

Dr R W Moss
Orchard Croft
Church Lane
Newbold on Stour
Stratford Upon Avon
Warwickshire
CV37 8TW

Our ref: PPN-00152

Date: 3 October 2017

Dear Dr Moss

Proposal to abstract and impound water for a hydroelectric-power scheme under the Water Resources Act 1991, as amended by the Water Act 2003.

Thank you for your pre-application enquiry about abstracting water for a 8.1 kW hydroelectric-power (HEP) scheme and for a private domestic water supply at Hafod y Rhedrydd near Carrog, Cwm Penmachno, National Grid Reference (NGR) SH 76167 45675.

In this letter we provide advice on the types of licence or consent you may need from us and how much water we think you can abstract for your hydropower scheme. We also provide you with advice on other environmental considerations that you will need to take into account whilst designing your scheme.

Our advice is based on the information you have provided with your pre-application enquiry. It should guide you in developing a hydropower scheme that will have a low impact on river habitats and wildlife.

Please note that if you do submit a formal application for an abstraction and/or impoundment licence for your scheme we may still need to ask you for further information once the licence determination process begins. Occasionally this may lead to a revision to some aspects of our pre-application advice.

Please take time to carefully read this letter, its appendices and our Hydropower Guidance Notes (available on our website) before you submit a formal application. Also, please note that our advice is only related to the abstraction and impoundment aspects of your scheme.

You should seek further guidance from your Local Authority about other permissions that you may need. It is your responsibility to ensure that you have obtained all the appropriate consents before you start building any part of your scheme. We recommend that you seek independent professional and legal advice before proceeding with your development.

Ffôn/Tel 0300 065 3000
Ebost/Email canolfanderbyntrwyddedu@cyfoethnaturiolcymru.gov.uk /
permitreceiptcentre@naturalresourceswales.gov.uk

Cyfoeth Naturiol Cymru, Maes y Ffynnon, Penrhosgarnedd, Bangor, Gwynedd, LL57 2DW
Natural Resources Wales, Maes y Ffynnon, Penrhosgarnedd, Bangor, Gwynedd, LL57 2DW

Gwefan/Website www.cyfoethnaturiolcymru.gov.uk
www.naturalresourceswales.gov.uk

Croesewir gohebiaeth yn y Gymraeg a'r Saesneg
Correspondence welcomed in Welsh and English

1 Permit requirements

Your proposal will require a full abstraction licence and an impoundment licence.

The application fee for the abstraction / impoundment licence based on the proposed installed capacity of your scheme will be **£375**.

The abstraction and impoundment licences are needed to ensure that the water in our streams and rivers are properly managed for people and wildlife.

2 Abstraction Regime

Your scheme is within a protected site with a flow-dependent feature which puts the scheme in the Zone 1 category (from our Hydropower Guidance Notes 2 (HGN2)). Your formal application will need to be accompanied by a bryophyte report following a full bryophyte survey of the depleted reach (carried out by a competent bryologist) to assist us in our determination of the percentage of water available for abstraction. If water dependant features are found then we may consider this site to be unsuitable for a hydropower scheme or only suitable for a Zone 1 abstraction regime as follows:

Maximum abstraction rate = 80 litres per second (equivalent to 1.3 x our assessment of Q_{mean} flow (at 62 l/s))

Protected low flow = 4 litres per second (equivalent to a Q₉₅ flow)

Percentage take = 10% or 40% of available flow (between the protected low flow and the maximum abstraction rate) all year – dependant on the results of your bryophyte survey.

Should you submit a report (as indicated above) which satisfies us that the site should not be considered as a Zone 1, then we will consider a Zone 3 regime scheme as follows:

Maximum abstraction rate = 62 litres per second (equivalent to Q_{mean} flow)

Protected low flow = 4 litres per second (equivalent to a Q₉₅ flow)

Percentage take = 70% of available flow (between the protected low flow and the maximum abstraction rate) all year.

You will need to design and construct the intake structure so as to physically ensure compliance with the above constraints – whichever is considered appropriate.

