Archimedean Screw Hydropower scheme at Charlestown Weir

Hydrology Assessment

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Executive summary

Hydrology of the affected watercourse, the River Irwell, is characterised from long-term local flow data. The data is used to model the relative extent of flow changes under the proposed operating regime, which has been intentionally designed so as to have least environmental impact while still allowing a viable hydropower scheme. The proposed regime is as protective as EA default guidance, or more so, and significantly exceeds guidance in terms of minimum residual flow.

Catchment character

The behaviour of the River Irwell is well-documented, with a long sequence of gauged flow data available. Flow data for the years 1953-2018 is available from the Environment Agency (EA) Adelphi gauging station (ID# 69002) *https://nrfa.ceh.ac.uk/data/station/info/69002*

Flow duration curve

Using a long data sequence is standard good practice. Gauged data 1953-2018 has been used to produce a Flow Duration Curve of the expected flows at this site. The gauging station lies a little distance downstream, and its data therefore represents a larger catchment to which the catchment at Guyzance Meander contributes 97.3% of area. Gauged data was therefore adjusted downwards by this ratio to represent the smaller catchment. (Given the small difference in these areas, no special allowances were made for any difference in rainfall between areas of lower and higher elevation etc.)

The influence of abstractions from and discharges to the river in the short distance between the site and the gauge is assumed to be nil or negligible. Information on licensed abstractions and discharge consents has been requested from the EA.

The data is analysed statistically and broken down into different flow bands, each occurring for 5% of the year. Each band then represents the percentile flow available, or minimum flow in the river for that percentage of the year. For example, Q90 flow means that for 90% of the year the flow is at this level or more. This data is then presented in the form of a Flow Duration Curve, indicating how often a given flow has occurred (see over).

When proposing a hydropower scheme, two important hydrological factors which need to be established are how much water may be taken by the proposed scheme – the Design Flow - and how much water must be left in the river at any time – the Residual Flow.

As the gauged data at this site is heavily influenced by existing abstractions and discharges upstream the flow data was then modified to represent the naturalised flows using the computer based analysis system Low Flows 2000.

Residual flow

The installation of a hydro scheme could hypothetically divert all of the water that currently passes over the weir into the hydro system. Protection of the river environment means that this must not happen. Thus the EA seeks to minimise the length of 'depleted reach' created by a scheme. Ensuring that a residual water flow continues to bypass the scheme is achieved by the EA imposing a **minimum** residual flow as a condition of the EA licence. Other factors may increase this amount (see below), but the **minimum residual flow** is a baseline condition below which abstraction will never take place.

EA licensing practice allows that the minimum residual flow is shared between any spills in the depleted channel - e.g. weir crests, sluices, fish easements or fish passes – hence its value is agreed so as to provide minimum flow for those features as well as to protect the form of the channel. Because of this, whenever the hydro runs, even the minimum flow left is sufficient to ensure continued functioning of any fish passes or other required services.

The latest published EA guidance (issued Dec 2013, in force April 2014 to 2016) continues to form the basis on which EA licensing decisions are made. The scheme proposed here is low-head (having a fall of less than 10m) and would be defined as “on-weir”. The guidance proposes that the minimum residual flow is set at the Q97 percentile of the river’s annual flow.

The present scheme proposal is to leave a minimum residual flow of Q95 or 1.63m3/s which is higher than the guidance permits.

Design flow

EA guidance indicates that the default maximum for the value of a low-head hydropower abstraction where a depleted reach is created, even on a river of ASB3 sensitivity with low or medium baseflow, would be 1.3x the river’s annual mean flow at the site. Present data at this site (as calculated above) gives a mean flow of 14.08 m3/s (~Q28) and a default maximum allowed abstraction of 1.3x Qmean, being 18.3 m3/s (~Q22). An application to abstract up to 18.3 m3/s would therefore fall within the conventional EA guidance without additional justification.

