Hafod y Rhedrwydd micro-hydro proposal.
R.W.Moss, October 2018

This micro-hydro system will provide power and domestic water to an off-grid cottage. Depending on the level of water in the stream, the system will be able to provide between 0.4 kW and 9 kW.

Water will be taken from Afon y Foel, extracting at a point 35 m higher than the house. This gives sufficient height for domestic water pressure and for the pipe to be routed over a spur instead of along the side of a ravine. The pipe length to the house is 380 m.

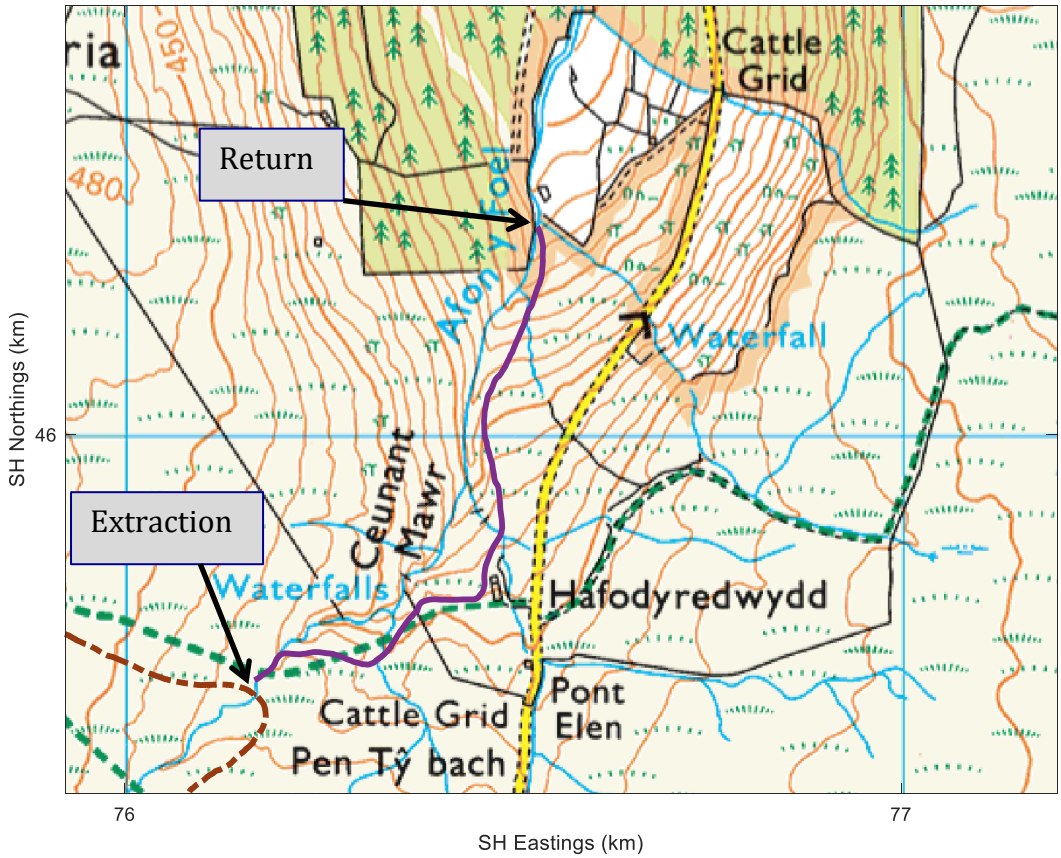

Figure 1. Pipeline route. See also drawing HyR_181006A.

The pipeline has a tee-off to the house before continuing for another 475m towards the bottom of the valley to achieve a total head of 150m. The return point is where the land starts to level out: the steep-sided gorges and ravines higher up make the stream above here quite inaccessible.

All pipes and wires will be buried except for the initial 47 m where the stream falls away until the pipe is above bank level and the pipe can curve away to pass across the spur. The above ground section will be wrapped in hessian to encourage the growth of vegetation.

