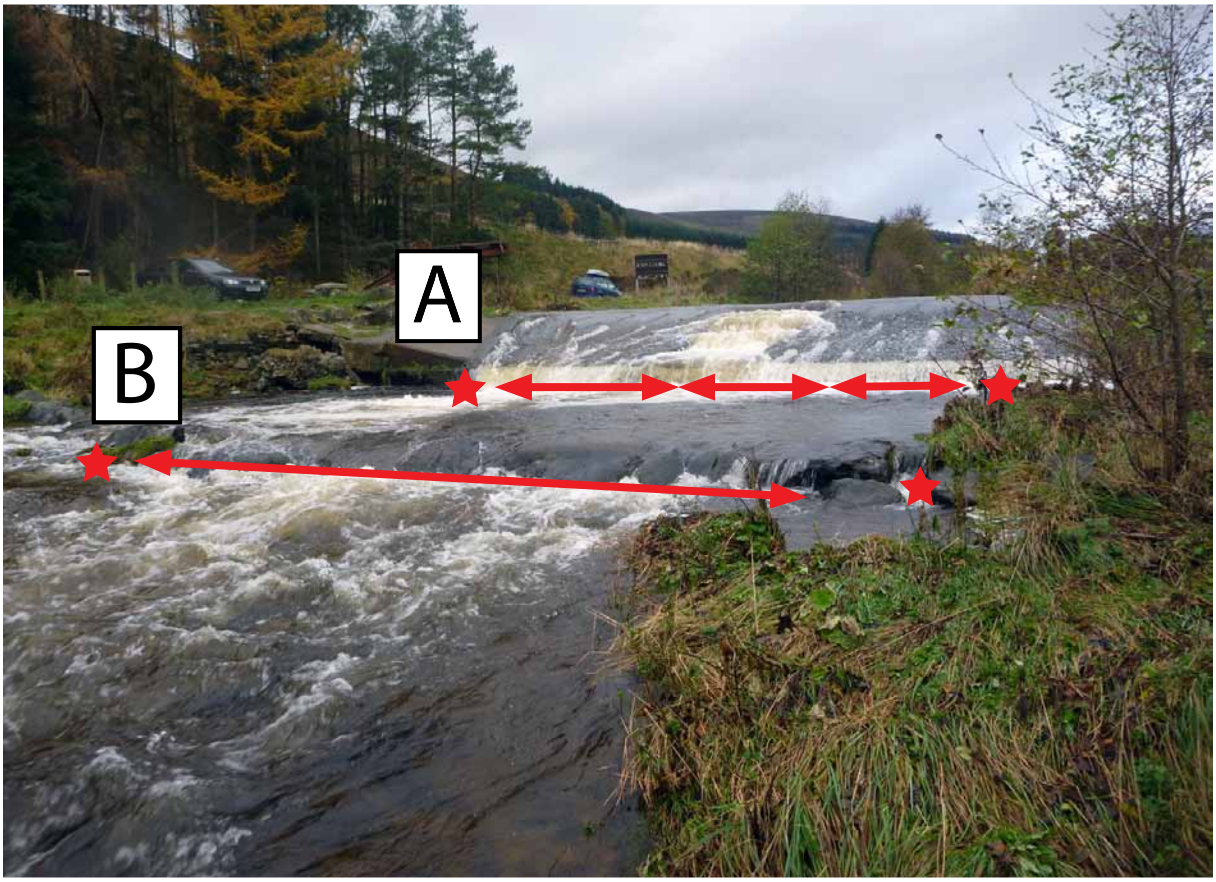


Figure 2: Example of complexity within an obstacle structure and assigning transversal sections. Structure A is a sloping weir and has three transversal sections assigned [the red arrows indicate two sloping surfaces - one roughened surface and one smooth - and a stepped weir (box-type fish pass)]. A distinct area of channel forming a pool then separates structure A from structure B (a secondary vertical weir) by a distance greater than one channel width. In this example, due to the distance between them, structures A (with three TS) and B (with one TS) should be assessed separately. Red stars indicate the areas of channel margin where flow conditions may be different to those further away from the channel banks. These may be considered as separate transversal sections by surveyors or included and measured within the longer sections.

Longitudinal complexity

Where a structure consists of surfaces that are of distinctly differing angles (e.g. a vertical drop at the downstream edge of a sloping weir or ford) then it displays longitudinal complexity. Longitudinal complexity can also occur where a larger structure is preceded by a smaller structure that has often been constructed to dissipate the energy of the water flow, or to provide an increased depth of water (Figure 2).

TS description

Describe the attributes of the TS as slope, vertical drop, steps. Mark one or more of these options to indicate the main functional components for the passage of fish moving in an upstream direction across the TS. Record the order of the components as presented to a fish approaching from downstream and estimate the percentage of total channel flow through the TS at the time of survey. For example, a simple ford with a vertical drop on the downstream edge (Plate 5) would be recorded as in Table 1.

Table 1: Section of recording sheet completed for a simple smooth-surface ford with small vertical drop

	Slope	Vertical drop	Steps	Other	% flow
TS A	X	X			100
Order (from downstream)	2	1			

Plate 5: A simple ford crossing

Field sketch

Include a simple plan indicating clearly where each labelled TS are located and the locations where measurements or estimates have been taken. It is important that the sketch is clearly labelled and any access points are indicated.

IMPORTANT: Section 7 on the reverse side of sections 1 and 2 SHOULD NOT be completed until all measurements and passability scores from each of the transversal sections have been completed. Proceed to Section 3.

Plate 6: A sloping weir associated with a bridge footing, located on the West Water, in the Tweed catchment. An example for the completed Sections 1 and 2 for this obstacle is shown in Figure 3.

Figure 3: Completed Sections 1 and 2 for the sloping weir pictured in Plate 6

BARRIER PASSABILITY ASSESSMENT – LEVEL A

Site Ref no: TW / LW / WW / 001 WB ID and name unknown	Date: 26/06/2009	Time: 1000hr	Surveyor names: CDB / RCM

1. SURVEY SITE DETAILS

River/Stream name	West Water
Tributary to:	Lynn water
GPS co-ordinates	14259 51162
No. photos taken:	6
Photo id no range:	001-006
Ownership (if known)	Unknown
Access notes: Parking on road 200m east. Approach from right bank down farm track.	

Antecedent conditions (circle one)	1	2	3	4	5
Flow conditions (circle one):	Bankfull		Elevated		Summer Low Level
Adverse conditions impeding survey?	Y			N	
If yes, describe: none					

2. STRUCTURE OF CONCERN

2.1. General Characteristics

Type

Weir	Vertical	
	-Notched	
	Sloping	X
	- Crump	
	- Flat-V	
	- Flume	
	Stepped	
Ford		

Bridge footing		X
Natural barrier	Waterfall	
	Rapid	
	Debris dam	
Dam		
Culvert		
Sluice		
Abstraction off-take		

Material

FCC		TMB	X	PVC		SPS	
SST		CPC		MRY	X	OTH:	
SPA		CAL		CST			

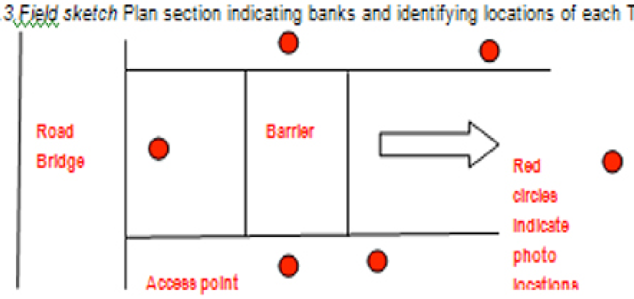
Total width of barrier along crest (m):	7.5	
Total width of channel (m):	8.5	
Total wetted width at barrier crest (m)	7.5	
Is structure drowned presently?	Y	N
Is structure currently dry	Y	N

2.2 Transversal sections (TS) including barrier parts or passage ways across total width of channel

Number of identified Transversal Sections (TS) across the total width of the channel	1

TS description Tick box if feature is present in the TS and enter the order the features are encountered by fish moving upstream across the barrier	*vertical drop: (weir, outlet drop, waterfall overshot sluice)* *JUMP AND/OR DEPTH BARRIER*	*Slope: (sloping weirs, fords, culverts, sloped fishway, rapids, chutes)* *SWIM AND/OR DEPTH BARRIER*	*Steps: (stepped weir, box-pass fish ways, complex rapids* *SWIM AND JUMP AND/OR DEPTH BARRIER*	*other: Complex waterfalls, debris dams or combinations* *SWIM AND/OR JUMP / DEPTH BARRIER*	*Estimate of % of total channel flow going through TS at time of survey*
TS 1		x			100
Order (from downstream)		1			
TS 2					
Order (from downstream)					
TS 3					
Order (from downstream)					

2.3 *Field sketch* Plan section indicating banks and identifying locations of each TS and photograph locations.



Section 3 Velocity and depth measurements for each transversal section (TS)

Section 3 enables surveyors to record water depth and velocity at points across the structure. This information is used to provide:

1. An estimation of the passability for each fish species/guilds at a maximum of 15 discrete points across the entire width of a single TS. There are five measurement points on each of three transversal transects located at the **crest or upstream inlet, the midpoint and the foot or outlet of a structure** (Figure 4).

2. Passability scores for each of the three transversal transect locations to indicate if a fish could theoretically hold station or make progress upstream against the water flow at some location across each transect.

Complete this section for all transversal sections on obstacles **apart from** abstraction points. Abstraction points are recorded in Section 5.

TS ID

Record this and ensure it is the same as that indicated on the field sketch (use A, B, C etc.).

Crest/inlet transect

Measurements should be taken at the crest of the structure, i.e. its highest submerged point where the water from upstream exhibits a noticeable break of slope, or where water enters the inlet structure (of a culvert pipe). See Figure 4 and Plate 7.

Where a vertical or near-vertical drop is presenting a jump feature to fish, then it is appropriate to **take only ONE transect set of depth and velocity measurements at the crest of the structure.** This reflects the situation whereby fish ascending the obstacle by jumping would have to re-enter the water at this point to successfully ascend.

IMPORTANT: It may be unsafe for surveyors to attempt to collect water depth and velocity data for the obstacle. If collection of data breaches the surveyor's health and safety guidance then no attempt should be made to undertake measurements. Estimations of water depth and velocity must then be made from a position of safety on the bank. It is the responsibility of the surveyor to asses the risks associated with data collection at an obstacle site and be responsible for their own health and safety.

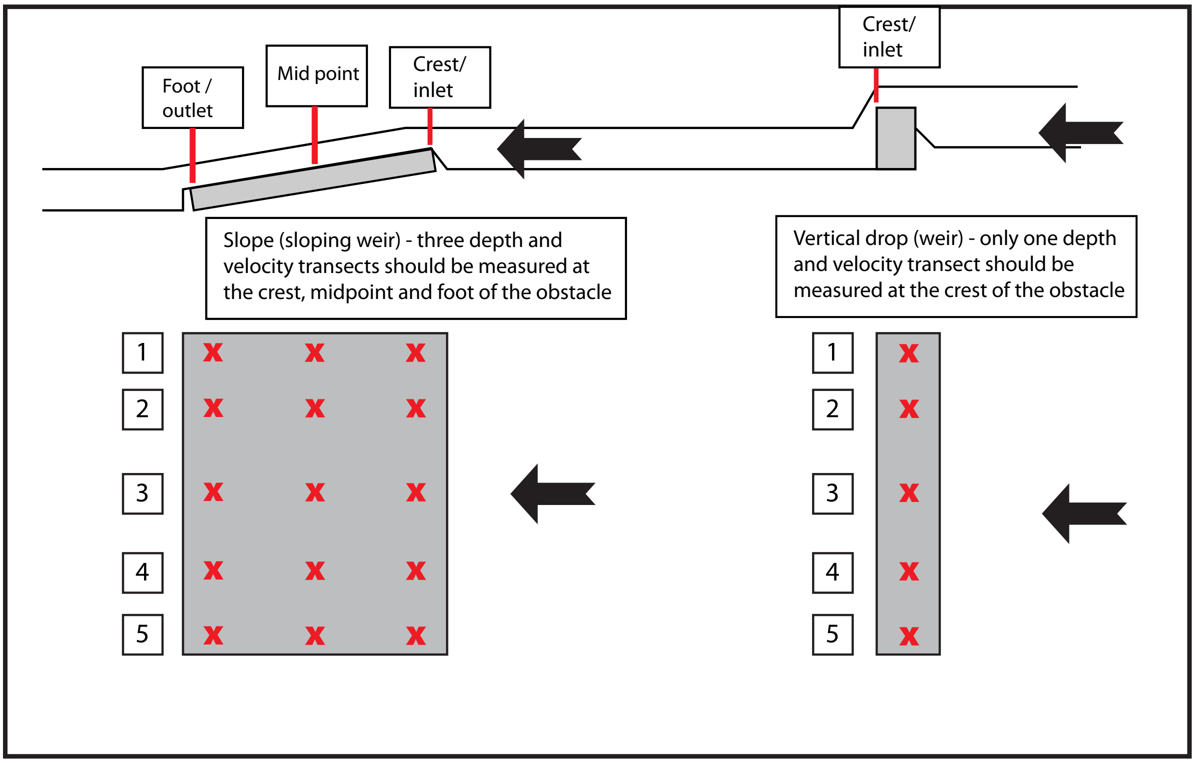


Figure 4: Illustration of the locations for transects to measure water depth and velocity across an obstacle. The example on the left is a simple sloping weir with three transects and 15 points recorded (X). On the right is a simple vertical weir with only one transect across the crest along which to measure depth and velocity (5 points). The measurement of depth and velocity via transects should be carried out for **every** transversal section that is recorded at an obstacle.

Mid-point transect

Measurements should be taken at the approximate midpoint of the structure only where this is safe to do so.

Foot/outlet transect

Measurements should be taken at the downstream submerged edge (foot) of a sloping structure or outlet of a pipe or culvert, only where it is safe to do so. Measurements should be taken on the edge of the structure and not in the pool downstream. Where a man-made structure is "perched" on a natural bedrock shelf, the measurements should be taken at the point where the bedrock reaches the downstream pool surface, as both bedrock and structure together constitute an obstacle.

The passability scores for downstream migration are only entered for the crest/inlet transect, as it is assumed that fish moving downstream past the obstacle would be committed to any further acceleration or reduction in water depth or drop by crossing the crest/inlet.

