

APPENDIX A

Calculation of change in percentage of time the Fairy Glen, Afon Conwy would be kayakable following a proposed HEP scheme.

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11th February 2014

Introduction

An indicative calculation has been made of the change in percentage of time the Fairy Glen, Afon Conwy would be kayakable following a proposed hydro-electric power (HEP) scheme.

Baseline

Through rainchasers.com, the kayaking community has calibrated river levels in the Fairy Glen with river levels recorded at the Environment Agency (EA) Cwmlanerch Gauging Station (National River Flow Archive Reference 66011). General kayaking conditions and levels at the gauging station are summarised in Table 1.

Table 1. Levels and Kayaking Conditions in the Fairy Glen (rainchasers.com)

Kayaking Condition	Level (m)
Low	1.15
Medium	1.35
High	1.65
Very High	1.85

Whilst the Cwmlanerch gauge is the closest to the Fairy Glen, level variations on this gauge do not always accurately reflect levels in the Glen. Local paddlers have found the Glen may sometimes be running when the level at Cwmlanerch is as low as 1.15 m. On other occasions the level at Cwmlanerch has reached 1.25 m or even 1.3 m before the Fairy Glen is in a kayakable condition. To account for this variability, these calculations have used 1.20 m on the Cwmlanerch gauge as the minimum acceptable level for kayaking in the Fairy Glen. This corresponds to a flow through the gauging station of $21 \text{ m}^3\text{s}^{-1}$ based on the rating equation below (EA, 2013).

$$Q = 23.599 \times (h - 0.24730)^{2.444}$$

Where,

Q = Flow (m^3s^{-1})

h = head (m)

The percentage of time in each year the Fairy Glen is kayakable has been estimated using the flow duration curve for the gauging station (CEH, 2013). The $21 \text{ m}^3\text{s}^{-1}$ flow at the gauging station is exceeded 33% of the year.

Proposal

RWE npower renewables propose to take up to $5.8 \text{ m}^3\text{s}^{-1}$ from the Conwy at an abstraction point approximately 250 m upstream of the confluence of the Afon Machno (RWE, 2013).

The impact of the proposed abstraction has been calculated using an approach based on scaling outlet flows by a factor of their on relative catchment areas.

The following sub-catchments have been used in these calculations:

- Abstraction Point Catchment – this represents all land that drains into the Conwy, upstream of the proposed abstraction point.
- Fairy Glen Catchment - this represents all land that drains into the Fairy Glen. This includes the Abstraction Point Catchment, as well as additional land downstream of the proposed abstraction point including the Machno Valley.

- Gauging Station catchment – this includes all land that drains into the Conwy above Cwmlanerch. This includes the Fairy Glen Catchment, as well as additional land downstream of the Fairy Glen, including the Lledr and Llugwy Valleys.

The following assumptions have been made in these calculations:

- An abstraction of $5.8 \text{ m}^3\text{s}^{-1}$ has been used to assess the impact at the minimum kayakable flow. The proposed abstraction is up to 45% or 65% of the flow (depending on the time of year). The maximum capacity of the turbines is $5.8 \text{ m}^3\text{s}^{-1}$ (RWE, 2013). The following calculations show that $11.28 \text{ m}^3\text{s}^{-1}$ is required at the Fairy Glen for it to be kayakable. When the Fairy Glen is at this minimum kayakable flow, the $5.8 \text{ m}^3\text{s}^{-1}$ maximum represents 51% of the flow.
- Any increase in time the Fairy Glen would be kayakable as a result of abstraction during very high flows is assumed to be negligible.
- The average annual rainfall is higher in the west of the Gauging Station catchment than in the east (CEH, 2013). The abstraction point sub-catchment covers the east of the larger Gauging Station catchment (see Map 1) and so is likely to receive a lower than average proportion of rainfall for its area. The rainfall totals over the abstraction point sub-catchment and larger Gauging Station catchment have been assumed to be the same, and the deficit to the lower rainfall total from which water would be abstracted has not been taken into account.
- Rainfall run-off is assumed to be instantaneous and the timing of flood peaks at the following outlet points are similar.

Flows at the abstraction point and Fairy Glen have been estimated based on the catchment areas shown in Table 2 and in Map 1.