The route avoids areas of blanket bog, passing below the stream draining the closest such area (Figure 2).

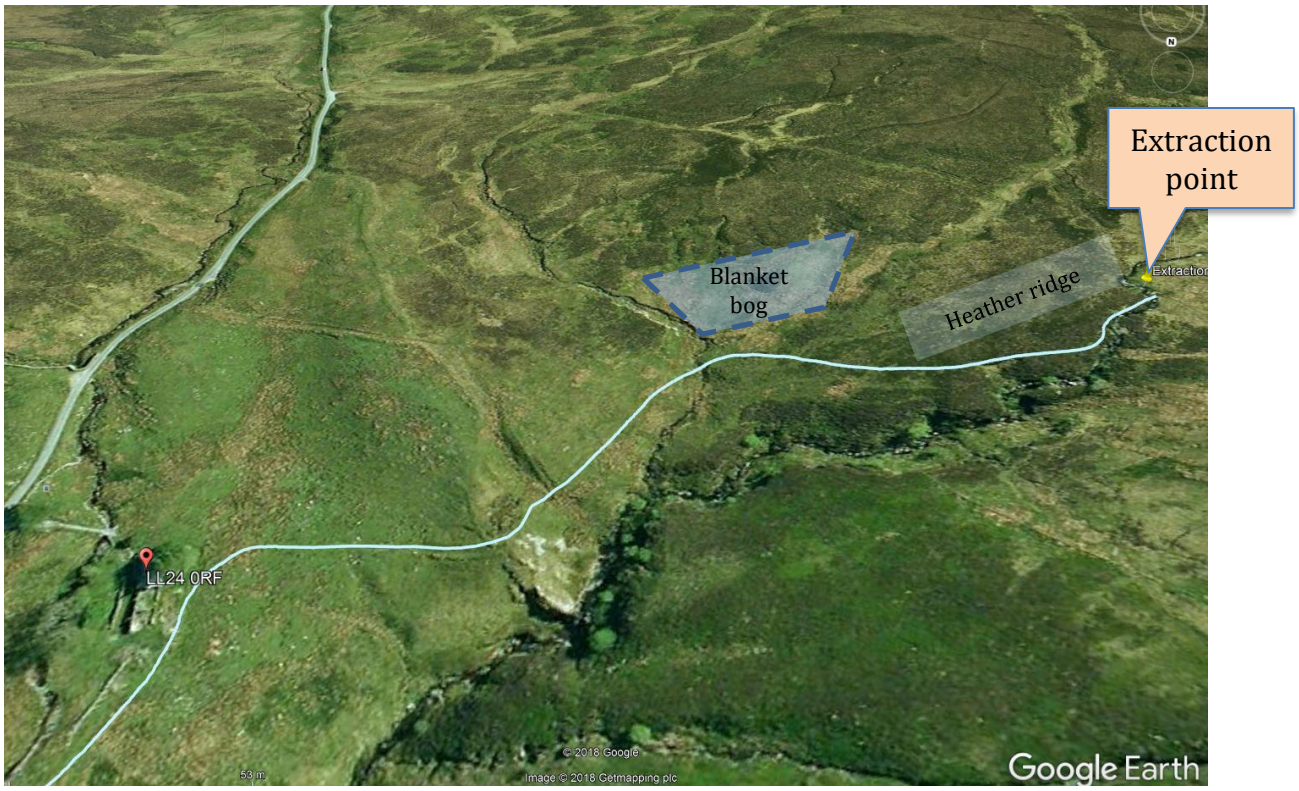

Figure 2. Route of upper section, looking South.

Figure 3. Small waterfall at the extraction point. The crests of the Coanda screens will be set approximately level with the waterfall lip to avoid any change in upstream water levels. [Stick with tape at 1 m intervals to show scale].

