# Afon Colwyn Hydro Scheme:

# Assessment of fish passage

## Colwydr Cyf

## APEM Ref: P00002921

## August 2018

Paul Gratton, Nigel Milner

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| **Client:** | **Colwydr Cyf** |
| **Address:** | **50 High St**<br>**Mold**<br>**Flintshire**<br>**CH7 1BH** |
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| **Project Director:** | **Nicola Teague** |
| **Project Manager:** | **Paul Gratton** |

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Riverview A17 Embankment Business Park,
Heaton Mersey,
Stockport,
SK4 3GN

Tel: 0161 442 8938

Registered in England No. 2530851

## Revision and Amendment Register

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# Contents

# 1. Introduction

Colwydr Cyf submitted a pre-application document to Natural Resources Wales (NRW) concerning the construction of a hydro-electric power (HEP) scheme on the Afon Colwyn in North West Wales. During their pre-app response NRW requested that an assessment of potential cumulative impacts on fish passage should be completed due to the presence of several other man-made in-river structures in close proximity to the proposed location of the intake weir.

## 1.1 Report purpose

This report outlines the existing baseline conditions with regards to fish passage and provides a qualitative assessment of fish passage at the new intake weir based on fish species populating the site and data from peer reviewed literature.

## 1.2 Summary of scheme proposals

Colwydr Cyf is proposing to construct a high head HEP scheme on the Afon Colwyn approximately 2.5 km northwest of Beddgelert, Gwynedd. The proposal would involve the construction of a *ca.* 1 m high intake weir at NGR SH5748250330, incorporating a Coanda intake structure with 2 mm mesh. The proposed powerhouse and tailrace would be located at NGR SH5755249693, resulting in a potentially depleted reach of approximately 700 m.

The scheme would begin to abstract water once the flow in the Afon Colwyn exceeds Q95 (56 l/s) – termed the hands off flow (HOF). Above the HOF the HEP scheme would abstract 40 % of available water up to a maximum of 370 l/s, whilst the remaining 60 % would pass through the depleted section of the Afon Colwyn as per the current arrangement. Maximum abstraction for the scheme would occur at approximately Q17, beyond which all additional flow would pass through the depleted reach. A flow duration curve for the site is provided in Figure 1-1.