Plate 7: Sloping weir on the West Water, River Tweed. Red dotted lines indicate the positions for the three transects to determine water depth and velocity across the face of the obstacle. The blue dotted line indicates a currently dry channel that should be noted and considered as a possible passage route under elevated flow conditions (in section 7)

Location for water depth and velocity measurement across a transect
Five points should be selected across a transect, corresponding approximately to:

- **Points 2 and 4** = at ~25% of wetted width.
- **Point 3** = the channel midpoint, at ~50% of the wetted channel width.
- **Points 1 and 5** = close to the edge of wetted channel. The actual location of points 1 and 5 will vary depending on channel shape, but as a guide they should be chosen to represent the conditions experienced by fish that are utilising the often calmer, shallow band of water **within 1m of the wetted channel edge**. As a result, measurement points should not be placed right at the very edge of the wetted channel, but somewhere representative of the edge 'zone'.

Water depth

This should be measured at each of the five locations across a transect, using a measuring staff and recorded to the nearest 0.01m, giving a total of 5 x water depth measurements for each transect. Record the water depths on the recording sheet. If water depth is >0.30m then measurement will probably not be safe and should be estimated from a position of safety on the bank.

Water velocity

This should be recorded at each of the five locations across a transect using a velocity meter (Figure 5). The velocity at the bed and at 0.6m depth should be recorded at each point, giving a total of 10 water velocity measurements for each transect.

The material on the streambed has an important role in determining the variation in water flow with depth, providing mixed velocities both across a structure and with distance towards the water surface. Smooth surfaced structures often show significantly less variation between surface and streambed velocities than those with a coarse substrate bed. Additionally, the flow dynamics of certain structures (e.g. undershot sluices) can create large differences in the water velocity profile. **Velocities are recorded at two depths** to account for changes in velocity profile and to recognise that certain fish species preferentially utilise the mid-water or streambed zones when migrating. The water velocity at the depth relevant to each species preference should therefore be applied to any estimate of passability. Where water depth is reduced to <0.05m one velocity measurement will suffice for both depth locations.

Water velocity should be recorded using an average of records collected during a minimum of 10 seconds at each point.

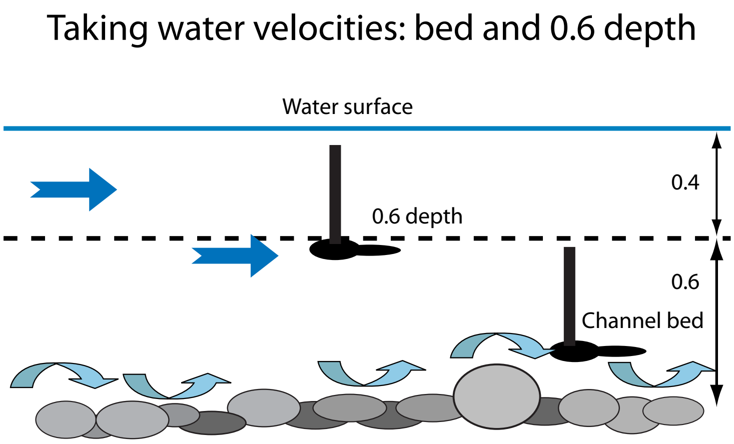


Figure 5: Collecting water velocity measurements using a hand-held velocity meter. The meter should remain suspended clear of the substrate when taking the bed measurement.

Passability scores

Passability scores for Section 3 are determined by considering both the water depth and velocity and comparing them with the stated ranges for swimming performance for each species/guild provided. Passability scores will be assigned ranging from **0.0 = Impassable** and a compete obstacle to **1.0 = Passable** and no obstacle as per the definitions in Table 2. In effect, the surveyor is scoring each point on the transect on its suitability in terms of depth and water velocity for the particular species/guild to be able to either hold station or make swimming progress upstream.

Table 2: Passability scores for riverine obstacles to fish movement.

Score 0.0 = Impassable, complete obstacle to fish movement if that the target species/life-stage, or species guild can not pass the obstacle.
Score 0.3 = A partial high impact obstacle is assigned if the obstacle represents a significant impediment to the target species/life-stage, or species guild, but some of the population (e.g. < one-third) will pass eventually; or the obstacle is impassable for a significant proportion of the time (e.g. > two-thirds).
Score 0.6 = A partial low impact obstacle is assigned if that the obstacle represents a significant impediment to the target species/life-stage, or species guild, but most of the population (e.g. > two-thirds) will pass eventually; or the obstacle is impassable for a significant proportion of the time (e.g. < one-third). Culverts represent good examples of partial obstacles if they impede fish during periods of high or low flow.
Score 1.0 = No obstacle, passable if that the obstacle does not represent a significant impediment to the target species/life-stage, or species guild, and the majority of the population should be able to pass during the majority of the period of migration (movement). This does not mean that the obstacle poses no costs in terms of delay, e.g. increased energetics, or that all fish will be able to pass.

3. VELOCITIES AND DEPTHS FOR AN INDIVIDUAL TRANSVERSAL SECTION (TS) *(except for abstraction points)* | **Site ref no:** TW / LW / WW / 001 | **TS ID:** 1

Wetted width (m)																				
		LB				RB	LB				RB	LB				RB	No barrier	Partial barrier Low Impact	Partial barrier High Impact	Complete barrier
Transect point		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5				
DEPTH (M)		0.05	0.15	0.1	0.16	0.25	0.06	0.1	0.26	0.13	0.25	0.09	0.12	0.15	0.1	0.19				
VELOCITY	0.6 depth	0.4	0.55	1.2	2.6	1.9	1.8	2.5	2.9	2	2.6	1.4	1.5	1.5	1.1	0.8	1.0	0.6	0.3	0.0
	Bed	0.2	0.5	1.1	1.4	1.2	1.2	1.8	1.5	0.9	1.6	1.2	1.2	1.1	1	0.6				
Adult Salmon (AS)		0.0	1.0	0.3	0.3	1.0	0.0	0.3	0.3	0.6	0.3	0.3	0.6	1.0	0.3	1.0	≥0.15 m	0.11 – 0.14 m	0.08 – 0.1 m	≤0.07 m
		US		DS			US		DS			US		DS						
use velocities at 0.6 depth		1.0					0.6					1.0		1.0			≤2 m/s	2.1 – 2.5 m/s	2.6 – 2.9 m/s	≥3 m/s
Adult Trout (AT)		0.0	1.0	1.0	0.3	1.0	0.6	0.3	0.0	0.3	0.3	0.6	1.0	1.0	1.0	1.0	≥0.1 m	0.075 – 0.09 m	0.06 – 0.074 m	≤0.05 m
		US		DS			US		DS			US		DS						
use velocities at 0.6 depth		1.0					0.6					1.0		1.0			≤2 m/s	2.1 – 2.5 m/s	2.6 – 2.9 m/s	≥3 m/s
Adult Grayling (AG)		0.0	1.0	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.6	1.0	1.0	1.0	1.0	≥0.1 m	0.075 – 0.09 m	0.06 – 0.074 m	≤0.05 m
		US		DS			US		DS			US		DS						
use velocities at 0.6 depth		1.0					0.3					1.0		1.0			≤1.5 m/s	1.6 – 1.9 m/s	2 – 2.8 m/s	≥2.9 m/s
Cyprinids (C)		0.0	1.0	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6	1.0	≥0.1 m	0.075 – 0.09 m	0.06 – 0.074 m	≤0.05 m
		US		DS			US		DS			US		DS						
use velocities at 0.6 depth		1.0					0.3					1.0		1.0			≤1 m/s	1.1 – 1.5 m/s	1.6 – 1.9 m/s	≥2 m/s
Adult Lamprey (AL)		0.3	1.0	0.6	0.3	0.3	0.3	0.0	0.0	0.6	0.0	0.3	0.3	0.3	0.3	0.6	≥0.08 m	0.06 – 0.079 m	0.04 – 0.059 m	≤0.03 m
		US		DS			US		DS			US		DS						
use velocities at streambed		1					0.6					0.6					≤0.5 m/s	0.6 – 0.99 m/s	1 – 1.4 m/s	≥1.5 m/s
Juvenile Eel (JE)																	≥0.05 m	0.03 – 0.049 m	0.021 – 0.03 m	≤0.02 m
		US		DS			US		DS			US		DS						
use velocities at streambed climbing substrate *		CLIMB SUB					CLIMB SUB					CLIMB SUB					≤0.3 m/s	0.31 – 0.49 m/s	0.5 – 0.79 m/s	≥0.8 m/s
		1.0					1.0					1.0								
Juvenile Salmonids (JS)		0.3	1.0	1.0	0.3	0.6	0.6	0.3	0	0.3	0.3	1.0	1.0	1.0	1.0	1.0	≥0.08 m	0.06 – 0.079 m	0.031 – 0.059 m	≤0.03 m
		US		DS			US		DS			US		DS						
use velocities at 0.6 depth		1.0					0.6					1.0		1.0			≤1.5 m/s	1.51 – 1.9 m/s	2 – 2.8 m/s	≥2.9 m/s
Juvenile Lamprey (JL)												1.0	1.0	1.0	1.0	1.0	≥0.02 m	0.011 – 0.019 m	0.006 – 0.01 m	≤0.005 m
												US		DS						
														1.0			n.a.	n.a.	n.a.	n.a.
Adult Eel (AE)												1.0	1.0	1.0	1.0	1.0	≥0.08 m	0.06 – 0.079 m	0.031 – 0.059 m	≤0.03 m
												US		DS						
														1.0			n.a.	n.a.	n.a.	n.a.

Notes:

For Upstream passability assessment:

1.Use both the **depth** and relevant **velocity** data.

2. Choose the **most limiting factor** that applies to the species/guild = either velocity or depth (e.g. for adult salmon (AS) if velocity is < 2.0 but depth is 0.09m then score for this point is 0.3).

3.Scan through the scores and circle the **maximum passability** score for each applicable location (inlet, midpoint, outlet)

For downstream passability assessment:

1.Only compete for **inlet**

2.Use only the **depth data** to determine the passability score

3.Scan through the scores and circle the **maximum passability** score

Figure 6: Example of initial data entry for Section 3. Highlighted areas are referred to in the text.

1. Record the depths and water velocities at the locations across the transects and enter into the corresponding cell in Section 3. Note the position of the left bank (LB) and right bank (RB) in relation to data entry and that outlet transect (the foot of the structure) is the column on the left.

2. Consider the fish species (or guilds/groups) present in the catchment (if known). Scores should only be completed for fish species known to be present in the waterbody i.e. scores for grayling should be omitted from assessments in North West Scotland and Northern Ireland.

3. Start with adult salmon (AS) and use the values given in the depth/velocity passability assessment guidance on the right hand side of Section 3 (red outline in Figure 6), the notes section (green outline in Figure 6) and the guidance relating to the correct velocity figure to use (yellow outline in Figure 6) to establish the passability scores for each of the five points on each of the transects. Follow the guidance in the notes section and use the most limiting factor (i.e. either water depth or velocity used to generate the score for the location). This is done as there is no point having adequate water depth if the velocity is too high for the species, or visa versa.

4. Enter the passability score in the correct box (red text entered in Figure 6).

5. Scan across these scores (red text in Figure 6) and identify the **highest** score for each of the transects (crest, midpoint and foot) for each of the species for upstream (US) migration (highlighted as blue text for each of the transects). This score should be entered into the US cell for the transect, indicating the passability score for the transect for the species/guild. It is, in effect, recording the most favourable position across the transect for the fish species/guild to be able to either hold station or make swimming progress upstream in terms of the water depth and velocity only (blue text in Figure 6). Do not enter anything in shaded or hatched boxes. These do not apply.

6. Repeat the passability scoring for downstream (DS) migration. Downstream scoring assessment differs from the upstream technique in that it only considers water depth as the limiting factor and scores are only assigned for the **inlet/crest** transect. To determine the DS score for the crest, scan through the depth records and check against the ranges associated with each species/guild in the depth/velocity assessment guidance on the right hand of the page. Use the **maximum** water depth recorded across the crest, as passive downstream migrating fish are likely to be drawn towards the area of greatest water depth and velocity.

7. Repeat the procedure for each species/guild down the table, taking care to use the correct values for scoring, and the appropriate guidance notes.

8. When making the assessment for juvenile eels (JE) the surveyor has to record if suitable climbing substrate is present and use of climbing substrate. The smallest juvenile eels can utilise wetted climbing substrate such as damp mosses and roughened rock surfaces to ascend most vertical obstacles, as long as there is a film of water present (Plate 8). Suitable wetted climbing substrates can be obscured behind plunging flows and it is important for surveyors to attempt to locate and identify it. Even very small patches of substrate can be used as a preferential ascent route if they are continuous and wetted, and their presence leads to the obstacle being considered as passable (scored as 1.0) for juvenile eels.

   If climbing substrate is **present** then enter 1.0 in the box provided for each of the transects in Section 3 **and do not fill in anything else for juvenile eels**.

   If climbing substrate is **absent** then the water depths and velocities should be used to provide passability scores for juvenile eels in the same way as for other species/guilds.


Plate 8: Examples of juvenile eels (elvers) ascending damp vertical surfaces utilising natural friction from the rock surface and attached algae. This enables them to pass obstacles that would normally be impassable for free-swimming elvers.

Completing Section 3 results in a minimum of one (for vertical drops) and a maximum of three (for sloping surfaces) upstream passability scores relating to the suitability of conditions for each species/guild. One downstream score will be entered for each species/guild for the inlet/crest. This procedure allows surveyors to clearly establish where there may be difficulties for the passage of certain fish species on the basis of restrictions caused by excessive water velocity or inadequate water depth.

By scanning the scores from each transect location (i.e. outlet, then midpoint, then inlet) it is possible to establish if a possible route upstream exists across the TS for the species/guild at the current flow conditions. If all three passability scores for the transects are >0.0 then there may be a potential for a partial route upstream. If one of the transects (crest, midpoint or foot) is scored entirely as 0.0 then there is currently no possible route for the species/guild to pass across the structure.