Table 2. Afon Conwy Catchment Areas (Lutra Consulting, 2013)

Catchment	Easting	Northing	Catchment Area (km ²)	Percentage of Gauging Station catchment (%)
Abstraction point	281150	353350	141.361	41.1
Fairy Glen	280125	354158	185.006	53.8
Gauging Station	280150	358050	343.745	100.0

When $21 \text{ m}^3\text{s}^{-1}$ is flowing through the gauging station, approximately 41.1% or $8.62 \text{ m}^3\text{s}^{-1}$ of this is flowing past the abstraction point and approximately 53.8% or $11.28 \text{ m}^3\text{s}^{-1}$ of this is flowing through the Fairy Glen. The minimum flow at the Fairy Glen for it to be kayakable is therefore taken to be $11.28 \text{ m}^3\text{s}^{-1}$.

An iterative approach has been used to find the scenario that will give $11.28 \text{ m}^3\text{s}^{-1}$ flow at the Fairy Glen following a $5.8 \text{ m}^3\text{s}^{-1}$ reduction in flow at the abstraction point upstream. This method has been used as the rainfall run-off from the catchment below the abstraction point but above the Fairy Glen is not influenced by the abstraction.

If $13 \text{ m}^3\text{s}^{-1}$ were to flow at the abstraction point, this flow would be reduced to by $5.8 \text{ m}^3\text{s}^{-1}$ to $7.20 \text{ m}^3\text{s}^{-1}$. If this were to occur without the abstraction, $31.6 \text{ m}^3\text{s}^{-1}$ ($13 \text{ m}^3\text{s}^{-1} / 41.1\%$) would be flowing through the gauging station. The catchment below abstraction point but above Fairy Glen is 12.7% (53.8% - 41.1%) of the Gauging Station catchment. If $31.6 \text{ m}^3\text{s}^{-1}$ were flowing through Gauging Station, $4 \text{ m}^3\text{s}^{-1}$ ($31.6 \text{ m}^3\text{s}^{-1} \times 12.7\%$) of this would be from the catchment below the abstraction point but above Fairy Glen.

Combining the $7.2 \text{ m}^3\text{s}^{-1}$ (the remaining water in the Conwy at the abstraction point, following the abstraction) and the $4 \text{ m}^3\text{s}^{-1}$ (flow from the unaffected catchment below the abstraction point but above the Fairy Glen) makes $11.21 \text{ m}^3\text{s}^{-1}$ at the Fairy Glen, slightly less than the required flow ($11.28 \text{ m}^3\text{s}^{-1}$) stated above.

The $31.6 \text{ m}^3\text{s}^{-1}$ flow needed at the gauging station for this situation to occur is exceeded 19% of the year. As such, the amount of time the Fairy Glen would have enough water for kayaking would drop from 33% of the year to 19% of the year. This represents a 42% reduction in the amount of time it is kayakable.