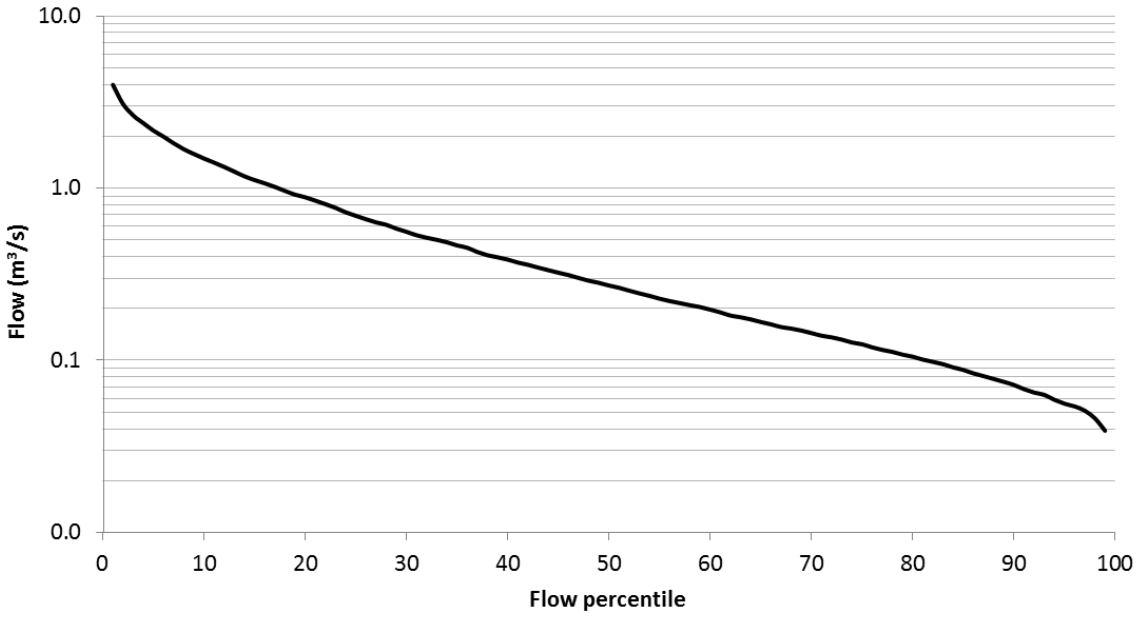


**Figure 1-1. A flow duration curve for the Afon Colwyn at the location of the proposed HEP scheme.**

Adjacent to the Coanda intake structure it is proposed to construct a fish pass to maintain habitat connectivity and passage for migratory fish species populating the Afon Colwyn. The fish pass would comprise a rock ramp/pool and traverse type structure, with a series of 150 – 300 mm traverses, formed using large stones/boulders set into a mass concrete fill.

## 1.3 Overview of existing structures

There are several structures located in close proximity to the proposed intake location.

The Colwyn at Hafod Wydr gauging station (station number 65014) is located approximately 15 m upstream of the intake location at NGR SH574502. The gauging station comprises a 5 m wide crump weir with adjoining wingwall structures to prevent flow bypassing the weir. There is no fish pass associated with the gauging weir, although the structure is considered to be passable for migratory salmonids due to the relatively low head drop across the weir. A short distance downstream of the gauging weir there is a short rock cascade with a head drop of *ca.* 0.40 m (Figure 1-2).

**Figure 1-2. Hafod Wydr gauging weir (background) and the rock step (foreground) immediately upstream of the proposed intake weir location.**

There is an existing HEP scheme downstream of the proposed tailrace location which comprises of a Coanda intake similar in form to that proposed for the new scheme. Water is abstracted at NGR SH5766349455 and returned via the tailrace at NGR SH5815248628, approximately 1.1 km downstream. There is a pool and traverse fish pass adjacent to the intake, comprising of three traverses and two intermediate pools (Figure 1-3).

**Figure 1-3. The Coanda intake structure and fish pass for the existing HEP scheme on the Afon Colwyn.**

A map showing the relative locations of these structures is provided in Figure 1-4.