The final score for the transversal section as determined by point scoring in section 3 has to be based not only on the actual scores collected at the points, but also on their actual locations in relation to each other, and the distance between them. This is a "sense-check" on the data collected and an appropriate final score has to be left to the surveyors' discretion. Figure 7 provides an example to illustrate this decision process for surveyors. The transversal section at the top of the figure has the largest number of potential routes for fish (red arrows) and has options for passage that are relatively close to each other. Fish A has the most likely chance of ascending the obstacle with neighbouring point scores that remain passable as it proceeds up the structure. Fish B has a passability score of 0.3 for its possible routes. The final score for this transversal section and this fish species/guild would be given as 0.6, considering the possibilities. The lower transversal section would be given a preliminary score of 0.3 based solely on the point velocities and depths. However, when the pattern of scores is considered, Fish C has no real possible routes for passage as the 0.3 points are separated by a distance of 20m. In this example the surveyor should consider giving a score of 0.0 for this obstacle and fish species/guild.

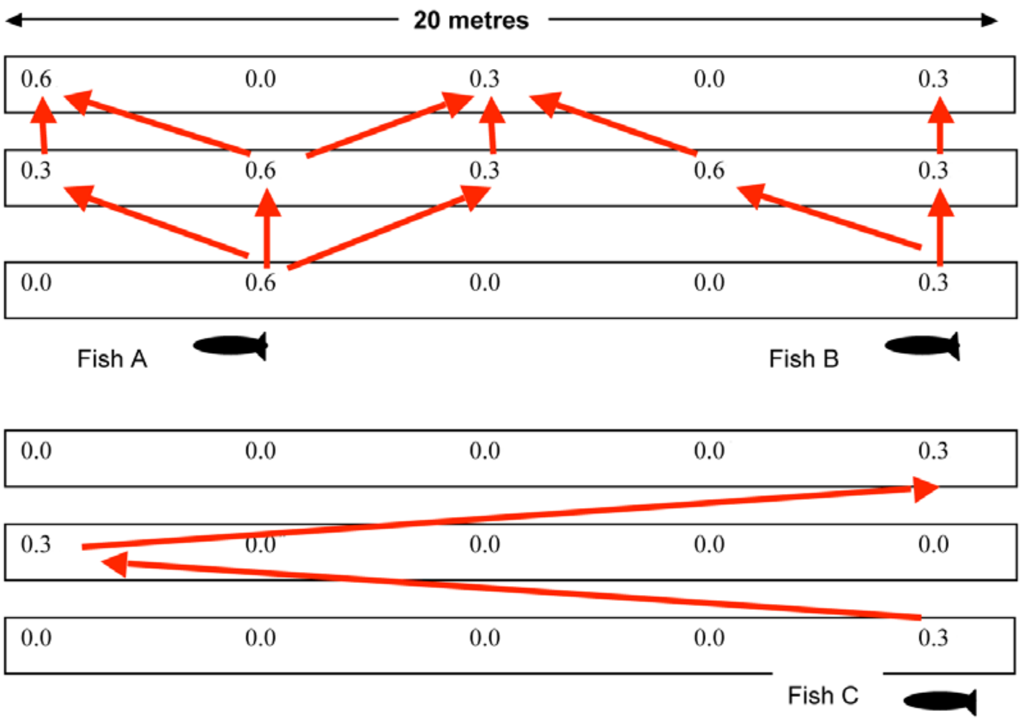


Figure 7: An example of possible routes upstream for fish across two hypothetical obstacles of 20m width with passability scores assigned to 15 points on transects located at the crest, midpoint and foot of the structure. Possible routes for fish are indicated by red arrows.

IMPORTANT: If the only possible passage routes for fish across the obstacle are separated by a distance that is considered by the surveyor too great a distance, preventing a fish from arriving at the next location where it can hold station or progress, then the surveyor should assign a LOWER passability score to the overall TS for that species/guild or consider a ZERO score. Final zero scores can be entered for the transversal section overall in Section 3 even if the scores recorded at points across the transects are all > 0.0.

For example, for the obstacle assessment scores shown in Figure 6:

- Adult salmon (AS) upstream passability scores are 1.0(outlet), 0.6 (mid-point), 1.0 (inlet) and 1.0 for downstream (inlet). The scores in each transect are scanned for distribution and the distance between them assessed. It is decided that there is a feasible passage route between the points assessed as > 0.0 as distance between each point does not present further difficulties for a swimming salmon to make progress up the obstacle. The final upstream score for salmon for section 3 is given as 0.6
- Cyprinids upstream passability scores are 1.0 (outlet), 0.3 (mid-point), 1.0 (inlet) and 1.0 for downstream. The scores in each transect are scanned for distribution and the distance between them assessed. In this instance the distribution of points for cyprinids varies from that for salmon but it is decided that the distance between points does not create an obstacle to passage across the structure. The final upstream score for Cyprinids for section 3 is therefore given as 0.3
- Juvenile eels (JE) upstream scores are all 1.0, as climbing substrate is present, and 1.0 for downstream. (CLIMB SUB has been entered on the field recording sheet.)

Therefore, on the basis of water depth and velocity over the structure, a possible passage route is available for adult salmon, cyprinids and juvenile eels in both upstream and downstream directions across this obstacle.

Where the passability scores assigned to the transversal section for a species/guild are all >0.0, the next step is to complete Section 4 to enable any additional features of the obstacle that may have a bearing on its passability to be included in any final assessment.

IMPORTANT: If passability scores of 0 are recorded on one or more of the three transects (crest, midpoint and foot) for a particular species/guild during completion of Section 3, then further scoring for this species guild in sections 4 or 5 is not required for this TS. The features in Section 4 still have to be measured and recorded, but the actual scoring for passability is not necessary as it is assumed as conditions for passage determined from water velocity and depth are unsuitable, the presence of any other features on the TS will not be able to improve conditions for passage.

Section 4 Physical attributes relevant to passability for an individual transversal section (TS)

This section enables surveyors to measure and record the presence of features that are important to fish passage at obstacle structures. The four tables included (4.1 – 4.4) relate to specific characteristics of the TS: obstacles presenting a vertical drop, a slope, steps and for gap dimensions.

Surveyors complete the appropriate table for each TS, noting the TS ID in the top right hand box. Surveyors will need to fill in the details in more than one of these tables if multiple features are present at a particular TS. (For example, a transversal section that has a vertical drop at the downstream edge of a ford, followed by a sloping road surface, should have entries in sections 4.1 and 4.2.)

IMPORTANT:
It is not necessary to complete Section 4 for a transversal section that is an abstraction point.
It is not necessary to complete Section 4 for juvenile eels if suitable climbing substrate is present.

Procedure for entering scores for Section 4 tables:

1. Surveyors should firstly complete the top row in the appropriate table, entering the value or a tick or symbol to indicate the presence of a certain feature.

2. Surveyors use the **passability assessment guidance tables** (Appendix 2) to complete the scores for the feature and species/guild, by looking up the appropriate table and entering the corresponding passability score. For debris blockages, scores should be entered to indicate possible restriction for both upstream and downstream movements. Presence of damaging structures downstream should be completed considering the possible impact on downstream migrants only. For all other features, passability should be recorded for upstream migration. Shaded/hatched boxes should not be considered for entering a passability score

4.1 Measurements to be taken at each transversal section of an obstacle to complete Section 4

4.1a Vertical and total hydraulic head: complete for tables 4.1, 4.2 and 4.3
Measuring the height of any vertical drop in water surface is obviously important as it presents an obstacle that all species will have to ascend by jumping. Measurements should be taken from the water surface at the crest of a structure to the water surface in the downstream pool, using levelling equipment (Figure 8). Where the obstacle presents a vertical drop, this should be recorded as a vertical hydraulic head in Table 4.1 and the individual passability scores recorded for each species/guild. The exception here is for juvenile eels, as they can bypass having to negotiate a vertical drop if suitable wetted climbing substrate is present. This should be noted in the previous section.

Where a head difference is apparent at an obstacle but there is no vertical drop, then the term Total Hydraulic Head is used, and the measurement is recorded in the box provided in Tables 4.2 for sloping structures and 4.3 for stepped structures. No passability score is entered for Total Hydraulic Head for each species/guild (the hatched boxes in the column in tables 4.2 and 4.3 indicate that no score has to be entered) but it is used to calculate the slope of the structure. For small structures where there is the possibility that species such as salmon or trout could leap across a sloping surface rather than have

to swim across it, the hydraulic head is used in association with the depth in the downstream pool, to provide a passability score for this.
The ability of a fish to successfully ascend using a vertical leap will depend upon the individual flow conditions at the location, and the swimming abilities of the species. Individual passability assessments for the species/guild should be made according to the guidance in the passability assessment guidance tables.

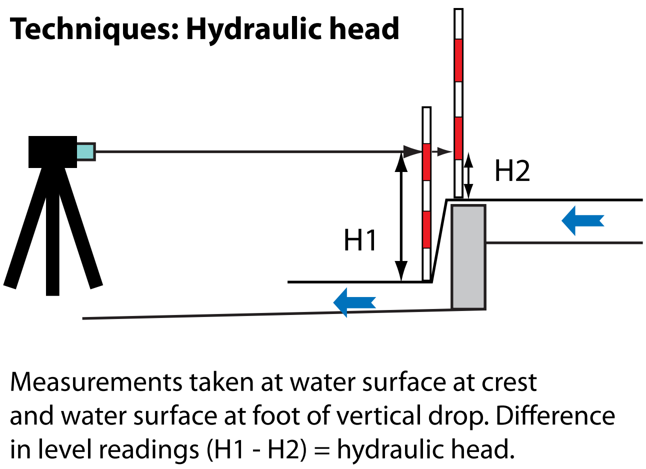


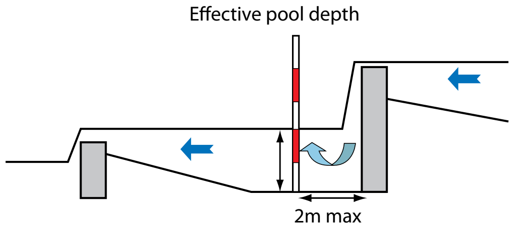
Figure 8: Measuring hydraulic head using standard levelling equipment. Measures should be taken from the water surface using a measuring staff.

4.1b Effective depth of a downstream pool: complete for tables 4.1 and 4.3
A pool downstream from an obstacle can occur naturally, or can have been constructed as part of the design. Any area downstream from a vertical drop structure that provides reduced water velocities and increased depth can improve the chances for fish to make a successful leap. A plunge pool occurs when water enters at speed from above (plunging) and is often deepened by scouring. The plunge pool is likely to have varied water depths, but the important measurement to obtain relates to **the depth at the point where fish are likely to start to make an attempt (jump) from.** It is not possible to provide definitive guidance on the exact location that fish will start an attempt from, as this will be determined by unique site-specific conditions, but as a guide, the area is likely to be in proximity to the point where the maximum water flow of plunging water returns to the surface, and within 2m of the structure face.

Therefore, as a guide to inform the assessment, surveyors should attempt to measure the effective depth within 2m of the foot of a structure, and in the area where the maximum water flow is entering the pool. (Figure 9).

Techniques: Effective pool depth

- The effective pool depth should be taken at the point considered to be where fish would begin a leap to ascend the structure. This is normally associated with the return to the return to the surface of a plunging flow.



- Measurement should not be undertaken further than 2m downstream from the structure foot.

Figure 9: Measuring the effective depth of a pool downstream from an obstacle structure.

The requirement for a certain depth of water in a downstream pool to facilitate a successful leap will depend on the unique combination of flow and morphological characteristics at a site. It is therefore difficult to provide further specific guidance on the threshold water depths for each species/guild in relation to their abilities to leap a certain height. However, as a guide for all species/guilds, the categories in Table 3 are proposed in relation to potential passability. The individual passability assessments for the species/guild should be made according to the guidance on effective pool depth in the passability assessment guidance tables.

Table 3: Proposed guidance relating the available water depth in a downstream pool to the hydraulic head of an obstacle in relation to fish passage.

Passability score	Effective pool depth and hydraulic head
1.0	Pool depth ≥ hydraulic head
0.6	Pool depth ≥ 0.6 x hydraulic head
0.3	Pool depth ≥ 0.3 x hydraulic head
0.0	Pool depth ≤ 0.3 x hydraulic head

For small slope and step obstacles there is the possibility that some fish species, such as salmon and trout, may be able to leap across the obstacle instead of swimming up the surface. In these situations where a short sloping surface typically < 2m in length is present, both the effective length and hydraulic head are considered and a score provided under the effective depth category.

4.1 c Effective resting locations for fish: complete for tables 4.1, 4.2, 4.3
This assessment should be made for the area **immediately downstream** from the structure only. The presence of resting locations for fish provides migrants with refuge from high velocity water, and a chance to recover between attempts at crossing an obstacle. The conditions that provide ideal resting locations will vary between species/guilds, but it is adequate to record the presence of resting locations by assessing whether areas of reduced velocity water (pools or glides) are present in the area downstream from the obstacle (Plate 9).

Record suitable resting areas as present or absent

The individual passability assessments for the species/guild should be made according to the guidance on effective resting locations in the passability assessment guidance tables.

Plate 9: Examples of effective resting locations for fish at obstacles. Suitable areas of reduced flow and increased water depth are indicated as areas surrounded by hatched red lines.

4.1 d Lips: complete for tables 4.1, 4.2 and 4.3

Lips protrude outwards and often up from the surface of a structure (Figure 10 and Plate 10), deflecting water off the surface and reducing water depth. They often extend across the entire width of a structure and have been fitted to create additional water depth in an upstream impoundment. Lips are often constructed of concrete or steel, but older structures can have wooden lips that have become exposed due to erosion. The local impact of lips will vary enormously depending upon their location, size and the relationship with other features at the obstacle, requiring individual consideration at each site. For the purposes of this assessment, a lip is defined as a distinguishable additional feature on an obstacle that is < 0.10m in height that clearly deflects water off the main surface of the structure.

A lip can either create or contribute to an existing vertical drop on a structure, depending upon its location. **Where a lip contributes to an existing vertical drop on a structure, then this should be assessed as part of the recording of a vertical drop (Section 3.1)** and no further consideration of the lip is necessary. Only when a lip is considered to be clearly separate from the main structural features (i.e. located in a position that does not contribute to an existing vertical drop), where it extends fully across a structure, and where it is clear that its presence significantly changes water flow across or through a structure, should an separate assessment of its potential impact on fish passage be undertaken.