Summary

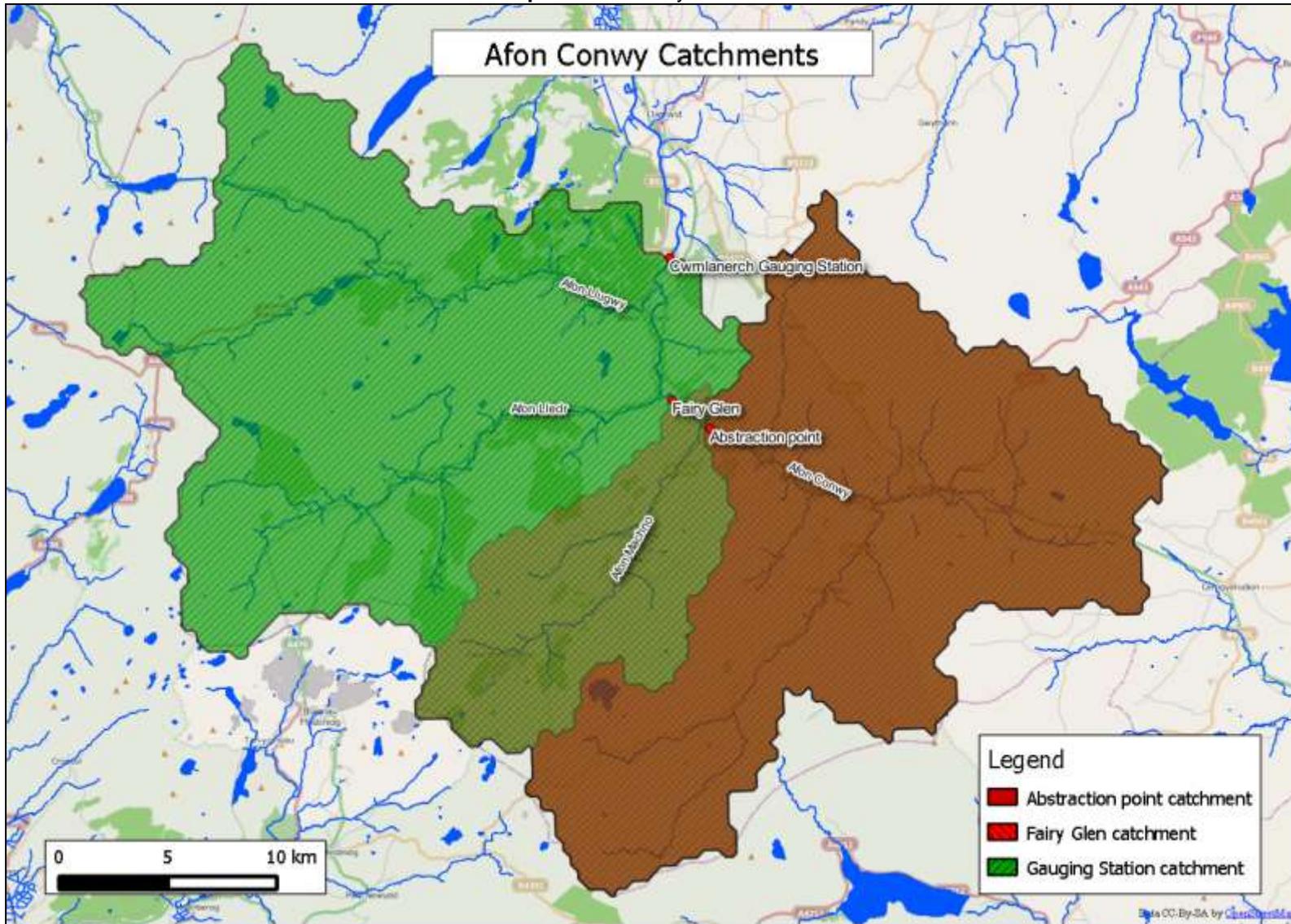
The impact of the proposed scheme has been discussed in this report in terms of a change in percentage of time the Fairy Glen is kayakable. However, to aid understanding, it may be useful to consider these percentages in terms of days. Currently there is enough water to kayak for 121 days each year (33% of the year). Following the proposed scheme, there would be sufficient flow to kayak for 69 days each year (19% of the year). This represents a loss of 51 paddling days each year (a 42% reduction).

This simplified approach indicates that there would be a significant reduction in the amount of time the Fairy Glen would kayakable, should the proposed Conwy HEP scheme go ahead.

References

- Rainchasers – Conwy: Fairy Glen, accessed Dec 2013 (<http://rainchasers.com/river/conwy/fairy-glen>)
- Environment Agency - High Flows, accessed Dec 2013 (<http://www.environment-agency.gov.uk/hiflows/station.aspx?66011>)
- Centre for Ecology and Hydrology (CEH) – National River Flow Archive (NRFA): 66011 - Conwy at Cwmlanerch, accessed Dec 2013 (<http://www.ceh.ac.uk/data/nrfa/data/station.html?66011>)
- RWE Conwy Falls Hydro Proposal, accessed Dec 2013 (<http://www.rwe.com/web/cms/en/2256320/rwe-innogy/sites/hydroelectric-power-station/united-kingdom/sites-in-development/conwy-fallos/>)
- Lurita Consulting Catchment Finder, accessed Dec 2013 (http://webgis1.lutraconsulting.co.uk/catchment_finder/)

Map 1. Afon Conwy Catchments



Based on catchments from Lutra Consulting, 2013