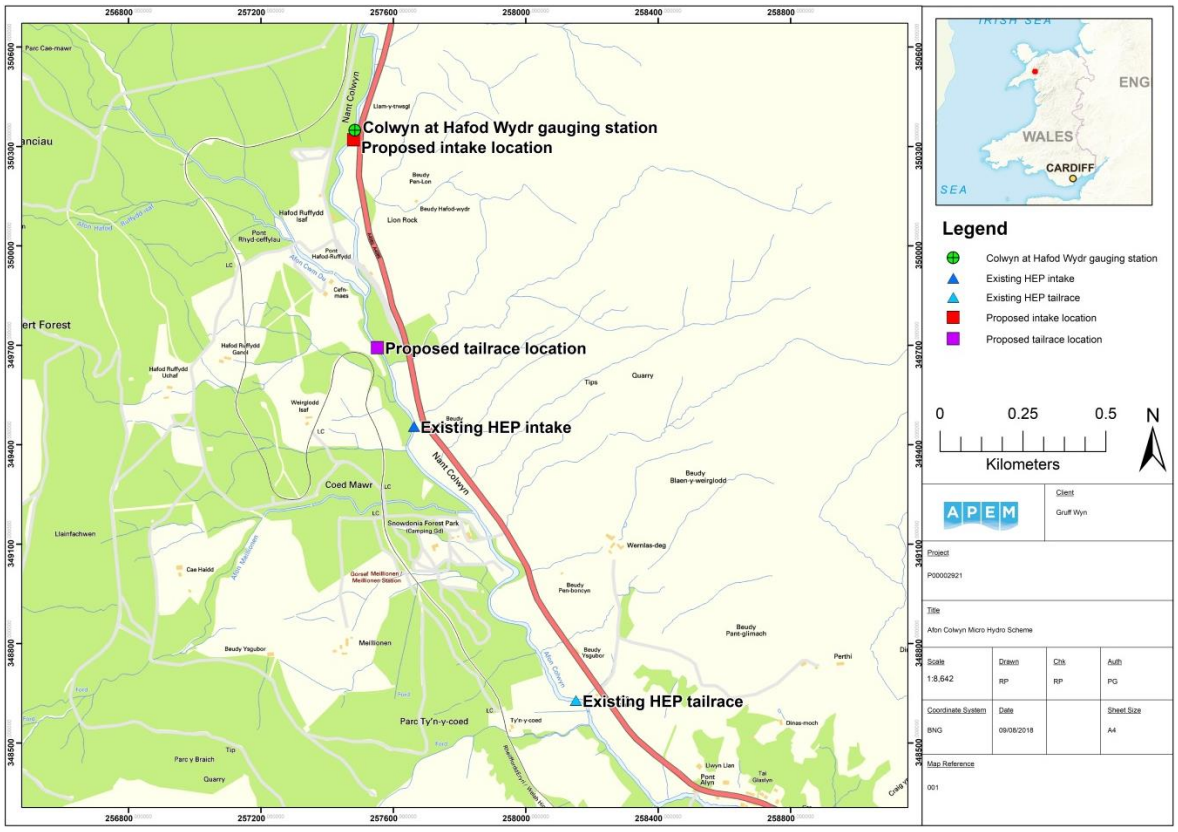


**Figure 1-4. A map showing the location of key structures of relevance to this report.**

## 1.4 Fish population data

The Glaslyn catchment (of which the Colwyn is part), supports migratory populations of both Atlantic salmon (*Salmo salar*) and brown/sea trout (*Salmo trutta*) (NRW, 2016). There are several NRW fish monitoring locations in close proximity to the proposed intake location which provide information on the overall species assemblage of the river. The site is located within the Colwyn WFD waterbody (ID GB110065053950) which has a total length of 8,309 m, 5,028 m of which is located upstream of the proposed intake location. There is a single monitoring site used to inform the status of fish populations of the waterbody under the WFD - NRW survey site ID 3237. The site is located at the downstream end of the Afon Meillionen, a tributary of the Afon Colwyn, approximately 600 m downstream of the proposed tailrace location. Due to the upland nature of the site only two species –salmon and trout - were expected to be present under the Fisheries Classification Scheme 2 (FCS2) model used to calculate WFD status. Each species was present during the most recent survey in July 2014 - densities for salmon (0.56 individuals/100m$^2$) and trout (27.5/100m$^2$) were consistent with High classification for fish under the WFD. It should be noted, however, that the densities of salmon recorded during the latest survey are relatively low in absolute terms – FCS2 model outputs for the site do not provide an expected prevalence or density value for salmon and it is therefore unclear if the High classification is a true reflection of the current waterbody status.

The second NRW monitoring site (ID 3244) is located on the Afon Glaslyn at NGR SH5945545795, approximately 5 km downstream of the proposed tailrace location. Due to the somewhat larger and lower gradient nature of the river channel at this location a total of four species were expected to be present at the site – salmon and trout, in addition to minnow (*Phoxinus phoxinus*) and European eel (*Anguilla anguilla*). The observed density of all four species was equal to or greater than the expected densities, leading to High classification for fish under the WFD during the most recent July 2014 survey.

The low salmon densities (in spite of the high FCS2 classification score) are reflective of the reduced level of salmon spawning in the Glaslyn along with many other Welsh west coast rivers. The Glaslyn is presently categorised as “Probably at Risk” under the National Salmon Assessment Scheme (NRW, 2016). Moreover, the Colwyn tributary has a history of acidification impacts on fisheries exacerbated by the intensive coniferous forestry plantation in its upper reaches (NRW, 2016).