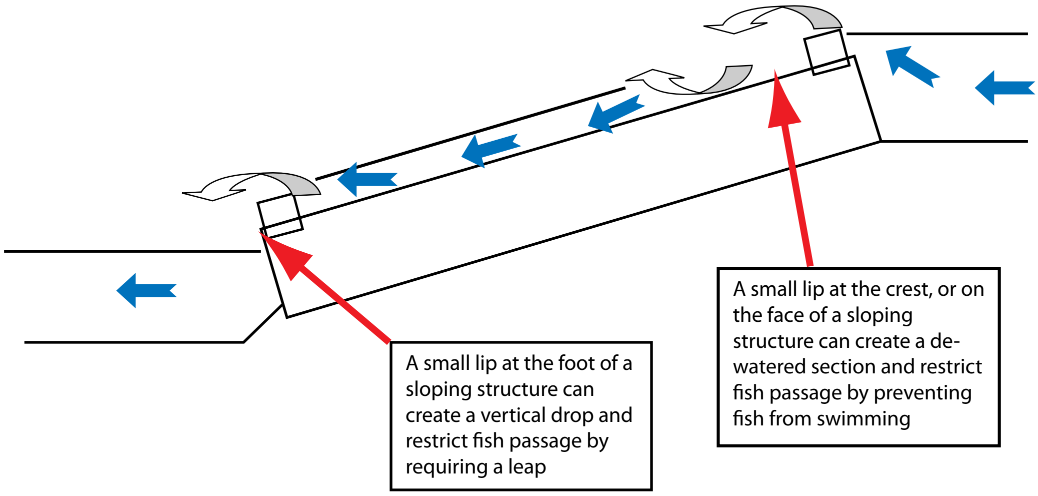


Figure 10: Illustration of effects of lips on the water flow at the crest and foot of a sloping structure. The nature and location of lips varies widely, and severity of impact of lips on fish passage will depend upon their construction, location and dimensions, and must therefore be assessed individually.

An example of when consideration of a lip would be required may be when a 10cm lip is found at the crest of a long shallow sloping weir face. The slope and length of the weir may be passable to active swimming fishes, but the lip positioned at the crest may be considered to create an additional obstacle to passage because the burst energy required by fish to swim up a long angled face may leave them incapable of overcoming a small lip obstacle at this point. If the same small lip was located at the very foot of the same weir, then it may not be considered to create the same magnitude of problem for fish passage if fish are able to jump over it and onto the sloping face.

If a lip is present, then surveyors are required to consider the potential impact of the lip on fish passage, on the basis of its size and location on an obstacle structure. It is often very difficult to determine the actual impact of a lip structure on fish movement unless direct observation is possible so it is not appropriate for surveyors to score these features at anything other than a coarse resolution. Therefore, when assigning passability scores for lips there are only two categories that surveyors should consider when assessing the potential impact:

1. Lip present but does not restrict fish passage.
2. Lip present and may locally restrict fish passage.

The individual passability assessments for the species/guild should be made according to the guidance on lips in the passability assessment guidance tables.

Plate 10: Lips at obstacle structures. Left: A lip at the foot of a sloping weir creating a small vertical head difference that, at this water level, would require fish to make a vertical leap up onto the sloping face of the structure. Here this should be assessed as part of a vertical drop. Right: a steel bar added as a lip across a stone crest at a small ford structure, increasing the hydraulic head at the obstacle and creating difficulties for fish landing from an ascent of the first vertical drop. Here this lip should be considered as a stand-alone feature on this structure.

4.1 e Standing waves: complete for tables 4.1, 4.2 and 4.3

A standing wave can form when water travelling at speed from upstream is forced down and under water lying at the foot of an obstacle. The standing wave can vary in appearance and magnitude, depending upon the individual hydraulic conditions, with some exhibiting high obvious crests of white water, and others smooth and less turbulent (Plate 11). All standing waves have a feature in common, and exhibit a localised area of raised water level as water is returned to the surface. Standing waves can present an obstacle to fish by causing disorientation, creating excessive turbulence and focal velocities that exceed the swimming capacities of the species/guild. As with lips, the impact of a standing wave on upstream fish passage will have to be assessed individually, as they will be influenced by characteristics of the obstacle.

Record if a standing wave is present or absent by entering a 'Y' for yes or 'N' for no. Assess if the standing wave creates a significant impediment to movement of fish across the obstacle by considering the individual features of the site, and the necessity for fish to have to travel through the feature to cross the obstacle.

As with lips, surveyors should consider the potential impact of a standing wave on fish passage on the basis of its size and location on an obstacle structure. It may be that a large standing wave is present but not creating difficulties as it can be easily bypassed by fish. It is not appropriate for surveyors to score these features at anything other than a coarse resolution. Therefore, when assigning passability scores for sanding waves there are only two categories that surveyors should consider when assessing the potential impact:

1. Standing wave present but does not appear to restrict fish passage.
2. Standing wave present and may locally restrict fish passage.

The individual passability assessments for the species/guild should be made according to the guidance on Standing waves in the passability assessment guidance tables.

Plate 11: Examples of free standing waves. Left: a large free-standing wave downstream from a flume of shallow angle. Note that the water surface shows an obvious rise at the point of the standing wave, with a white water crest. Right: a much smaller standing wave forming where water is returning to the surface downstream from a flat V weir.

4.1 f Levels of turbulence: complete for tables 4.1, 4.2 and 4.3
Water turbulence is a feature of water flow at riverine obstacles, occurring where water is forced through confined gaps (pipes or orifices), where air is entrapped creating cavitation (bubbles), or where high bed roughness in shallow water creates chaotic flow conditions, visible on the surface. The impact of turbulence on fish passage is generally related more to upstream migrations, and it can either assist fish passage by dissipating some of the energy of the water flow, and reducing water velocity, or can hinder fish passage by disorientating fish as they attempt to determine the direction to take up an obstacle. Turbulence can also adversely affect fish swimming performance of some species, by requiring increased energy expenditure to maintain position, or reduce swimming efficiency with entrapped air reducing the power of each tail sweep. The impact of turbulence at an obstacle site on fish movement will depend largely upon the size of the fish, the associated water velocity and depth, and the individual swimming performance of the species/guild.

Plate 12: Examples of turbulence at riverine obstacles. Top two pictures show high turbulence across the entire channel width, resulting from steep gradients down a structure and high channel discharge. The lower left picture shows moderate turbulence occurring across a large portion of the channel width at a sloping weir and the lower right shows low turbulence occurring at a localised point at a flat V weir.

Determining the level of turbulence can be difficult, but surveyors should use the presence of white water to indicate entrained air and **high** turbulence (Plate 12). High turbulence is likely to result in reduced passability for most fish species.

The levels of turbulence should be scored as **high**, **moderate** or **low**:

- **High turbulence** is best described by the presence of abundant entrained air bubbles with several directions of flow obvious along with a broken surface. Extensive white water is present across the entire cross-section of the channel.

- **Moderate turbulence** is exhibited a chaotic flow pattern with entrained air bubbles but surface area covered by white water is lower than for a high turbulence area.

- **Low turbulence** is indicated by the presence of mostly smooth unbroken water surfaces across the majority of the channel cross-section.

The individual passability assessments for the species/guilds should be made according to the guidance on levels of turbulence in the passability assessment guidance tables.

4.1 g Debris blocking structures: complete for tables 4.1, 4.2 and 4.3
River-borne debris can become trapped and accumulate at structures, blocking possible routes for fish passage and reducing the potential for passage. The extent to which debris blockages can prevent a fish species/guild from successfully passing a structure will depend upon the size of the fish, the location and severity of the blockage, and the size of any gaps remaining in the debris dam/pile through which fish may be able to pass (Plate 13).

If debris is present and is thought to present a blockage to fish passage then this should be recorded as a **yes**. If no debris is present then record **no**. It is possible for debris to be present at a structure and for it to only cause difficulties for fish travelling in one direction, as it may be bypassed by fish moving in the opposite direction.


Plate 13: Debris accumulation present at the inlet of a multi-pipe culvert array. Surveyors should assess if the debris is likely to cause restriction to fish movement at the current water level.

It is not appropriate for surveyors to score debris blocking features at anything other than a coarse resolution, due to inherent variability in their potential for impact on fish passage. Therefore, when assigning passability scores for debris blockages there are only two categories that surveyors should consider when assessing the potential impact:

1. Blockage present but does not appear to restrict fish passage
2. Blockage present and may locally restrict fish passage.

The individual passability assessments for the species/guild for both upstream and downstream movement should be made according to the guidance on debris blockages in the passability assessment guidance tables.

4.1 h Structures damaging to downstream (DS) migrants: complete for tables 4.1, 4.2 and 4.3
As water (and migrating fish) move downstream and across an obstacle, structures or accumulations of debris may be encountered that have the potential to cause physical harm to fish. Damaging structures are usually located at the foot of a plunging flow of water, obstructing water as it falls into the receiving pool downstream (Plate 14). Structures can be natural (e.g. a rock shelf or boulders at a waterfall) or man-made (e.g. concrete steps, gabion baskets or rip rap reinforcement). Where such structures are present, the potential for impact on the downstream movements of the species/guilds should be assessed accordingly.

Plate14: An example of a structure that could cause damage to downstream migrants. At this location, the bedrock shelf extending out from the stepped weir (indicated by the red dashed line) creates a structure that would potentially cause physical damage to fish carried down with water off the series of steps.

4.1 i Effective length: complete for sloping structures (Table 4.2) and for obstacles presenting steps (Table 4.3)
The effective length of a sloping surface (i.e. sloping weir or culvert) will influence the passability of the structure for fish, as longer lengths will require greater burst energy expenditure than shorter lengths. Longer effective lengths often exhibit reductions in water depth across the face, leading to difficulties for larger fish.

The effective length of the slope is the length that the fish would have to travel across the TS under the current water conditions. It should be measured using a tape measure or measuring staff. Measurements should be taken from the same points as hydraulic head (water surface to water surface). For structures presenting a slope (Table 4.2), the overall effective length will have a bearing upon upstream fish passage, and a passability score should be entered for each species/guild from the passability assessment guidance tables. For structures presenting steps (Table 4.3), the effective length is not considered critical to score for passability. Of greater importance is the series of vertical or near-vertical ascents that will have to be undertaken throughout the effective length of the obstacle. For Table 4.3, the effective length is measured and entered. This is used to determine the overall percentage of the slope and is not in itself given passability scores for species guilds (as indicated by hatched boxes).

The effective length of the sloping surfaces associated with passability scores are considered in classes (e.g. <10m or 10-30m).

The individual passability assessments for the species/guild for both upstream and downstream movement should be made according to the guidance on effective length in the passability assessment guidance tables.

4.1 j Slope of a structure: complete for obstacles presenting a slope (Table 4.2) and steps (Table 4.3)

The angle of the sloping surface will influence the passage of fish across an obstacle, as steeper angles will lead to increased water velocity and therefore increase the energy expenditure required to swim against the flow. Even when combined with a short effective length at a structure, a high slope angle can lead to a significant obstacle to fish movement, whereas a more shallow-angled sloping face may be passable for fish across a longer effective length.

For the purposes of the assessment it is adequate to estimate the slope by combining the effective length and hydraulic head measurements. The slope is estimated by dividing the hydraulic head by the effective length and expressing as a percentage (Figure 11). Slope should be measured and recorded for obstacles presenting a slope and for obstacles where steps are present.

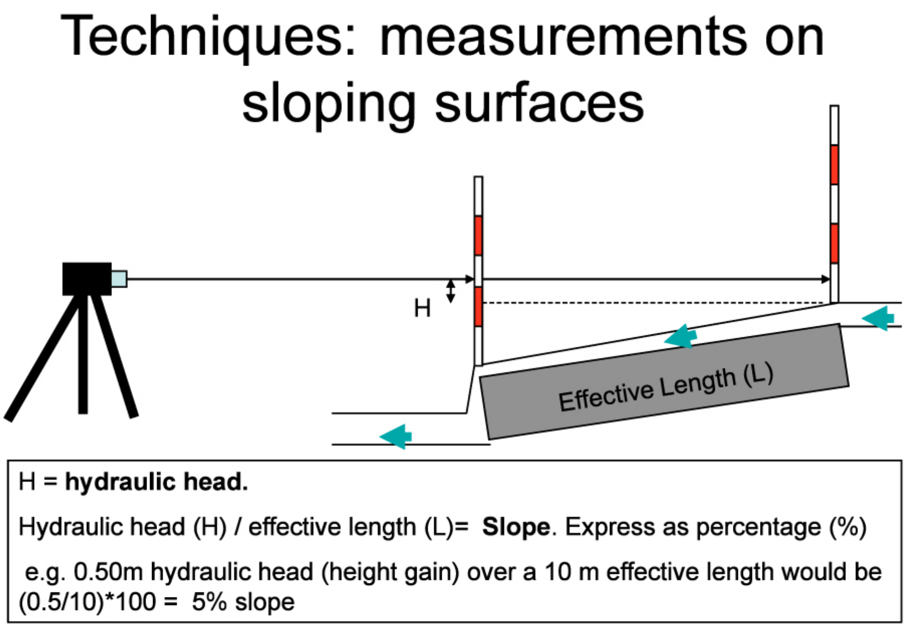


Figure 11: Measuring the effective length and slope of a sloping surface.

The potential impact on fish passage of a slope angle at a structure will have a higher potential to impact on fish passage when found in association with a longer sloping surface. Therefore the passability scores associated with slop angle are considered for categories of effective length as shown in the example of Table 4.

Table 4: An example of the relationship between slope angle and effective length of sloping surface used for passability scoring in the passability assessment guidance tables

Slope of structure	Passability score 1.0	Passability score 0.6	Passability score 0.3	Passability score 0.0
Effective length ≤ 3m	≤25%	26-40%	41-59%	≥60%
Effective length 4 - 9m	≤15%	16-20%	21-39%	≥40%

The individual passability assessments for the species/guild should be made according to the guidance on effective length and slope in the passability assessment guidance tables.

4.1 k Individual step/box characteristics = number, depth, length and height of steps: complete for obstacles presenting steps (Table 4.3)

The stepped structures can take a variety of forms, ranging from one or more smooth surfaces separated by short vertical faces designed to dissipate water energy and erosive power, to specifically designed series of boxes to facilitate fish passage. They are often located either upstream or downstream of a river crossing point, or are integrated into the design of a structure as a means of assisting fish passage, consisting of various designs of boxes separated by small vertical drops (Plate 15). The individual characteristics of the steps should be recorded at the TS, as the passability for the fish species/guilds will be assessed.

Plate 15: Examples of stepped structures. Left: the steps form a single complete transversal section from bank to bank. Right: the steps have been designed to facilitate fish passage across the structure.