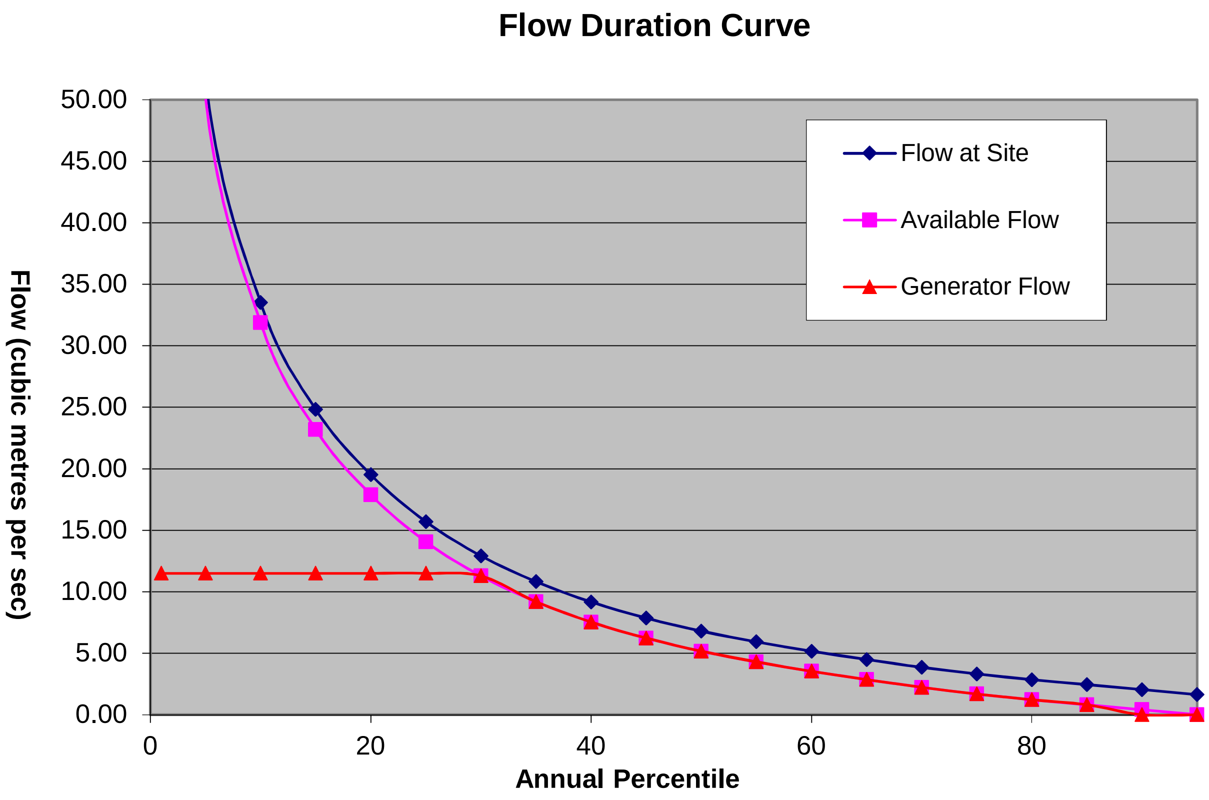
This project, however, seeks a maximum abstraction of only 11.5 m3/s which is less than the river’s mean flow, and hence very far within the EA’s guidance limits.

The proposed maximum abstraction is 11.5 m3/s (equivalent to the river’s Q33 flow in present data) – and this amount to be taken at peak operation only. An abstraction varying up to this maximum amount will efficiently supply a hydropower scheme of the proposed design which represents economic viability to the applicant.

NB: Where a technical fish pass is proposed to be co-located with the screw, a dedicated minimum flow for this would be calculated in relation to the size of the hydropower abstraction.

A co-located fish pass is proposed that would take 0.85m3/s of the residual flow, with the rest passing over the weir

A flow duration curve is shown below for the proposed regime at this site, as discussed above.



Method of controlling the proposed regime

The "hands-off" condition would be controlled by a conventional electronic level sensor (submerged pressure transducer) at the hydropower intake, connected to the control system and operating to ensure that the hydropower scheme could not begin or continue to abstract unless the Q95 water level could be maintained at the intake.

Stage data (water levels)

The proposed design is predicated on a known minimum water condition at the proposed intake (Q95), and on making no change to river behaviour at flows/levels below this datum state. It is therefore unnecessary to represent a stage/discharge relationship to vouchsafe protection of the river at low flows. In high flows, hydropower operation will be suspended, and will have zero net impact. It is therefore unnecessary to represent a stage/discharge relationship for high water or flood purposes.

Cumulative impacts and lifecycle impacts

There are no cumulative impacts on hydrology, as the scheme's effect ceases at the point of discharge. In lifecycle terms, hydrological impacts of the project are largely limited to its operational lifespan. Construction involves only small temporary cofferdams close to the bank line. Decommissioning of the project at some future stage requires only the dismantling of steel mechanical parts from the offline channel, and the backfilling of the intake and channel if so desired. The sluice gate can remain in place as part of this closure. The river itself needs no remediation. After cessation, all flows remain in the river channel as at present.

Head duration curve

The height that the water falls over the hydropower site is known as the head. This varies with the flow in the river. Site measurements have indicated a gross head of 2.3m between the water levels at the intake and discharge, in conditions representative of lower flows. Having then allowed for intake design and losses, the net head available is some 2.2m for an Archimedean screw turbine, reducing gradually as the tailwater rises in higher conditions.

Effect of likely tailwater rise at this site, based on sites of similar geometry, is presented in an indicative graph below. As the river flow increases (blue) towards the left, the head decreases (pink). Head does not diminish to zero until close to bank-full conditions.