The data from the upstream monitoring site (ID 3237) is considered to be most representative of the fish species assemblage expected to occur at the proposed intake location due to the characteristics of the river channel being more comparable (e.g. a similar bed gradient and channel width). The two fish species of relevance to the fish passage assessment are therefore considered to be salmon and brown/sea trout. The gradient of the Afon Colwyn in proximity to the proposed site (discussed further in the following section) is considered too great to provide suitable habitat for eel and therefore migration of this species is not considered further.

# 2. Assessment of fish passage

## 2.1 Overview of salmonid migration

The migrations of adult salmonids in rivers can be strongly influenced by river flow, although the relationship is highly variable, site-specific and confounded by co-related factors (Banks, 1969; Thorstad *et al.*, 2008; Milner *et al.*, 2012). Sensitivity to flow changes appears to be lowest in large rivers with deep unobstructed passage and greatest in small tributaries or at any partial barriers where passage is flow-limited (Thorstad *et al.* 2011). Moreover, salmonids are not believed to respond directly to flow (discharge volume) *per se*, but to its hydraulic attributes such as velocity, depth, shear, turbulence, or to variables associated with flow such as temperature, chemical cues, turbidity, and noise.

The volume of flow in isolation does not capture all the features of the hydrograph relevant to fish migration and spawning behaviour. Thus, additional metrics (ecological flow components, EFC) are used that describe the hydrograph in ways more relevant to fish, such as spate size, frequency, flow variability and antecedent flows (e.g. Olden and Poff, 2003; Tetzlaff et al 2005, 2008). Finer time scale changes are also significant; salmonids tend to move at night except in spates or turbid water and can respond to very short term (< one hour) flow changes. Flow response during salmon migration can vary markedly depending on the location of individual fish between the sea and spawning grounds. Three broad behavioural phases cover much of this range (Milner *et al.*, 2012), as follows:

- Phase 1: fish move from the estuary to the river.
- Phase 2: the longest and most variable phase in which fish may move almost continuously upstream, holding for short periods or long periods (days or weeks) at key holding locations.
- Phase 3: when mature fish make rapid movement upstream at or just before spawning time onto main stem spawning areas or into tributaries, usually in response to spates, and remain there for the short duration (hours or days) when spawning takes place, before dropping back downstream.

Given the upland nature of the Afon Colwyn catchment north of Beddgelert, some salmon and trout are likely to be Phase 2 but mostly in Phase 3 of migration, late in the season probably confined to the September to November period.

A number of tracking studies have been carried out previously to identify the flow requirements to initiate and sustain the upstream movement of adult salmonids in UK rivers, which helps to define the ecological relevance of flows on the Colwyn with regards to migration. One of the most comprehensive studies was completed by Solomon et al. (1999), which involved the tracking of 1,830 adult salmon into and through six rivers in the southwest of England over a 10 year period.

Solomon et al. (1999) established that a minimum flow threshold (expressed as a percentage of Q95) was required to trigger movement of fish from the lower reaches of main stem rivers during the summer months. With increasing distance up each studied catchment, the flow threshold as a percentage of local Q95 showed a clear increase on four of the five rivers (**Error! Reference source not found.**).