Number of steps

Record the number of steps or boxes in the series that would have to be crossed by fish.

Height of the steps

Measure from water surface to water surface for each step, as with establishing the hydraulic head for a vertical drop. If height varies between steps, surveyors should **record the maximum height of a step** that would be encountered by fish as they travelled across the stepped structure.

Depth across the steps/pool depths

Measure or estimate the water depth on the steps/boxes or pools being created by the steps. This is important when considering the ability of fish to ascend up any vertical face into the next step or box. If water depth varies between steps, surveyors should **record the minimum depth of water on a step** that would be encountered by fish as they travelled across the stepped structure. This is then related to the maximum height of the step in the same way that effective pool depth is related to hydraulic head.

Length of the steps

Measure the length of the steps or boxes. This is important to consider for fish passage as longer steps/boxes (>2m) can provide resting locations for fish during their ascent, and enable water turbulence to be reduced in comparison to boxes with short (<1m) distances between the vertical drops. If length of the steps varies, surveyors should **record the minimum length of a step** that would be encountered by fish as they travelled across the stepped structure.

4.1 l Gap dimensions: complete for obstacles presenting gaps (Table 4.4)
Gaps are considered to be any relatively confined area through which water, and fish, are forced to pass when encountering a riverine structure (Plate 16). Gaps are therefore a feature of a number of man-made potential obstacles, such as pipe culverts, weirs used for gauging water flows where water is allowed through notches of known size, and sluices where water is released beneath the surface (undershot). Gaps are also a feature of naturally-occurring debris dams.

Plate 16: Examples of gaps at riverine structures through which fish have to pass to successfully move across the structure. Pipe culverts are shown in the pictures on the left, a rectangular notched gauging weir (top right) and debris dam (bottom right).

Gaps can provide physical obstacles to fish by being too small to enable the fish to pass through, and by creating accelerated water velocities. Fish can also be deterred from passing through gaps if they are darkened (i.e. pipe entrances) or do not have sufficient water depth. The severity of the gap in relation to fish passage will be related not only to the actual dimensions of the gap itself, but also with the surrounding structural features and flow conditions (water velocity and depth). In order to simplify for the purposes of this initial assessment, the gaps occurring at these structure are all considered to have similar potential to impact on fish passage with gap size being the key variable. It is therefore important that gaps are measured as accurately as possible. Wherever it is not safe to do so, the dimensions of any gaps should be estimated.

Notched weirs – notch shape and width

Gaps (notches) in gauging weirs are often regularly shaped in order to aid the measurement of flows. The measurements to take is the width of the notch **currently submerged at its widest point**. The water depth in the notch will already have been recorded during the transect of the structure crest in Section 3. The actual shape of the notch is recorded (as V-shaped, rectangular etc.) but not actually scored for fish passage. The passability score for the width of the notch should be assigned for both upstream and downstream movement using the passability assessment guidance tables.

Culverts – number of pipes and gap shape

Culverts are often formed using an array of pipes that split the flow between a number of orifices. Where multiple gaps occur (e.g. multiple pipe arrays), surveyors should choose **one representative gap size** for the structure and obtain measurements of the dimensions of gap width at the widest submerged point. The actual shape of the gaps should be recorded as **round**, **rectangular** or **other**, but is not in itself of direct relevance for fish passage. The number of pipes should likewise be recorded, but will not be assessed for fish passability scores. The passability scores should be assigned for both upstream and downstream fish movement only for the width of the representative gap size.

Culverts – tide gate gaps

Tide gates may be fitted to culverts as non-return valves preventing the influx of tidal surges in low-lying watercourses. Each tidal gate will comprise an orifice (or series of orifices) through which fish will have to pass, but restrictions on passage will be placed by the state of the tide. Passability scores should be assigned for both upstream and downstream movement, based on the ease by which movement appears to be possible through the structure at the time of survey. As with pipe arrays, choose one representative tide gate to make an assessment of its passability for fish using the passability assessment guidance table based on the gap width at its **widest submerged point.**

Debris dams – gaps

Gaps in naturally-formed debris dams are likely to be irregular shaped and varied in size. Surveyors should choose **one representative gap** though which fish would appear likely to make attempts to pass and obtain measurement or estimate of gap width. Make an assessment of the passability for fish using the passability assessment guidance table based on the gap width at its **widest submerged point.**

Undershot sluices – gaps

The gap in an undershot sluice will be submerged and therefore difficult or impossible to measure safely. Surveyors should only attempt to measure the dimensions if safe to do so, otherwise estimate the height and width of the orifice.

The passability scores for the individual species/guilds for the gap widths of the undershot sluice should be determined from the passability assessment guidance table.

Section 5 Abstraction points

Riverine water abstraction points are often associated with some other potential obstacle to fish movement, such as a weir. They can be associated with delays to fish migration by attracting fish to them and diverting them away from other more passable routes up an obstacle or down a channel. Abstraction points may have both an intake and return point (Figure 12) or just an intake. Abstraction points will normally have some arrangement of trash screens in place to prevent large debris entering the abstraction channel, and may or may not be fitted with screens specifically designed to prevent the passage of fish into the diversion channel.

An abstraction intake or return point may be allocated a transversal section by surveyors. However, unlike all other obstacle transversal section, Section 3 is not completed for abstraction points.

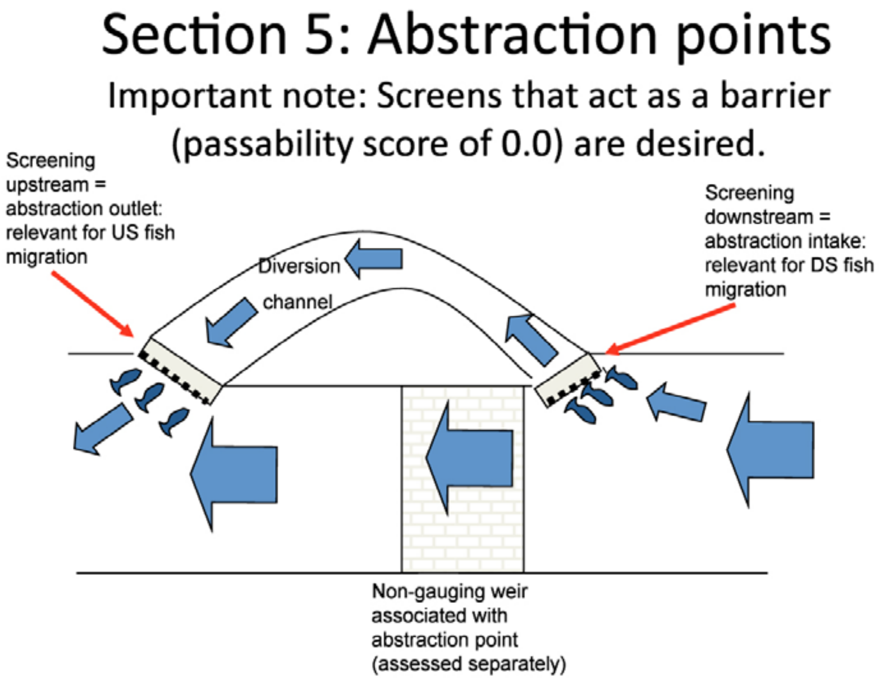


Figure 12: Schematic of the components of a commonly-occurring riverine abstraction point. A weir structure maintains a water level that is guided into a diversion channel. The diversion channel often returns to the main river at a point downstream from the weir. Both the entrance and exit points of the diversion channel are screened to prevent trash and fish from entering.

At some locations the proportion of flow entering and leaving an abstraction channel in relation to the main channel can be great enough to divert a significant number of passively moving fish, as they migrate downstream, into the diversion channel where they can be trapped or damaged. Additionally, the discharge from the return point can prove an attraction to upstream migrants and they can attempt to enter and possibly become trapped or damaged. To prevent this, in addition to trash screens, specially-designed fish screens are often attached at both the intake and return point (Plate 17). However, they may only be in operation during specific times of the year, such as the salmonid smolt run in spring.

Plate 17: Fish screening at a water offtake (top left) and return point (top right). Screens are often made of vertical bars and sloped to aid cleaning and increase the surface area to prevent concentration of flow at certain points. Detail of a 2mm gap bar screen designed to prevent the passage of salmonid smolts into a diversion channel is shown in the lower picture.

Screens are often designed with one species or size of fish in mind and may, therefore, be too large to prevent movement of smaller fish. If they are improperly designed, located or maintained, the acceleration of water in front of the screen can cause entrapment and fish death.

Section 5 allows surveyors to enter information for the abstraction intake and return point and to assess each location in terms of its possible impact on fish. It is important to note that the aim of screening at abstraction points is to physically stop fish access, and that the potential impact on riverine fish movement is **minimised** by the provision of a well designed and maintained screen. Therefore, for this assessment, a complete obstacle at an abstraction point with a good screen is scored as 0.0 (a complete obstacle to movement into the diversion channel and therefore no problem to fish movement in the main channel) and an ineffectively or non-screened abstraction point is scored as 1.0 (i.e. no obstacle into the diversion channel and therefore a problem to fish movement in the main channel). This is a change from the way of thinking for other features of riverine obstacles and will require attention from surveyors addressing abstraction screening points. Where screens are not present, movement into the diversion channel is possible and this is considered to be a potential impact on the fish population.

An exception to this scoring procedure for passability at abstraction points occurs when **all the water is being drawn through a diversion channel** and functional screening is preventing any movement up or down the channel. In this instance, the passability scores for the screens at the abstraction point must be considered as complete obstacles, and passability scored as 0.0.

For the purposes of this assessment, the surveyor should assess the abstraction points that are relevant to upstream migrants (US) and downstream migrants (DS). In many cases only one point will be present. Surveyors should note the position of the abstraction points, whether effective screens are present, and condition and flow conditions at the screens. Passability scoring is only undertaken for screen gap size, effectiveness of the screens and attraction flow to the abstraction point, but the other information should be collected as it may be required for further assessment.

5.3 Position in relation to main channel flow
Abstraction points are normally either in a bankside or streambed location. Streambed abstraction points may have more of a potential impact on fish species that are associated more with this area of the channel (i.e. lamprey and eel) than bankside locations. Record if located on **left bank/right bank** or **streambed**. No further assessment in terms of passability for fish are required in relation to position.

5.4 Angle to channel flow
The angle of the abstraction or water return point in relation to the main flow may influence how attractive the location is to fish with more acute angles for intakes, presenting a more likely face at which passively- migrating fish moving downstream may encounter. For the returning water, the angle is less important to upstream migrating fish. Attractiveness is controlled more by water volume relative to the river channel. Record the angle as **perpendicular**, **angled** or **parallel** to the channel flow. No further assessment in terms of passability for fish are required in relation to angle to channel flow.

Mesh gap size
Measure the distance between the edges of the bars or mesh (i.e. the gap size that is effective for fish) and record in metres (i.e. a 5mm gap is 0.05m). Record **none** if no screens are present. The potential impact of the screens will depend upon the size of the fish species/guilds, and so it is necessary to consult the passability guidance tables to determine the appropriate score for the screen gap size present.

Effective screening?
Record **yes** if screens are intact and in good state of repair with no holes or distortions (i.e. effective). Debris accumulation can also impact upon the effectiveness of the screens. Record **no** if in disrepair or clogged with debris (i.e. ineffective). Record **none** if no screens are present. Consult the passability guidance tables to determine the appropriate score considering the effectiveness of the screens.

Proportion of the flow going through abstraction
Estimate the amount of the river flow that is leaving/or entering via the abstraction point. Be aware that the discharge from the return point may be significantly less than that leaving at the intake. Express this as a **percentage (%)** of the total channel flow.

Approaching depth and velocities to screen
Use a velocity meter to establish the range of water depths and average column water velocities within 1m of the side of the screen facing the river channel. **Only do this if water depth and flow conditions make it safe to do so, and estimate if not**. These measurements should only be used as a guide to estimate the severity of the attraction flow for fish approaching from either upstream (DS screening point) or downstream (upstream screening point) when compared to the conditions in the main river channel. Consult the passability guidance tables to determine the appropriate score considering the attractiveness of the approaching flow conditions.

The individual scores should be determined from the passability assessment guidance table and the completed Section 5 used to inform the overall passability scores assigned for the abstraction point in Section 6.

Section 6 Passability assessment for an individual transversal section

The table presented in this section enables the surveyor to summarise the information collected in sections 3, 4 (vertical, sloping and stepped features) and 5 (abstraction points), to provide a passability score for each species/guild for each individual transversal section (TS). The table allows scores to be estimated for each species/guild for both upstream and downstream migration. There are boxes to enter the degree of estimation and also to record an estimate of the passability under high water flows. Hatched boxes should not be completed as they do not require individual passability scoring.

Ideally this section should be completed on site, but it is possible to do the assessment of passability by examining photos and information collected in previous sections.

Completing the passability assessment for an individual transversal section:

1. Where it is safe to do so, surveyors should position themselves downstream from the TS being assessed and consider the order in which a fish moving upstream would encounter each individual component feature of the TS. This will allow surveyors to order their comparisons between the various tables. Where this is not possible, the photograph taken from downstream should be used.

2. Surveyors should start with the completed Section 3 and consider the passability scores for the TS transects. A single upstream (US) passability score should be selected for each species/guild and indicated by circling (red circles). With regards to selecting a final US passability value for the species/guild across the TS, the decision has to be based not only on the actual scores collected at the points, but also on their actual locations in relation to each other, and the distance between them. The appropriate value to enter has to be left to the surveyors' discretion (this is addressed in Section 3). Normally, this will be the **lowest** score (indicated by the red circled values in Figure 13), as this reflects the potential limiting point across the obstacle for fish passage. There will only be one score per species/guild for downstream migration (DS) from the inlet/crest of the structure, so the surveyor has no choice to make here.