For any formal application to be considered valid, you will need to ensure that you have provided the appropriate application forms and the supporting information requested in this letter. In particular, please read Section 1.4 of Appendix 1 which provides details of the supporting information required, including design and residual flow calculations.

A **maximum abstraction** rate ensures that the hydropower scheme allows high flow events to occur within the depleted reach that are important for channel shaping and sediment transport.

Having a **protected low flow** is important in making sure that a minimum flow is always maintained for the environment in the depleted reach and that the hydropower scheme doesn't cause the river to dry out completely.

Percentage take means that at any time the hydropower scheme cannot abstract more than a certain percentage of the available river flow. This prevents the hydropower scheme from taking most of the water during medium and low flows and allows the remaining flow in the depleted reach to rise and fall, as it would do naturally, which is important for the plants and animals living in the channel and on the bankside.

Our approach on how we decide how much water can be abstracted and how much must be left for the river environment is detailed in our *Hydropower Guidance Note 2 - Hydropower flow standards* which is available on our website. (Please see the website address for all our guidance in the appendix *Useful websites*).

Your current abstraction for domestic purposes is currently exempt from licensing (being less than 20 cubic metres per day). However your future total abstraction (HEP + domestic use) will be greater than 20 cubic metres per day, consequently the domestic purpose will also (now) need to be specified as a separate purpose (with separate quantities) in your licence. You will therefore need to include this purpose **and separate rates of abstraction** in your application form when submitting your formal application.

I would also point out that, while the abstraction of water for hydropower generation does not attract an annual abstraction licence charge, the water abstracted for domestic use will **not** be exempt from the annual licence charge and will therefore be chargeable. For small abstractions such as for domestic purposes, the annual charge is likely (currently) to be the minimum charge of £25.

I would also draw to your attention that, if you propose to take a tee off your pipeline for the turbine to supply your domestic needs, then you should be aware that at flows below Q95, there will be no flow over the coanda screen to enter this pipeline. You may therefore wish to review your proposal for your method of abstraction for your domestic supply.

3 Time Limit

If we were to issue an abstraction licence for this scheme it would be time limited to 31st March 2028 in accordance with our local licensing policy for the Conwy Catchment Abstraction Management Strategy (CAMS).

All time limited licences carry a presumption of renewal provided the scheme is not having an unacceptable ecological impact, there is a continued justification of need for the water, and the water is used efficiently.

4 Nearby Abstractions and Water Interests

We do not have records of any licensed abstractions or discharges upstream of the proposed development nor within the depleted reach.

It is your responsibility to ensure that the development will not affect any water features or interests (i.e. wells, boreholes, springs, streams or ponds) in the area. We advise all applicants to consult other abstractors, local river users and interest groups before submitting an application. You should submit details of any other abstractors in the vicinity that may be affected by your abstraction with your formal application. In this respect I would point out that the Local Authority's Environmental Health Department may hold information on unlicensed abstractions that we may not be aware of.

5 Flood Risk Activity Permit

You may need to apply to Conwy County Borough Council for a Flood Risk Activity Permit. Please contact Shaun Wasik, Flood Risk Project Manager, Conwy County Borough Council, Mochdre Offices, Conway Road, Mochdre, LL28 5AB, Tel: 01492 575337, email: Land.drainage@conwy.gov.uk for further details.

6 Flood Consequences Assessment

You should also be aware that any planning application required for your proposed scheme is likely to require a Flood Consequences Assessment (FCA) to consider flood risk to any property.

The FCA should be undertaken by a suitably qualified person carrying an appropriate professional indemnity. However, prior to undertaking a FCA please contact our Flood Risk Analysis Engineer Iwan Huws at iwan.huws@cyfoethnaturiolcymru.gov.uk or by telephone on 03000 653783 for additional advice and information on preparing a FCA which is appropriate to the scale and nature of the development

7 Fish screening

The screening aperture of **1** mm at the intake and **10** mm at the outflow that you have proposed should be suitable for this scheme unless eels are present at the discharge point in which case you should contact our fisheries officer Joel Rees-Jones for further details (by telephone on 03000 65 3751 or by email at joel.rees-jones@cyfoethnaturiolcymru.gov.uk).