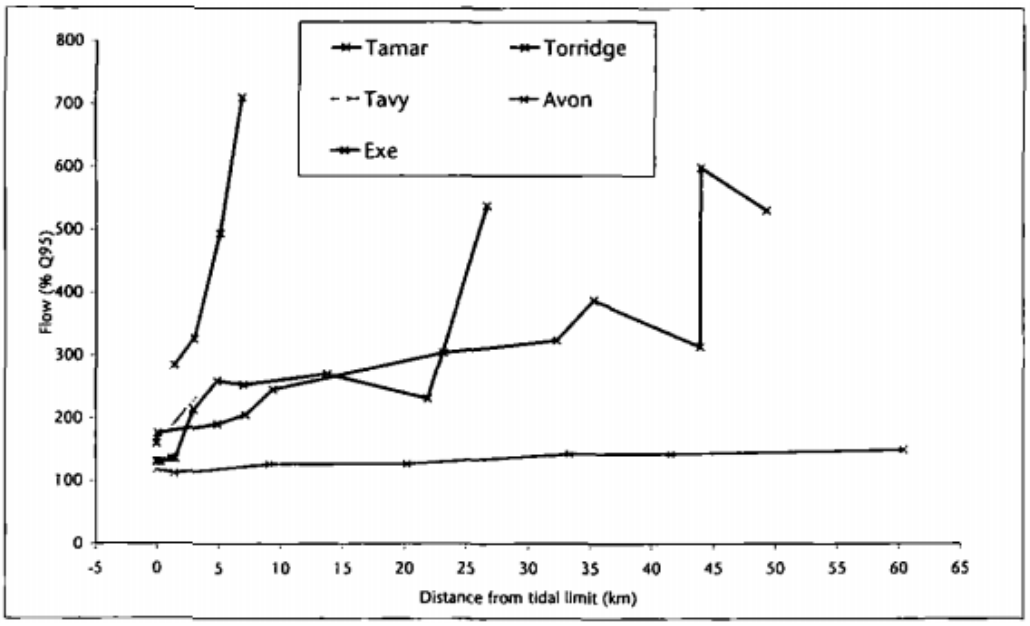


**Figure 2-1. Data from Solomon et al. (1999), showing the relative increase in flow (as a percentage of Q95) required to sustain upstream migration of adult salmon.**

## 2.2 Potential routes of impact

Migration through the Afon Colwyn would occur under elevated flow conditions – typically coinciding with the receding limb of spate events. The proposed scheme may impact on the upstream migration of salmonids through the following routes:

1. Creation of an additional in-river structure (in this instance the proposed intake weir) which may prevent or delay the upstream movement of fish, potentially acting in combination with other man-made structures in close proximity; *or*
2. A reduction in river flows through the depleted section of river channel due to the HEP abstraction which depletes the volume and frequency of spate events such that salmonids are no longer motivated to move upstream.

Each potential route of impact is assessed in turn below.

*In-combination effect of in-river structures*

As outlined in Section 1.3, there are two existing man-made structures on the Afon Colwyn located upstream and downstream of the proposed intake weir. Consideration of potential in-combination impacts on migration associated with the two existing structures and the new intake weir were therefore raised by NRW during their pre-application response.

When considering the potential impacts it is important to consider the context of the wider waterbody, which in this case comprises an upland river with a steep bed gradient. The Colwyn at Hafod Wydr gauging station is at an elevation of 171 mAOD, whilst the next gauging station downstream (Glaslyn at Beddgelert) is at an elevation of 32.9 mAOD, equating to a total change in elevation of 138.1 m. Between the two stations there is a river length of 3.5 km, equating to a mean channel gradient of 3.9 %. Given that the proposed intake weir is located at the upper end of this 3.5 km reach, the local bed gradient may be somewhat above this average value – perhaps in the region of 5 %. A number of natural cascade and chute features are evident along the Afon Colwyn upstream and downstream of

the proposed intake location and therefore salmonids must successfully navigate these structures under the baseline conditions to progress upstream.

The proposed intake structure would be constructed approximately 6 m downstream of the existing rock cascade structure (Figure 1-2). The impounding effect of the weir would therefore increase the tail water level at the toe of the rock cascade and reduce the overall head drop to approximately 150 mm, increasing the passability of this structure. Therefore, providing that the rock ramp fish pass is appropriately designed, with depth and velocity ranges in line with best practice recommendations such as the EA (2010) Fish Pass Manual, the overall impact of this structure on upstream migration of adult salmonids is likely to be minimal compared to the baseline situation when considered in isolation. Indeed in principle, it may improve passage by reducing the head drop at the natural rock ramp.