3. VELOCITIES AND DEPTHS FOR AN INDIVIDUAL TRANSVERSAL SECTION (TS) *(except for abstraction points)*	Site ref no: TW / LW / WW / 001	TS ID: 1

Wetted width (m)																				
		LB				RB	LB				RB	LB				RB	No barrier	Partial barrier Low Impact	Partial barrier High Impact	Complete barrier
Transect point		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5				
DEPTH (M)		**0.05**	**0.15**	**0.1**	**0.16**	**0.25**	**0.06**	**0.1**	**0.26**	**0.13**	**0.25**	**0.09**	**0.12**	**0.15**	**0.1**	**0.19**				
VELOCITY	0.6 depth	**0.4**	**0.55**	**1.2**	**2.6**	**1.9**	**1.8**	**2.5**	**2.9**	**2**	**2.6**	**1.4**	**1.5**	**1.5**	**1.1**	**0.8**	**1.0**	**0.6**	**0.3**	**0.0**
	Bed	**0.2**	**0.5**	**1.1**	**1.4**	**1.2**	**1.2**	**1.8**	**1.5**	**0.9**	**1.6**	**1.2**	**1.2**	**1.1**	**1**	**0.6**				
Adult Salmon (AS)		**0.0**	**1.0**	**0.3**	**0.3**	**1.0**	**0.0**	**0.3**	**0.3**	**0.6**	**0.3**	**0.3**	**0.6**	**1.0**	**0.3**	**1.0**	≥0.15 m	0.11 – 0.14 m	0.08 – 0.1m	≤0.07 m
		US			DS		US			DS		US			DS					
use velocities at 0.6 depth		**1.0**					**0.6**					**1.0**			**1.0**		≤2 m/s	2.1 – 2.5 m/s	2.6 – 2.9 m/s	≥3 m/s
Adult Trout (AT)		0.0	1.0	1.0	0.3	1.0	0.6	0.3	0.0	0.3	0.3	0.6	1.0	1.0	1.0	1.0	≥0.1m	0.075 – 0.09 m	0.06 – 0.074 m	≤0.05 m
		US			DS		US			DS		US			DS					
use velocities at 0.6 depth		1.0					0.6					1.0			1.0		≤2 m/s	2.1 – 2.5 m/s	2.6 – 2.9 m/s	≥3 m/s
Adult Grayling (AG)		0.0	1.0	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.6	1.0	1.0	1.0	1.0	≥0.1m	0.075 – 0.09 m	0.06 – 0.074 m	≤0.05 m
		US			DS		US			DS		US			DS					
use velocities at 0.6 depth		1.0					0.3					1.0			1.0		≤1.5 m/s	1.6 – 1.9 m/s	2 – 2.8 m/s	≥2.9 m/s
Cyprinids (C)		0.0	1.0	0.6	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.6	0.6	0.6	0.6	1.0	≥0.1m	0.075 – 0.09 m	0.06 – 0.074 m	≤0.05 m
		US			DS		US			DS		US			DS					
use velocities at 0.6 depth		1.0					0.3					1.0			1.0		≤1 m/s	1.1 – 1.5 m/s	1.6 – 1.9 m/s	≥2 m/s
Adult Lamprey (AL)		0.3	1.0	0.6	0.3	0.3	0.3	0.0	0.0	0.6	0.0	0.3	0.3	0.3	0.3	0.6	≥0.08 m	0.06 – 0.079 m	0.04 – 0.059 m	≤0.03 m
		US			DS		US			DS		US			DS					
use velocities at streambed		1					0.6					0.6					≤0.5 m/s	0.6 – 0.99 m/s	1 – 1.4 m/s	≥1.5 m/s
Juvenile Eel (JE)																	≥0.05 m	0.03 – 0.049 m	0.021 – 0.03 m	≤0.02 m
		US			DS		US			DS		US			DS					
use velocities at streambed		CLIMB SUB					CLIMB SUB					CLIMB SUB					≤0.3 m/s	0.31 – 0.49 m/s	0.5 – 0.79 m/s	≥0.8 m/s
climbing substrate *		1.0					1.0					1.0								
Juvenile Salmonids (JS)		0.3	1.0	1.0	0.3	0.6	0.6	0.3	0	0.3	0.3	1.0	1.0	1.0	1.0	1.0	≥0.08 m	0.06 – 0.079 m	0.031 – 0.059 m	≤0.03 m
		US			DS		US			DS		US			DS					
use velocities at 0.6 depth		1.0					0.6					1.0			1.0		≤1.5 m/s	1.51 – 1.9 m/s	2 – 2.8 m/s	≥2.9 m/s
Juvenile Lamprey (JL)												1.0	1.0	1.0	1.0	1.0	≥0.02 m	0.011 – 0.019 m	0.006 – 0.01 m	≤0.005 m
												US			DS					
															1.0		n.a.	n.a.	n.a.	n.a.
Adult Eel (AE)												1.0	1.0	1.0	1.0	1.0	≥0.08 m	0.06 – 0.079 m	0.031 – 0.059 m	≤0.03 m
												US			DS					
															1.0		n.a.	n.a.	n.a.	n.a.

Notes:

For Upstream passability assessment:

1.Use both the **depth** and relevant **velocity** data.

2. Choose the **most limiting factor** that applies to the species/guild = either velocity or depth (e.g. for adult salmon (AS) if velocity is < 2.0 but depth is 0.09m then score for this point is 0.3).

3.Scan through the scores and circle the **maximum passability** score for each applicable location (inlet, midpoint, outlet)

For downstream passability assessment:

1.Only compete for **inlet**

2.Use only the **depth data** to determine the passability score

3.Scan through the scores and circle the **maximum passability** score

Figure 13: Example of selecting a final US passability score for a transversal section for adult salmon, trout and grayling from the water depth and velocity data collected in Section 3.

3. Surveyors then need to assign the Upstream passability scores to the measurements and assessments of features collected in Section 4 (tables 4.1, 4.2, 4.3, 4.4) or Section 5 if an abstraction point. The passability guidance tables should be used to determine the appropriate score in the table for each species/guild (Figure 14). Care should be taken to ensure that the correct table is used for the obstacle structure and for the species/guild.

2 Slope/swim

Table 1: Adult salmon U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	Passability score 1.0	0.6	0.3	0.0
Effective length of structure For all structures:	≤ 10 m	11 – 30 m	31 - 99 m	≥ 100 m
Slope of structure Structure effective length ≤ 3m Structures effective length 4-9m Structures effective length ≥10m	 ≤ 25% ≤15% ≤ 5%	 26 – 40% 16 - 20% 6 – 10%	 41 – 59% 21 - 39% 11 – 14%	 ≥ 60% ≥ 40% ≥ 15%
Effective pool depth Only score for structures ≤ 2m effective length AND ≤ 1.4m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris / sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.50 m	0.25 - 0.49 m	0.16 - 0.26 m	≤ 0.15 m

Figure 14: An example from the passability guidance tables showing the scores for Adult salmon at a sloping/swim feature. These tables are used to assign the scores in section 4.

4. Once this has been done, surveyors should highlight the **lowest** scores for each species/guild in the appropriate table (tables 4.1, 4.2, 4.3, 4.4) or table 5. Using the example of a simple sloping weir used previously, the information recorded along the top line of Table 4.2 (Red text in Figure 15) is used to generate the passability scores. For example, using the appropriate passability table (4.1), the slope of 22% and effective length of 7.5m results in a score of 0.3 for adult Atlantic salmon. This value is entered into the correct box. Once each row is completed, the lowest scores in Table 4 should be highlighted (circled in red in Figure 15) for each species guild for upstream passage. The same procedure should be undertaken to establish the **lowest** scores for downstream passage for each species/guild.

4.2.FOR BARRRIERS PRESENTING A SLOPE: WEIRS , CULVERTS, FORDS BRIDGE FOOTINGS , RAPIDS ,CHUTES AND DIVERSION CHANNELS

	Total hydraulic head (inlet-outlet, m)	Effective length(m)	% Slope	Eff. pool depth (m)	Effective resting locations? (Y,N)	Lip (Y, N)		Standing wave (Y,N)	Levels of turbulence (H, M, L)	Debris blocking structure? (Y,N)		Structures damaging to DS migrants present? (Y,N)
						crest	foot					
measure	1.65	7.5	22	0.75	Y	N	N	none	H	N		N
										US	DS	DS
AS		1.0	0.3	NA	1.0	1.0	1.0	1.0	0.3	1.0	1.0	1.0
AT		1.0	0.3	NA	1.0	1.0	1.0	1.0	0.3	1.0	1.0	1.0
AG		0.6	0.0	NA	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0
C		0.3	0.0		1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0
AL		0.6	0.0		1.0	1.0	1.0	1.0	0.0	1.0		
JE		NA							NA	1.0		
JS		0.6	0.0	NA	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0
JL											1.0	1.0
AE											1.0	1.0

Figure 15: An example of a completed Section 4.2 for a sloping weir. Lowest passability scores have been circled in red and should be used along with the scores in Section 3 to complete Section 6 of the TS.

5. For each individual species or guild, surveyors should first scan through all the **upstream** passability scores obtained from sections 3, 4 (and 5 if an abstraction point) for the transversal section, and select the **lowest score** encountered in Section 6 (i.e. the feature that presents the greatest challenge or obstacle to that particular fish species passage). The corresponding box for 'current conditions' in Section 6 should then be ticked. This is the final passability score for the TS for this species/guild and will reflect the probability of passage upstream across the transversal section, based firstly on water velocity and depth across the structure (Section 3), and also taking into account other features such as vertical height, effective depth of pool and influence of structures such as lips or gap dimensions (Sections 4 or 5).

6. Surveyors should then scan through the **downstream** scores for the species/guild and repeat the procedure, entering the **lowest score**.

IMPORTANT: If a circled upstream passability scores from Section 3 for a species/guild is ZERO then the overall passability score for the transversal section to be entered in Section 6 has to be ZERO, regardless of other features scores.

If any upstream passability scores of ZERO have been recorded against the species/in sections 4 or 5 then the overall passability score for the transversal section to be entered in Section 6 has to be ZERO, regardless of other features scores.

7. Surveyors are then asked to consider the situation for fish passage across the TS under elevated flow conditions. It is important for surveyors to attempt to consider the severity of the transversal section under higher flows, and enter an estimate for passability for each species/guild. This is useful to indicate if passage is likely be improved or reduced by higher flow across the TS. It is recognised that any score entered here is extremely subjective and surveyors should therefore **not** allocate a lot of time to this section. However, the completion of this section may provide some useful indication of whether the obstacle will remain completely impassable for the species/guild under higher flow conditions.

To give an example of where this estimation under elevated flows may be useful, a 3m vertical waterfall is likely to remain with a passability score of 0.0 for most species, regardless of the water flow conditions, as the vertical height difference is the limiting factor. This would therefore be reflected in the scores for passability remaining the same for current and elevated flow conditions. However, a 1m high gently sloping weir may give scores of 0.0 under low flow conditions as a result of there being insufficient water depth for certain fish species to pass. But, with an elevation in water level, it could be envisaged that the limiting factor of water depth may be removed, enabling a higher chance of passage. In this example the surveyor may choose to indicate this by entering a higher passability score for elevated conditions.

8. Once the passability scores have been entered, surveyors should then tick the 'Degree of estimation' box to indicate whether all required measurements were taken, partially taken or fully estimated. This will provide an estimate of the degree of confidence to be placed on the final passability scores.

9. Once completed, surveyors should repeat the procedure for each TS at the obstacle location, completing a separate Section 6 table for each TS (Figure 16).

The outcome of the assessment of each individual transversal section in Section 6 will enable comparison of the passability scores for each species/guild and each potential route across the entire obstacle in Section 7.

6. PASSABILITY ASSESSMENT FOR AN INDIVIDUAL TRANSVERSAL SECTION (TS)

Site Ref No. : TW / LW / WW / 001

Transversal Section ID:		UPSTREAM MIGRATION							DOWSTREAM MIGRATION						
						Degree of estimation							Degree of estimation		
		No barrier	Partial barrier Low impact	Partial barrier High impact	Complete barrier	All measurements undertaken	Measurement partially undertaken	All measurements estimated	No barrier	Partial barrier Low impact	Partial barrier High impact	Complete barrier	All measurements sundertaken	Measurement partially undertaken	All measurements estimated
		1.0	0.6	0.3	0.0				1.0	0.6	0.3	0.0			
Adult Salmon (AS)	current conditions			✓		✓			✓				✓		
	high flows		✓						✓						
Adult Trout (AT)	current conditions			✓		✓			✓				✓		
	high flows		✓						✓						
Adult Grayling (AG)	current conditions				✓	✓			✓				✓		
	high flows				✓				✓						
Cyprinids (C)	current conditions				✓	✓			✓				✓		
	high flows				✓				✓						
Adult Lamprey (AL)	current conditions				✓	✓									
	high flows				✓										
Juvenile Eel (JE)	current conditions	✓				✓									
	high flows	✓													
Juvenile Salmonid (JS)	current conditions				✓				✓				✓		
	high flows				✓				✓						
Juvenile Lamprey (JL)	current conditions								✓				✓		
	high flows								✓						
Adult Eel (AE)	current conditions								✓				✓		
	high flows								✓						

Figure 16: An example of a competed Section 6 for the sloping weir. Ticks placed against the appropriate passability score determined from sections 3 and 4. Estimations for passability have been entered for elevated flows and the degree of estimation has been completed.

Section 7 Final passability assessment for site

This table should be the end point of the assessment, and combines the passability assessments of each TS at the obstacle location as compiled in Section 6 is a summary of all previous transversal sections assessments (Section 6), reflecting any potential passage ways for different fish species both upstream and downstream and for both current and high flow conditions.

It is possible for fish to preferentially use one area on the obstacle (i.e. a TS) to move upstream and another one to move downstream. It is also likely that certain areas on an obstacle will be used by certain species (or sizes) of fish, whereas different locations will be preferred as passage routes for others.

Surveyors should use all the Section 6 tables (one is completed for each TS at the obstacle location) and scan the scores, selecting the **highest** for each species/guild for both the upstream and downstream directions. This will therefore reflect if a certain TS at an obstacle location provides a possible passage route for a species/guild for a certain direction, and enables the surveyor to incorporate the complexity of a structure into the final assessment (Figure 17).

Currently dry channels should be considered in Section 7, and notes on the potential for areas to provide fish passage routes under elevated flows should be made in the Notes section. These dry channels should be assessed in conjunction with the scores given to each of the transversal section in Section 6 to provide a final score that evaluates all the options available to fish under elevated flows. It is recognised that this assessment will be subjective, but notes and scores may be useful to guide further investigation at the location.

Example
A sloping weir has three transversal sections A, B, C.
Passability scores for adult Atlantic salmon upstream for each TS are A = 0.6, B = 0.3 and C = 0.3.
Passability scores for adult Atlantic salmon downstream are A = 0.3, B = 1.0 and C = 0.3.
The final obstacle passability score for Atlantic salmon at the current conditions would be:

Upstream = 0.6 i.e. low impact partial obstacle (fish utilising transversal section A).