8 Fish and eel passage

The intake weir will need to be designed so as to be passable to fish, including eels, moving both upstream and downstream.

The intake design will need to incorporate a plunge pool with a minimum water depth of 300mm across the full width of the structure for fish to fall into. There should be no part of the structure/pipeline that could injure fish as they drop over the weir immediately in front (downstream) of the weir.

You will need to ensure that the outflow is suitably positioned and that the discharge flow will not cause erosion or attract fish.

Please contact our Fisheries Officer, Joel Rees-Jones (contact details above) for further advice if required.

9 Timescale for works

No in-river works nor river diversions should be carried out during the main migratory period for fish – 17th October to 15th May.

Any in-stream engineering works may require a fish rescue. Please contact our Fisheries Officer (contact details above) for further advice if required.

10 Geomorphology

Building in-river structures and changing flow rates can affect the natural processes of erosion, movement of sediment and sediment deposition. These changes can affect the stability and operation of your scheme as well as the river environment. Careful siting and design of your scheme can reduce these effects.

Our assessment of your Stage 1 Geomorphology Photosurvey has shown that, provided your intake is sited immediately below one of the bedrock falls within the reach and is contained by bedrock on either bank (eg. within approximately 2 metres downstream of the staff location shown in figure 5, page 4 of your survey) there is likely to be a low risk of changes to site geomorphology as a result of this scheme and no further geomorphology assessment is required.

We recommend that you contact our Geomorphologist, Oly Lowe at oliver.lowe@cyfoethnaturiolcymru.gov.uk if you need any further information or advice on this aspect of your scheme.

11 Designated sites and protected species

Due to the sensitivity of this site, while the bryophyte survey of the depleted reach will be necessary for our determination of the percentage abstraction of water, your bryophyte survey will also need to include the scheme's full working footprint (access routes, pipeline & river crossings, cable routes etc.) as we are likely to request this as a Statutory Consultee in the Planning Authority's Application process.

The pipe route appears to pass through the following SAC features : Blanket bog and Dry Heath. SPA features that may be impacted include breeding hen harrier and merlin since both species have been recorded within 600m of the project proposal. SSSI features that may be impacted include Upland broad-leaved woodland and scrub; Blanket bog; Dry Heath; Flush and spring; acid grassland; running water and; the upland breeding bird assemblage since red grouse have been recorded close to the work proposal area.

More information and detail will be required with your planning application regarding the method statement: Machinery to be used; access route; Information relating to pipeline diameter, pipeline burial depth/method (installation on the surface and covering may be preferred at some locations), pipeline river crossings and specification for the pipeline trench; annotated map required showing sections of pipe intended for burial. Further details of the land take for the construction phase relating to the width of the pipeline work corridor. Timings of work; detail relating to

construction methods to facilitate the installation of the abstraction point. Detail of footprint of the construction of the turbine house. Detail on how the pipeline shall cross a number of streams along the proposed route before reaching the outflow point. You will need to demonstrate necessary measures to avoid any impact on SSSI/SAC features including pollution prevention measures. Details of proposed measures to avoid the introduction of non native/invasive species also need to be included.

Otters have been recorded within 250m north of the depleted reach. Section 42 Welchs money spider has been recorded within 600m of the site which forms part of what is considered an exceptional assemblage of rare upland spiders including species such as *Erigone welchi*, *Hilaira pervicax*, *Maro lepidus*, *Clubiona norvegica*.

An Otter survey by qualified and experienced ecologist will therefore also be required with your planning application to ensure no destruction or disturbance of otter holts or resting sites as a result of your proposal.

You will also need a Section 28 consent before any works can proceed, the Notice of intent will require a detailed method statement and will need to be submitted by the land occupier/owner. The initial pipeline route runs through Common land; consent will be required from Welsh Government under section 38 of the Commons Act 2006. In order to mitigate against any impact on the breeding bird assemblage and SPA features we would advise for all works to be undertaken outside of the bird breeding season. There is concern over potential fire risk at the site and the exposure of the pipeline to a fire.