Similarly, no significant cumulative impacts are anticipated in relation to the existing structures on the Afon Colwyn for several reasons. Migration delay at the existing HEP intake weir is likely to be low given the absence of any significant competing attraction flows for much of the year (e.g. see Figure 1-3), whilst there is a distance of approximately 1 km between the existing intake weir and the new weir and therefore fish are not required to exert significant energy traversing the two structures in quick succession.

The proposed intake weir is located much closer to the gauging weir (approximately 15 m downstream of the gauging station). However, as discussed above, the structure would not pose a significant increase to migration delay compared to the baseline situation due to the increase in passability of the rock cascade structure. Additionally, the overall height of the weir is low (1 m) and so the energy expended in order to reach the base of the gauging weir is not likely to be considerable, particularly compared to the baseline situation. Additionally, there is a pool of deeper water with overhanging vegetation towards the left bank downstream of the gauging weir that appears to provide a suitable holding and recovery area, if required (Figure 2-2).

**Figure 2-2. The base of the gauging weir looking towards the rock cascade, showing the presence of a deeper resting pool towards the left bank.**

*Alterations to river flows*

Based on the findings of Solomon et al. (1999), it is likely that a flow elevation in the order of 3 x the local Q95 flow would be required through the depleted reach of the Afon Colwyn to provide appropriate conditions for upstream movement of adult salmonids (Figure 2-1). The proportional abstraction rate for the HEP scheme (40 % of water above the HOF) and low maximum abstraction rate (equivalent to 0.64 x Qmean) ensures that a large proportion of flow elevations are maintained through the depleted reach. An annual flow duration curve is provided in Figure 2-3 and a seasonal flow duration curve for the key upstream salmonid migration period (September to November) is provided in Figure 2-4.

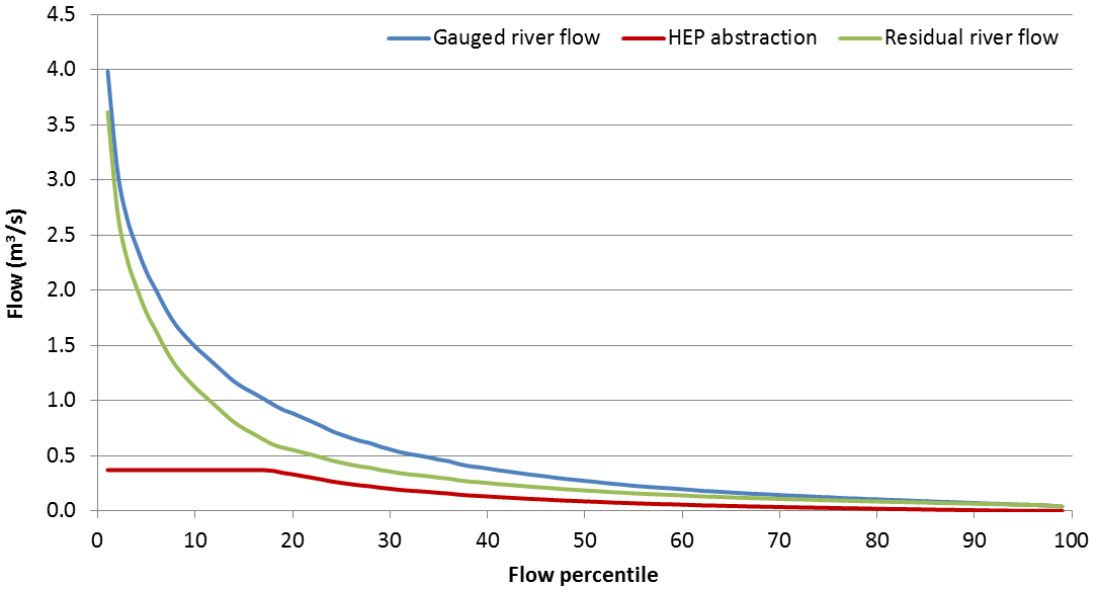


**Figure 2-3. A flow duration curve for the proposed Afon Colwyn HEP scheme, showing gauged river flow, abstracted HEP flow and residual river flow through the depleted reach.**