Downstream = 1.0 no obstacle (fish utilising transversal section B)

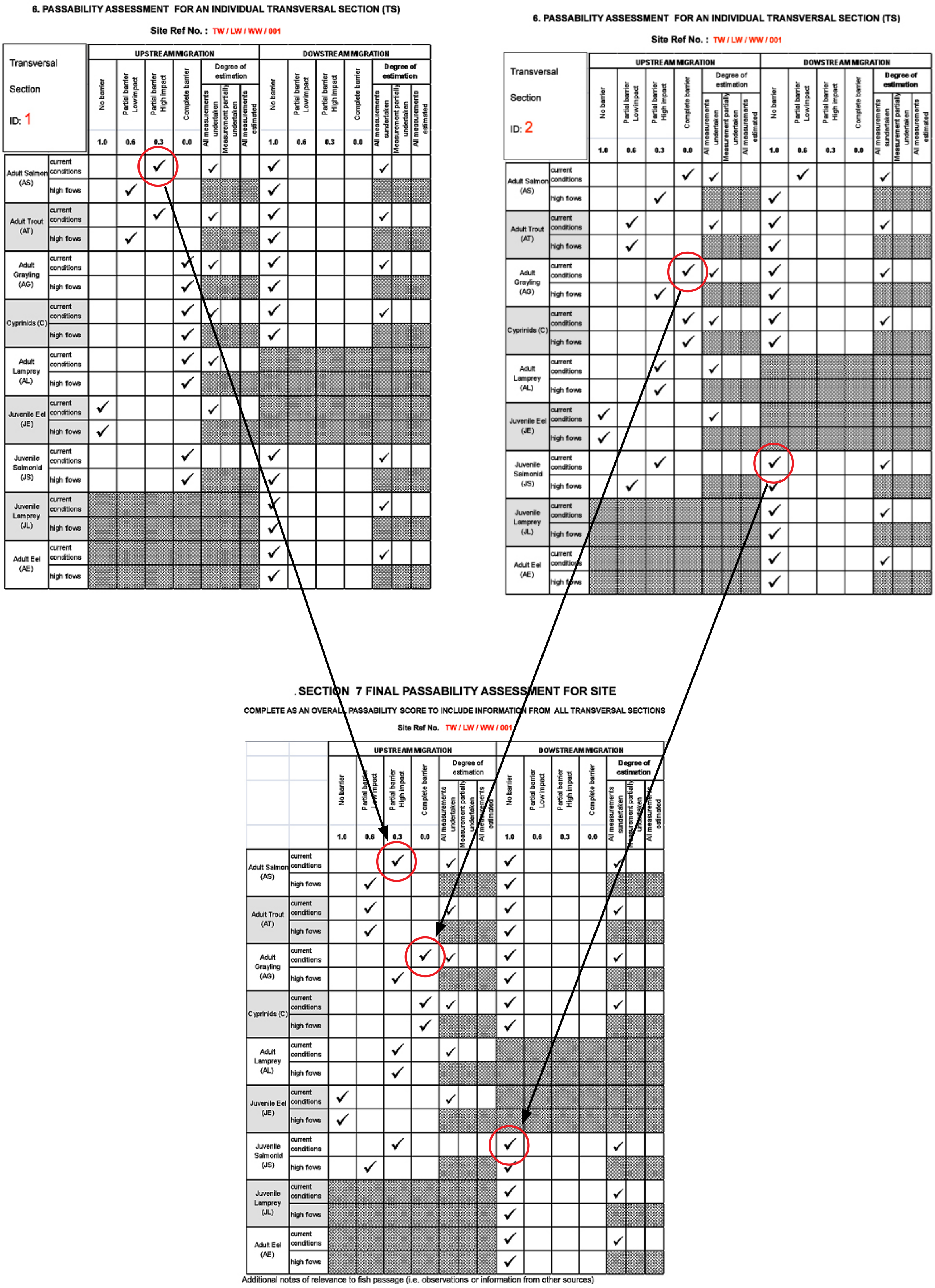
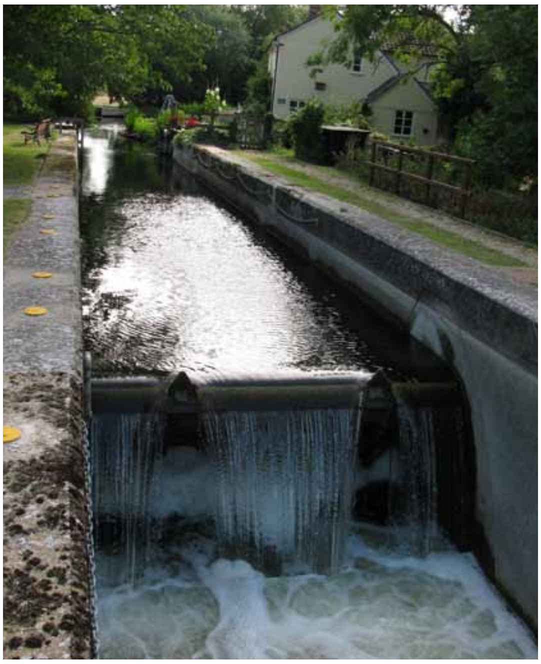


Figure 17: An example of completed Section 7 at an obstacle location with two transversal sections (resulting in 2 x completed Section 6 tables). The highest scores from Section 6 tables are used to populate the Section 7 table and provide a set of final passability scores for the obstacle location.

Appendix 1 Examples of riverine obstacles



Vertical weir with smooth wooden crest. Water clearly plunging down away from face of the structure.

Vertical weir with smooth wooden crest.

Vertical weir with smooth concrete crest.

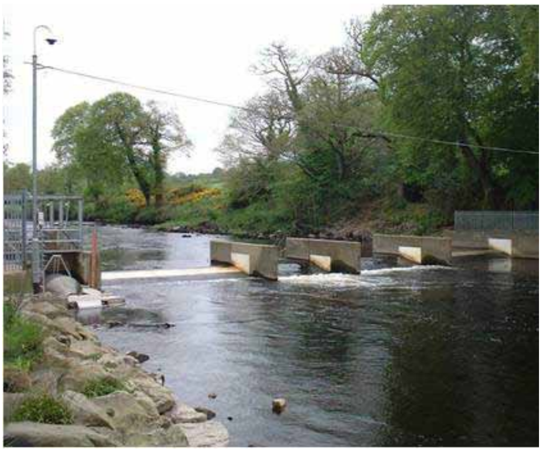
Vertical weir with masonry face in disrepair.

Vertical notched weir with steel crest and notch section fixed to concrete.

Sloping weir with masonry face and stone coping across crest.

Sloping weir with masonry face.

Crump weir with smooth concrete face.



Compound crump weir with sections of varying heights separated by concrete walls.

Flat –V type weir with smooth concrete face

Gauging flume with smooth concrete face and three crest heights separated by vertical walls.

Gauging flume with smooth concrete face

Stepped weir comprising five equally-sized steps.

Stepped weir comprising three steps of differing dimensions.

Stepped weir comprising four steps of differing dimensions.

Stepped weir – a pool and traverse style fishway with three vertical steps.

A small road crossing ford with a lip along the crest and a vertical outlet drop.

Ford with a smooth concrete face and small vertical outlet drop.

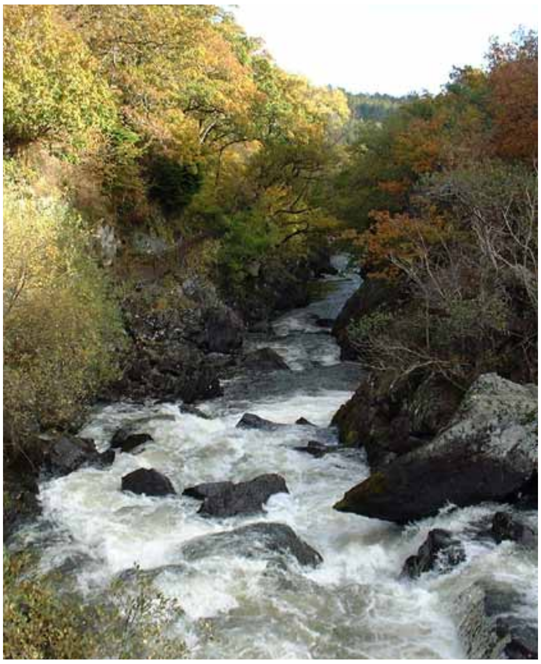
Ford with smooth concrete face and vertical outlet drop.

Bridge footing with masonry face and small vertical drop.

A culvert beneath a road bridge with smooth concrete floor and sides. Some bed substrate has accumulated on the culvert floor. Boulder placement has been undertaken downstream to minimize the impact of the vertical outlet drop.

Waterfall - a single vertical drop into a large plunge pool.

Natural waterfall - a series of two waterfalls over bedrock.

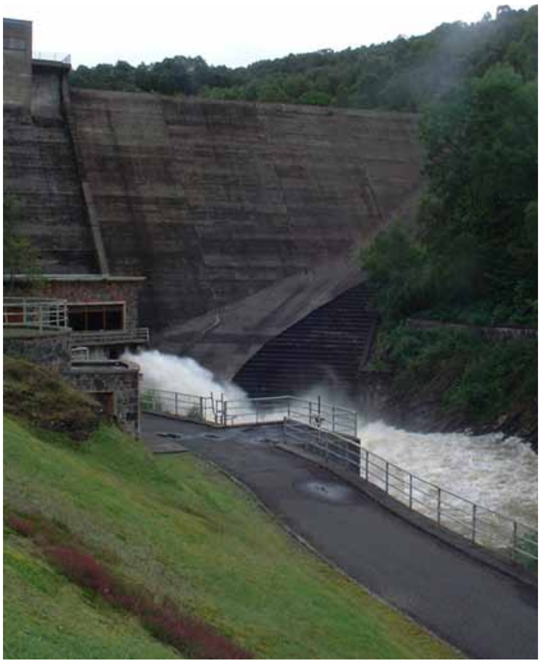


A complex series of rapids.

A single rapid section.

Debris dam.

Debris dam.



A water storage dam.

A single pipe culvert with concrete bridge apron extending out on downstream side.

Twin pipe culvert with concrete sandbag reinforcing banks and bed.

A multi pipe array culvert comprising nine pipes within a precast concrete bridge section.

Overshot sluice under high flow conditions.

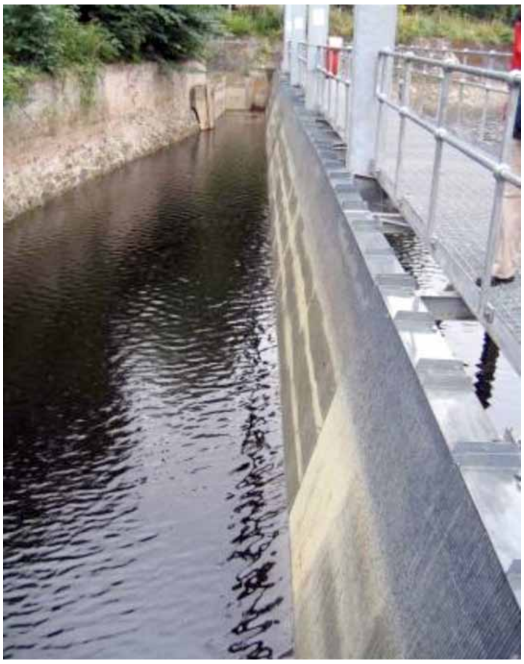
Overshot sluice.

Undershot sluice.

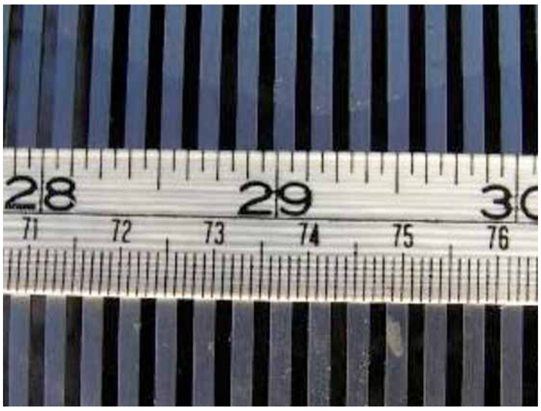
Abstraction point intake screens upstream from the crest of a flow diversion weir.

Abstraction point intake screens showing vertical bar arrangement.

Abstraction point outlet screens on stream bed showing vertical trash bar screening.



Long angled fish screens at an abstraction point intake.



Detail of screens designed to prevent the passage of salmonid smolts.