12 European Protected Species (EPS)

If your proposal has the potential to affect a European Protected Species (EPS), for example during construction, then you may require an EPS licence from NRW. Further information is available on NRW's website at <https://naturalresources.wales/permits-and-permissions/protected-species-licensing/european-protected-species-licensing/do-i-need-a-european-protected-species-licence/?lang=en>

13 Other information

You will need to provide details on why you want to abstract this water to describe your 'justification of need'. This is a requirement of the licencing process to make sure that water resources are being used responsibly and efficiently. For hydropower schemes you will need to give us information detailing turbine transmission and generator efficiencies with your formal application. This can be done by completing the attached HEP Water Usage Calculation Sheet and submitting it with your formal application.

14 Planning

We recommend that you contact Snowdonia National Park Planning Authority as soon as possible (preferably prior to submitting your formal abstraction/impoundment licences application) to find out whether you need planning permission.

You may need to review your proposal in light of their response. A copy of their response should be submitted to us with your formal licence application, describing any changes to your scheme.

The purpose of this pre-application advice is to help inform you about how your scheme may affect the river environment and what you need to consider when developing your final design and before you submit applications for abstraction and impoundment licences.

The advice we have provided in this letter is based on the information you have given us with your pre-application, existing legislation and our current guidance. It is not approval of your proposed scheme and does not guarantee that any formal application will be successful. You may need to reconsider your proposal in the event of any changes in law, guidance or availability of water.

Please do not hesitate to contact me if you have any further queries.

Yours sincerely,



T V Evans

Senior Natural Resources Planning Officer (Water Resources)
Area Account Manager (Hydropower)

Tel: 03000 653689

E-bost / E-mail: Tecwyn.evans@cyfoethnaturiolcymru.gov.uk

APPENDIX 1 - LICENCE APPLICATION REQUIREMENTS

1.1 Licence requirements and application forms

[Licence application forms](#) and guidance on how to fill them in are available from our website.

To apply for a full/transfer abstraction licence you will need to complete forms:

- *WRD: Application for an abstraction licence*

To apply for an impoundment licence you will need to complete form:

- *WRE: Application for an impoundment licence*

In both cases you will need to complete:

- *WRA: Application details and proposal outline (unless this has already been submitted as part of your pre-application and there are **no** changes to the proposal)*

You should send the completed forms and all supporting information as one complete application pack to the following address:

Permit Receipt Centre
Natural Resources Wales
Cambria House
29 Newport Road
Cardiff
CF24 0TP

or via email to: permitreceiptcentre@naturalresourceswales.gov.uk / canolfanderbyntrwyddedau@cyfoethnaturaolcymru.gov.uk

1.2 Licence application process

Once a valid formal application has been accepted we aim to make a decision within 4 months (or 3 months if advertising is not required). There will be a fee for processing your application. The fee will be based on the installed capacity of your scheme as shown in the table below. Where applications for an abstraction licence and an impoundment licence are submitted together and the activities are associated at a single site (i.e. for one hydropower scheme) then a single fee will be charged according to the capacity of the hydropower scheme.

Scheme capacity	Application fee (£)
25kW or less	375
>25kW to 50kW	750
>50kW to 100kW	1,125
>100kW	1,500

Please make your cheque payable to *Natural Resources Wales* and make sure that 'A/C Payee' is written across the cheque if it is not already printed on. To enable us to allocate the cheque to the correct application, please label the back of the cheque with an identifier in the following format:

- *Name*
- *Abstraction and Impoundment Licence Application*
- *Site name / works description*

e.g. "Dai Jones Consulting – Abstraction and Impoundment Licence Application – Jones Farm HEP".

Payments can also be made by card payment or BACS. Please see the 'Cost of applications' section of [WRX - Guidance Note for completing Water Resources application forms](#).

It is likely that your application will need to be advertised – we will do this by publishing a press notice in a local newspaper and on our website; you will need to pay for the press advert. In addition there will be a £100 advertising administration fee. Advertising costs vary between newspapers but can be in the region of up to £1,000. Please direct any specific queries about the advertising process to the Wales Permitting Centre (Cardiff) on 0300 065 3000.

We will not consider applications which are sent to us without the correct application charge. We will not usually refund the application charge if we refuse your application or if you withdraw it. However, we will refund the application charge if we tell you to withdraw the application and send in a different one.