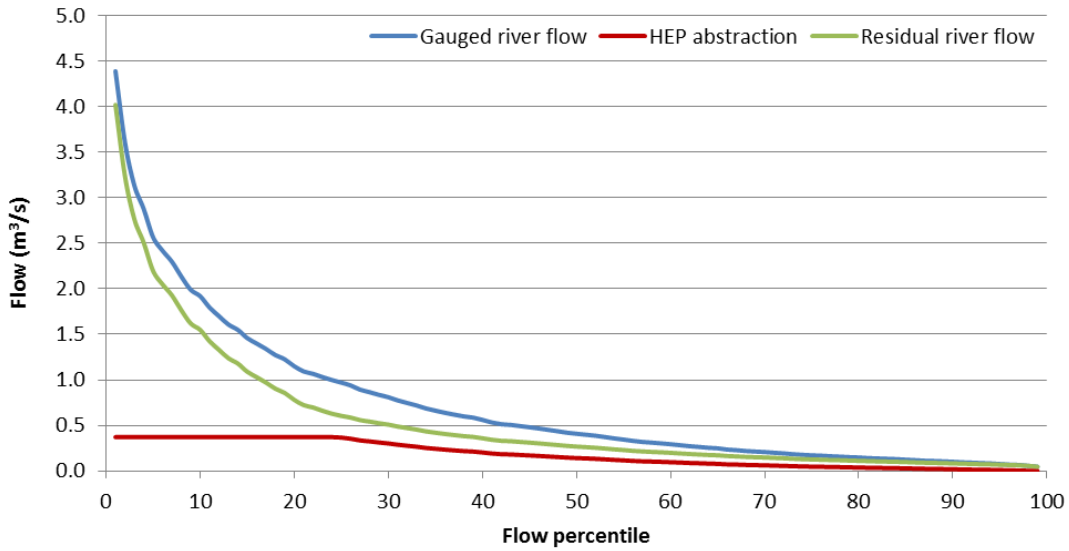


**Figure 2-4. A seasonal flow duration curve (September – November) for the proposed Afon Colwyn HEP scheme, showing gauged river flow, abstracted HEP flow and residual river flow through the depleted reach.**

Under the current baseline conditions a migratory flow elevation of 3 x Q95 (0.17 $m^3/s$) would occur when flow upstream of the intake exceeds the seasonal Q75. Following construction of the HEP scheme river flow upstream of the intake would need to rise to the seasonal Q65 before the same flow elevation occurs. Therefore, although there would be a marginal reduction in the frequency of elevated flows, suitable flow elevations for upstream migration would remain present through the depleted reach for approximately 65 % of the seasonal September – November migration period, compared to approximately 75 % prior to the construction of the HEP scheme, which is considered to be an insignificant change. Additionally, the magnitude of larger spate events (e.g. flows above Q20), which may be required for fish to traverse some of the natural cascade structures, remain largely unaffected by the proposed abstraction (Figure 2-4).

# 3. Conclusions

The proposed HEP scheme is located in a section of the Afon Colwyn characterised by a high bed gradient and a series of natural cascade structures. A rock ramp fish pass structure at the new intake location designed in accordance with best practice guidance would not differ markedly in character compared to the wider reach, whilst the intake weir would also be expected to increase passability over the existing rock cascade structure. Therefore, no significant impacts on migration are anticipated from the construction of the proposed intake structure.

Based on the low height of the existing HEP intake weir and the length of channel prior to the location of the proposed intake weir, no cumulative impacts are anticipated with regards to this structure. Similarly, the new intake weir is small (1 m high) and an area of deep water is present towards the left bank upstream providing resting and holding opportunities for adult fish prior to traversing the gauging weir.

Due to the proportional abstraction rate for the HEP scheme and the low maximum abstraction as a percentage of Qmean, sufficient flow elevations would be maintained through the depleted reach of the Afon Colwyn to support the upstream movement of adult salmonids.

# 4. References

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