Appendix 2 Passability assessment guidance tables for sections 4 and 5

1 Vertical drop/jump obstacles

Table 1: Adult salmon U/S (for vertical weirs, culverts fords and bridge footings with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Hydraulic head For all structures: For debris dams: if gap sizes > 0.25 m	≤ 0.60 m Any height	0.61 – 1.00 m Any height	1.01 – 1.39 m Any height	≥ 1.40 m Any height
Effective pool depth For all structures:	Pool depth ≥ hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.3 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For notched weirs, culverts, waterfalls, debris dams and overshot sluices:	≥ 0.50 m	0.25 - 0.49 m	0.16 - 0.24 m	≤ 0.15 m

Table 2: Adult trout U/S (for vertical weirs, culverts fords and bridge footings with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Hydraulic head For all structures: For debris dams: if gap sizes > 0.2 m	≤ 0.40 m Any height	0.41 – 0.60 m Any height	0.61 – 0.99 m Any height	≥ 1.0 m Any height
Effective pool depth For all structures:	Pool depth ≥ hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.3 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For notched weirs, culverts, waterfalls, debris dams and overshot sluices:	≥ 0.30 m	0.20 - 0.29 m	0.11 - 0.19 m	≤ 0.10 m

Table 3: Adult grayling U/S (for vertical weirs, culverts fords and bridge footings with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Hydraulic head For all structures: For debris dams: if gap sizes > 0.2 m	≤ 0.20 m Any height	0.21 – 0.25 m Any height	0.26 – 0.29 m Any height	≥ 0.30 m Any height
Effective pool depth For all structures:	Pool depth ≥ hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.3 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For notched weirs, culverts, waterfalls, debris dams and overshot sluices:	≥ 0.30 m	0.20 - 0.29 m	0.11 - 0.19 m	≤ 0.10 m

Table 4: Cyprinid U/S (for vertical weirs, culverts fords and bridge footings with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Hydraulic head For all structures: For debris dams with porous gap sizes > 0.2 m	≤ 0.10 m Any height	0.11 – 0.15 m Any height	0.16 – 0.24 m Any height	≥ 0.25 m Any height
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For notched weirs, culverts, waterfalls, debris dams and overshot sluices:	≥ 0.20 m	0.10 - 0.19 m	0.06 - 0.09 m	≤ 0.05 m

Table 5: Juvenile salmonids U/S (for vertical weirs, culverts fords and bridge footings with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Hydraulic head For all structures: For debris dams with porous gap sizes > 0.2 m	≤ 0.10 m Any height	0.10 – 0.24 m Any height	0.25 – 0.34 m Any height	≥ 0.35 m Any height
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For notched weirs, culverts, waterfalls, debris dams and overshot sluices:	≥ 0.15 m	0.10 - 0.14 m	0.06 - 0.09 m	≤ 0.05 m

Table 6: Adult lamprey U/S (for vertical weirs, culverts fords and bridge footings with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Hydraulic head For all structures: For debris dams with porous gap sizes > 0.2 m	≤ 0.15 m Any height	0.16 – 0.25 m Any height	0.26 – 0.29 m Any height	≥ 0.30 m Any height
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	Present and may locally restrict fish passage	-	-
Gap width For notched weirs, culverts, waterfalls, debris dams and overshot sluices:	≥ 0.15 m	0.10 - 0.14 m	0.06 - 0.09 m	≤ 0.05 m

Table 7: Juvenile eel U/S (for vertical weirs, culverts and fords with outlet drop, waterfalls, debris dams and overshot sluices)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Climbing substrate For all structures:	Present	-	-	-
Water turbulence associated with structure In absence of climbing substrate	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	Present and may locally restrict fish passage	-	-

2 Slope/swim

Table 1: Adult salmon U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective length of structure For all structures	≤ 10 m	11 – 30 m	31 – 99 m	≥ 100 m
Slope of structure Structure effective length ≤ 3m Structures effective length 4-9m Structures effective length ≥ 10m	≤ 25% ≤15% ≤ 5%	26 – 40% 16 - 20% 6 – 10%	41 – 59% 21 - 39% 11 – 14%	≥ 60% ≥40% ≥ 15%
Effective pool depth Only score for structures < 2m effective length AND < 1.4m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.50 m	0.25 - 0.49 m	0.16 - 0.26 m	≤ 0.15 m

Table 2: Adult trout U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective length of structure For all structures	≤ 10 m	11 – 30 m	31 – 99 m	≥ 100 m
Slope of structure Structure effective length ≤ 3m Structures effective length 4-9m Structures effective length ≥ 10m	≤ 25% ≤15% ≤ 5%	26 – 40% 16 - 20% 6 – 10%	41 – 59% 21 - 39% 11 – 14%	≥ 60% ≥40% ≥ 15%
Effective pool depth Only score for structures < 2m effective length AND < 1.0m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.30 m	0.20 - 0.29 m	0.11 - 0.19 m	≤ 0.10 m

Table 3: Adult grayling U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Effective length of structure For all structures	≤ 5 m	6 – 15 m	16 – 99 m	≥ 100 m
Slope of structure Structure effective length ≤ 3m Structures effective length 4-9m Structures effective length ≥ 10m	≤ 15% ≤10% ≤ 5%	16 – 25% 11 - 15% 6 – 10%	26 – 39% 16 - 19% 11 – 14%	≥ 40% ≥20% ≥ 15%
Effective pool depth Only score for structures ≤ 1m effective length AND ≤ 0.3m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.30 m	0.20 - 0.29 m	0.11 - 0.19 m	≤ 0.10 m

Table 4: Cyprinids U/S for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective length of structure For all structures	≤ 1 m	2 – 6 m	7 – 19 m	≥ 20 m
Slope of structure Structure effective length ≤ 1m Structures effective length 2-4m Structures effective length ≥ 5m	≤ 15% ≤10% ≤ 5%	16 – 25% 11 - 15% 6 – 10%	26 – 39% 16 - 19% 11 – 14%	≥ 40% ≥20% ≥ 15%
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.20 m	0.10 - 0.19 m	0.06 - 0.09 m	≤ 0.05 m

Table 5: Juvenile salmonids U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective length of structure For all structures	≤ 3 m	4 – 9 m	10 – 49 m	≥ 50 m
Slope of structure Structure effective length ≤ 3m Structures effective length 4-9m Structures effective length ≥ 10m	≤ 15% ≤10% ≤ 5%	16 – 25% 11 - 15% 6 – 10%	26 – 39% 16 - 19% 11 – 14%	≥ 40% ≥20% ≥ 15%
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.15 m	0.10 - 0.14 m	0.06 - 0.09 m	≤ 0.05 m

Table 6: Adult lamprey U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective length of structure For all structures	≤ 3 m	4 – 9 m	10 – 49 m	≥ 50 m
Slope of structure Structure effective length ≤ 3m Structures effective length 4-9m Structures effective length ≥ 10m	≤ 15% ≤10% ≤ 5%	16 – 25% 11 - 15% 6 – 10%	26 – 39% 16 - 19% 11 – 14%	≥ 40% ≥20% ≥ 15%
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-
Gap width For culverts, debris dams and undershot sluices:	≥ 0.15 m	0.10 - 0.14 m	0.06 - 0.09 m	≤ 0.05 m

Table 7: Juvenile eel U/S (for sloping weir, culverts, fords and bridge footings, rapids, undershot sluices and sloping fishways)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Climbing substrate For all structures:	Present	-	-	-
Effective length of structure In absence of suitable climbing substrate:	≤ 3 m	4 – 6 m	7 – 29 m	≥ 30 m
Water turbulence associated with structure In absence of climbing substrate:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	Present and may locally restrict fish passage	-	-

3 Steps/series of jumps

Table 1: Adult salmon U/S for stepped weirs, stepped fish passes or complex natural features

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective pool depth Only score for structures < 2m effective length AND < 1.4m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Individual step/box characteristics Maximum step hydraulic head Minimum water depth Minimum length of step/box	≤ 0.4 m ≥ 1.0 x step hydraulic head ≥ 2.0 m	0.41 – 0.60 m ≥ 0.6 x step hydraulic head 1.0 – 1.9 m	0.61 -0.69 m ≥ 0.4 - 0.5 x step hydraulic head 0.4 – 0.9 m	≥ 0.7 m ≤ 0.3 x step hydraulic head ≤ 0.3 m
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-

Table 2: Adult trout U/S (for stepped weirs, stepped fish passes or complex natural features)

Criteria	**Passability score**			
	1.0	**0.6**	**0.3**	**0.0**
Effective pool depth Only score for structures < 2m effective length AND < 1.0m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Individual step/box characteristics Maximum step hydraulic head Minimum water depth Minimum length of step/box	≤ 0.4 m ≥ 1.0 x step hydraulic head ≥ 1.5 m	0.41 – 0.60 m ≥ 0.6 x step hydraulic head 1.0 – 1.4 m	0.61 -0.69 m ≥ 0.4 - 0.5 x step hydraulic head 0.3 – 0.9 m	≥ 0.7 m ≤ 0.3 x step hydraulic head ≤ 0.2 m
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	Moderate	High	-
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-

Table 3: Adult grayling U/S (for stepped weirs, stepped fish passes or complex natural features

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Effective pool depth Only score for structures < 2m effective length AND < 0.3m hydraulic head:	Pool depth ≥ 1.0 x hydraulic head	Pool depth ≥ 0.6 x hydraulic head	Pool depth ≥ 0.3 x hydraulic head	Pool depth < 0.29 x hydraulic head
Individual step/box characteristics Maximum step hydraulic head Minimum water depth Minimum length of step/box	≤ 0.1 m ≥ 1.0 x step hydraulic head ≥ 1.5 m	0.11 – 0.20 m ≥ 0.6 x step hydraulic head 1.0 – 1.4 m	0.21 -0.29 m ≥ 0.4 - 0.5 x step hydraulic head 0.3 – 0.9 m	≥ 0.30 m ≤ 0.3 x step hydraulic head ≤ 0.2 m
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-

Table 4: Cyprinids U/S for stepped weirs, stepped fish passes or complex natural features)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Individual step/box characteristics Maximum step hydraulic head Minimum water depth Minimum length of step/box	≤ 0.1 m ≥ 1.0 x step hydraulic head ≥ 1.0 m	0.11 – 0.15 m ≥ 0.6 x step hydraulic head 0.5 – 0.99 m	0.16 -0.24 m ≥ 0.4 - 0.5 x step hydraulic head 0.19 – 0.49 m	≥ 0.25 m ≤ 0.3 x step hydraulic head ≤ 0.2 m
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-

Table 5: Juvenile salmonids U/S (for stepped weirs, stepped fish passes or complex natural features)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Individual step/box characteristics Maximum step hydraulic head Minimum water depth Minimum length of step/box	≤ 0.1 m ≥ 1.0 x step hydraulic head ≥ 0.5 m	0.10 – 0.24 m ≥ 0.6 x step hydraulic head 0.21 – 0.49 m	0.25 -0.34 m ≥ 0.4 - 0.5 x step hydraulic head 0.11 – 0.20 m	≥ 0.35 m ≤ 0.3 x step hydraulic head ≤ 0.10 m
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-

Table 6: Adult lamprey U/S (for stepped weirs, stepped fish passes or complex natural features)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Individual step/box characteristics Maximum step hydraulic head Minimum water depth Minimum length of step/box	≤ 0.15 m ≥ 1.0 x step hydraulic head ≥ 1.0 m	0.16 – 0.25 m ≥ 0.6 x step hydraulic head 0.5 – 0.99 m	0.26 -0.29 m ≥ 0.4 - 0.5 x step hydraulic head 0.19 – 0.49 m	≥ 0.30 m ≤ 0.3 x step hydraulic head ≤ 0.20 m
Effective resting locations for fish downstream For all structures:	Present	-	Absent	-
Lip and/or standing wave present For all structures:	May be present but do not restrict fish passage	-	May be present and may locally restrict fish passage	-
Water turbulence associated with structure For all structures:	Low	-	Moderate	High
Debris/sediment blockage For all structures:	May be present but does not restrict fish passage	-	Present and may locally restrict fish passage	-

Table 7: Juvenile eel U/S (for stepped weirs, stepped fish passes or complex natural features)

Criteria	Passability score			
	1.0	**0.6**	**0.3**	**0.0**
Climbing substrate For all structures:	Present	-	-	-
Water turbulence associated with structure In absence of climbing substrate:	Low	-	Moderate	High
Debris/sediment blockage	May be present but does not restrict fish passage	Present and may locally restrict fish passage	-	-

4 Abstraction points

Table 1: All species upstream and downstream migration

Criteria		Passability score			
		1.0	0.6	0.3	0.0
Mesh or screen gap size	Adult salmon	> 0.04 m	0.031 – 0.04 m	0.02 - 0.03 m	< 0.02 m
	Adult trout	> 0.04 m	0.031 – 0.04 m	0.02 - 0.03 m	< 0.02 m
	Adult grayling	> 0.025 m	0.021 – 0.025 m	0.015 – 0.02 m	< 0.015 m
	Cyprinids	> 0.025 m	0.021 – 0.025 m	0.015 – 0.02 m	< 0.015 m
	Adult Lamprey	> 0.025 m	0.021 – 0.025 m	0.015 – 0.02 m	< 0.015 m
	Adult Eel	> 0.025 m	0.021 – 0.025 m	0.015 – 0.02 m	< 0.015 m
	Juvenile salmonid	> 0.006 m	0.004 – 0.006 m	0.002 – 0.004 m	< 0.002 m
	Juvenile Lamprey	> 0.006 m	0.004 – 0.006 m	0.002 – 0.004 m	< 0.002 m
Effective screening	For all species:			Screens in poor state of repair, damaged or accumulated debris reducing efficiency and creating concentrations of flow	Screens in good state of repair and no debris build up or damage
Attraction flow to abstraction point or screen	For all species:		Water velocity and/or depth greater than that in main channel and acting to attract fish to abstraction point or screen –		Water velocity and depth significantly less than main channel and does not attract fish to abstraction point or screen

5 Downstream migration

Table 1: All species for all structures

Criteria		Passability score			
		1.0	0.6	0.3	0.0
Maximum DEPTH at crest					
	Adult salmon	> 0.15 m	0.11 – 0.15 m	0.07 – 0.10 m	< 0.07 m
	Adult trout	> 0.10 m	0.075 – 0.10 m	0.05 – 0.074 m	< 0.05 m
	Adult grayling	> 0.10 m	0.075 – 0.10 m	0.05 – 0.074 m	< 0.05 m
	Cyprinids	> 0.10 m	0.075 – 0.10 m	0.05 – 0.074 m	< 0.05 m
	Juvenile salmonids	> 0.08 m	0.06 – 0.08 m	0.03 – 0.059 m	< 0.03 m
	Juvenile Lamprey	>0.02m	0.01 – 0.02m	0.005 - 0.01m	<0.005m
	Adult Eel	> 0.08 m	0.06 – 0.08 m	0.03 – 0.059 m	< 0.03 m
Minimum Gap dimensions For Notched weirs, Culverts, Waterfalls, Debris dams and Overshot sluices:					
	Adult salmon	> 0.5 m	0.25 - 0.50 m	0.15 - 0.26 m	< 0.15 m
	Adult trout	> 0.3 m	0.20 – 0.30 m	0.10 – 0.19 m	< 0.10 m
	Adult grayling	> 0.3 m	0.20 – 0.30 m	0.10 – 0.19 m	< 0.10 m
	Cyprinids	> 0.3 m	0.20 – 0.30 m	0.10 – 0.19 m	< 0.10 m
	Juvenile salmonids	> 0.15 m	0.10 – 0.15 m	0.05 – 0.09 m	< 0.05 m
	Juvenile Lamprey	> 0.05 m	0.02 – 0.05 m	0.01 – 0.02 m	< 0.02 m
	Adult Eel	> 0.15 m	0.10 – 0.15 m	0.05 – 0.09 m	< 0.05 m
DAMAGING STRUCTURES For all species:structures that could damage fish moving downstream over obstacle		No damaging structures present	-	Damaging structures present	-
Debris blockage For all species:		May be present but does not present an obstacle for fish passage	May be present and could restrict fish pas-sage	-	Present and prevents fish passage