Any existing (or proposed) abstraction from the same source of supply for any purpose other than hydropower generation must be considered in aggregate with the quantities for which you have applied. If this brings the total abstraction to above the exempted de minimus (20m³/day) the previously exempt/unlicensed (or proposed) abstraction will now need to be licensed **and may become chargeable**. You must inform us if you already (or propose to) abstract water for another purpose other than hydropower when you make a formal application.

1.3 Self-destruct condition

Any abstraction and impoundment licence issued will be subject to a "self-destruct" condition stating that the licence shall cease to be of any effect if the abstraction/construction it authorises has not commenced within three years of the date of issue of the licence.

You will be required to give Natural Resources Wales prior notice of:

- when construction is to commence,
- when construction is completed and
- when the initial abstraction for generation is to take place.

This is so that we can visit the site if necessary during those periods.

1.4 Technical drawings and design statement

With your formal licence application you will need to submit:

- Location maps and technical drawings that detail the design of your hydropower scheme.
- Detailed scale drawings of your proposal showing the proposed abstraction point and / or impoundment structure, and how you will ensure provision of the protected low flow and the remaining percentage of river flow over the intake structure.
- A detailed design statement.

Location maps and technical drawings should be clearly presented and drawn to scale to the specifications below. Poor quality maps and drawings may result in your application being invalidated or delayed.

The drawings should meet the following requirements:

- Location Plan at 1:5000, 1:10,000 or larger scale subject to the extent of the development with the land boundary clearly marked.
- Site plans of the intake and discharge structures at 1:1250 or 1:2500.
- Plan, profile and cross-section drawings for the abstraction structure at a scale of 1:50 or higher resolution to show construction detail.
- A design statement will be required that:
 - Clearly explains how the structure will operate in accordance with the abstraction regime.
 - Includes details of how the protected low flow and variable abstraction will be maintained.
 - Includes supporting design calculations.

The drawings must detail weir crest, intake and residual flow structure crest heights or invert levels.

Where screening for fish and fish passage / easement are required, details of these should be provided on the design drawings submitted as part of your formal application.

Your formal application will need to include a map clearly showing the land ownership, abstraction and discharge points, turbine house and the proposed pipeline route.

1.5 Maintaining continuous flow during construction

If flow is to be disrupted during the construction phase to provide an inriver working area, a continuous flow should be maintained downstream, leaving the de-watered section as short as practicable without causing pollution. Please see also Appendix 4 on pollution prevention guidance.

Stones for facing structures should not be taken from the river but an alternative local source.

1.6 Planning

Please note that, even though your proposed scheme may not affect a designated conservation area, the Local Planning Authority is likely to consult us on the impact of the scheme on any protected species in the vicinity. This may result in a request for ecological surveys, for example for bats, otters, water voles and nesting birds.

Please note that we may object to any future planning permissions if we are not in a position to grant an abstraction and / or impoundment licence for the scheme as submitted.

APPENDIX 2 - POLLUTION PREVENTION AND CONSTRUCTION CONSIDERATIONS

Landowners or contractors intending to carry out construction work for hydropower schemes should ensure that they clearly understand their responsibilities in managing their operations to minimise the risk of pollution.

It is important that method statements are produced for all site operations and that they include measures to reduce the risk of pollution of watercourses.

Detailed guidance is available from the Environment Agency's Pollution Prevention Guidance (PPG) series at <https://www.gov.uk/government/collections/pollution-prevention-guidance-ppg>.

In particular we recommend that you read the following guidance documents that are relevant to hydropower developments:

PPG1: Understanding your environmental responsibilities

PPG5: Working in, or near or over watercourses

PPG6: Construction and demolition sites

Please also read our regulatory position on de-watering excavations:
<http://publications.environment-agency.gov.uk/pdf/GEHO0810BSYE-E-E.pdf>

If tree felling is required for this development the developer/contractor should follow the Forest and Water Guidelines. These can be obtained from the former Forestry Commission's website at <http://www.forestry.gov.uk/fr/HCOU-4U4JAM>.

APPENDIX 3 – GLOSSARY OF TERMS

Abstraction regime	A description of how an abstraction is operated, usually characterised by a specific pattern of operation with rates of abstraction varying over time or with changes in river flows.
Full licence	A licence to abstract water from a source of supply over a period of 28 days or more.
Impoundment	An impoundment is a structure that obstructs or impedes the flow of inland water, such as a dam, weir or other constructed works.
Percentage take	To maintain flow variability in the depleted reach of a watercourse, our guidance allows a percentage of the <i>available</i> flow to be abstracted. Available flow is that above the protected low flow rate and up to the maximum rate of abstraction. The percentage of water that can be abstracted is dependent on scheme location and ranges from 10% to 70% of the available flow (See Hydropower Guidance Note (HGN) 2 – Hydropower Flow Standards).
Protected Low Flow	A low flow rate that must be allowed to pass freely downstream of the abstraction to maintain a minimum environmental flow in the watercourse. An abstraction should not cause the flow in the watercourse to fall below the protected low flow rate. The protected low flow rate is often, but not always, set at Q95 which is equivalent to a low summer flow.
Protected right	Means a right to abstract, which someone has by virtue of the small abstractions exemptions defined in the Water Act 2003 or by virtue of having an abstraction licence. The right protected is the quantity that can be abstracted up to that allowed by the exemption or the terms of the licence. The small abstraction exemptions defined by the Water Act 2003 are for domestic and agricultural purposes (excluding spray irrigation) not exceeding 20 m ³ /d.
Surface water	This is a general term used to describe all water features such as rivers, streams, springs, ponds and lakes.
Time limit	<p>All new licences within a Catchment Abstraction Management (CAMS) area have a common end date (CED) so that they can be reviewed at the same time. CEDs are assigned on a 12 year cycle. When an application is made within six years of the CED, we will generally apply the subsequent CED to any licence granted. This is to avoid issuing shorter and shorter duration licences as the CED approaches and means that the initial CED on a licence may be between six and 18 years duration. On replacement the duration will then usually be 12 years.</p> <p>However, where we are uncertain about the long term impacts of an abstraction, we will grant a short term licence during which time potential impacts are monitored.</p> <p>You can view our CAMS documents on our website.</p>

Transfer licence	<p>A licence to abstract water from one source of supply over a period of 28 days or more for the purpose of;</p> <ol style="list-style-type: none"><li data-bbox="443 232 1082 264">1. transferring water to another source of supply; or,<li data-bbox="443 295 1238 427">2. transferring water to the same source of supply, but at another point, in the course of dewatering activities in connection with mining, quarrying, engineering, building or other operations (whether underground or on the surface); <p>without intervening use.</p>
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APPENDIX 4 – USEFUL WEBSITES

You may find the following websites useful when planning your scheme or preparing your formal application. We have included these links for information only.

For our Hydropower Guidance Notes	Natural Resources Wales Natural Resources Wales / Before you apply
For our licence application forms	Natural Resources Wales Natural Resources Wales / How to apply for your hydropower scheme
For Pollution Prevention Guidelines	Environment Agency https://www.gov.uk/government/collections/pollution-prevention-guidance-ppg .
For water, ecology and geomorphology specialists	The Chartered Institute of Ecology and Environmental Management http://www.cieem.net/ The Chartered Institute of Water and Environment http://www.ciwem.org/
For advice on scheme design and developers	The British Hydropower Association http://www.british-hydro.org/
For site specific hydrology data	Wallingford HydroSolutions Ltd http://www.hydrosolutions.co.uk/
For flow data from gauging stations	Centre for Ecology & Hydrology (CEH) http://www.ceh.ac.uk/data/nrfa/ Natural Resources Wales E-mail: enquiries@naturalresourceswales.gov.uk 0300 065 3000 (Mon-Fri, 8am - 6pm)

The inclusion or exclusion of a website, or any individual or company named on the websites, is not an endorsement, or otherwise, by Natural Resources Wales and it is the applicants' responsibility to seek individual advice.

Water Usage Calculation Checklist

This checklist shall be used to calculate the Hydro Abstraction Factor for the proposed scheme (HAF_{site}) to allow conversion of electrical output to quantities abstracted.

The HAF_{site} is the amount of water used in m^3 per kWh generated for any period.

Site Data	
Site name	
Pre-application Ref.	WA
Turbine manufacturer	
Turbine type	
Number of jets <small>(where relevant)</small>	

Performance Data		
Parameter	Value	How was the parameter determined?
Net operating head of the system at maximum power output ($H_n (P_{max})$) in metres		
Turbine/water wheel efficiency at maximum power output ($e_{turbine/water\ wheel (P_{max})}$)		
Transmission system efficiency at maximum power output ($e_{transmission (P_{max})}$)		
Generator efficiency at maximum power output ($e_{generator (P_{max})}$)		

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{system (P_{max})}$)

$$e_{system (P_{max})} = e_{turbine/water\ wheel (P_{max})} \times e_{transmission (P_{max})} \times e_{generator (P_{max})}$$

$$= \boxed{} \times \boxed{} \times \boxed{}$$

$$e_{system (P_{max})} = \boxed{}$$

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

$$= 366.972 / (H_n (P_{max}) \times e_{system (P_{max})})$$

$$= 366.972 / (\boxed{} \times \boxed{})$$

$$= \boxed{} \quad (m^3/kWh)$$

Where:

$H_n (P_{max})$ = net head at max. power.

366.972 = a constant in order to bring the final HAF into the correct unit of $m^3/kWhr$ (it is arrived at by dividing the number of seconds in an hour (3600) by gravity ($9.81\ m/s^2$))

The volume of water abstracted for any period (V_{period}) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

$$V_{period} (m^3) = kWh_{period} (kWh) \times HAF_{site} (m^3/kWh)$$

See example overleaf:

(kWh is a measure of energy, whilst kW is a measure of power: at full efficiency, a 50 kW turbine will produce 50 kWh of energy in one hour, 100 kWh in two hours, 150 kWh in three hours etc.).

EXAMPLE

Performance Data		
Parameter	Value	How was the parameter determined?
Net operating head of the system at maximum power output ($H_n (P_{max})$) in metres	150	Site survey
Turbine/water wheel efficiency at maximum power output ($e_{\text{turbine/water wheel } (P_{max})}$)	0.9	From manufacturer
Transmission system efficiency at maximum power output ($e_{\text{transmission } (P_{max})}$)	0.85	From manufacturer
Generator efficiency at maximum power output ($e_{\text{generator } (P_{max})}$)	0.85	From manufacturer

Calculation of overall system efficiency of the rotating parts of the hydro system, at maximum power output ($e_{\text{system } (P_{max})}$)

$$\begin{aligned}
 e_{\text{system } (P_{max})} &= e_{\text{turbine/water wheel } (P_{max})} \times e_{\text{transmission } (P_{max})} \times e_{\text{generator } (P_{max})} \\
 &= \boxed{0.9} \times \boxed{0.85} \times \boxed{0.85} \\
 e_{\text{system } (P_{max})} &= \boxed{0.65}
 \end{aligned}$$

Calculation of HAF_{site}

HAF_{site} = Hydro Abstraction Factor for the site in question

$$\begin{aligned}
 &= 366.972 / (H_n (P_{max}) \times e_{\text{system } (P_{max})}) \\
 &= 366.972 / (\boxed{150} \times \boxed{0.65}) \\
 &= \boxed{3.764} \quad (\text{m}^3/\text{kWh})
 \end{aligned}$$

The volume of water abstracted for any period (V_{period}) can then be calculated by simply multiplying the HAF_{site} by the number of kiloWatt hours generated thus:

$$V_{\text{period}} (\text{m}^3) = \text{kWh}_{\text{period}} (\text{kWh}) \times HAF_{\text{site}} (\text{m}^3/\text{kWh})$$

If, for example your total export of electricity for the period was 68400 kWh, then you would have abstracted a total volume of water of:

$$V_{\text{period}} (\text{m}^3) = 68400 \text{ kWh} \times 3.764 \text{ m}^3/\text{kWh} = 257457.6 \text{ m}^3$$