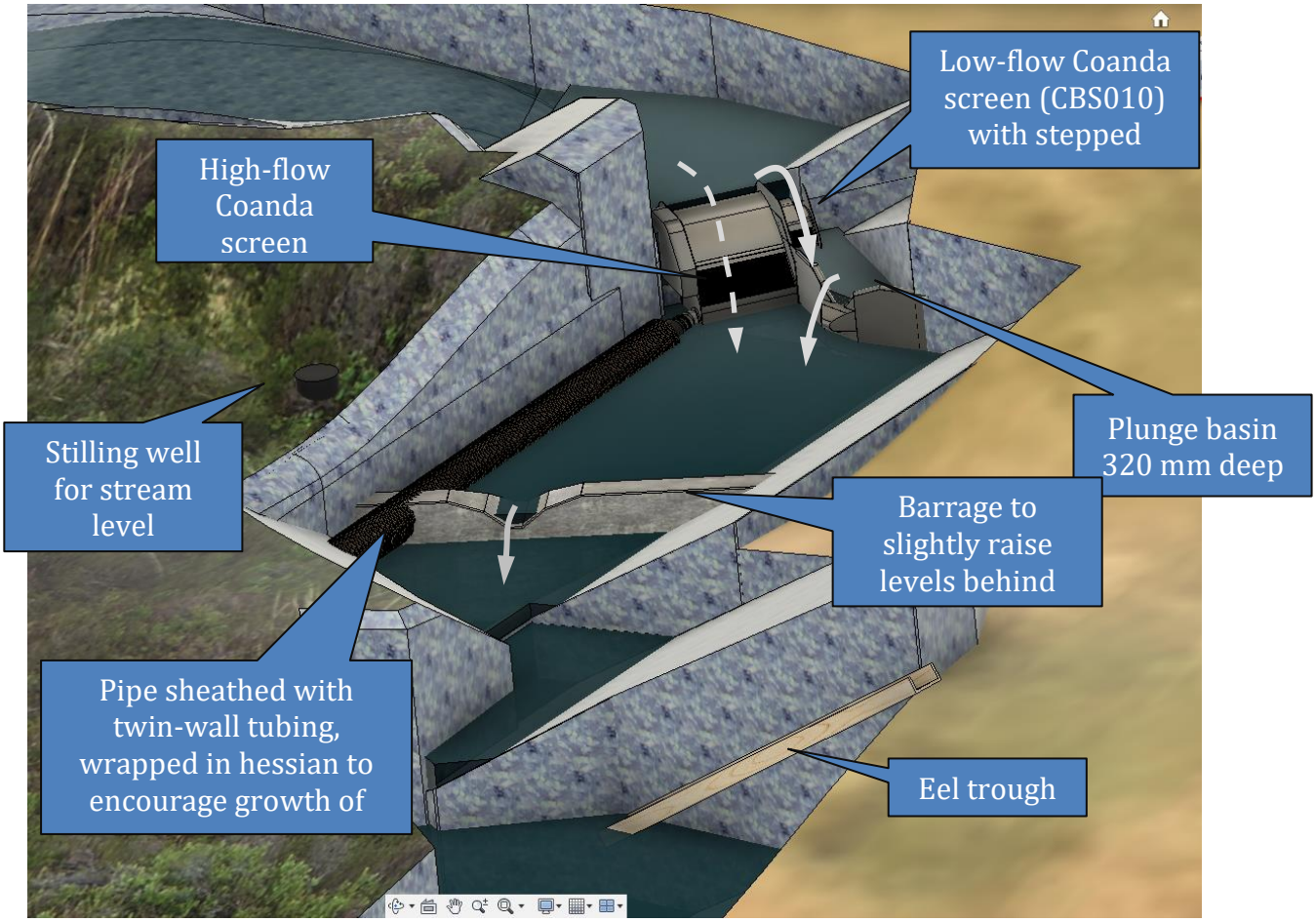

Figure 4. Abstraction system. Fish can progress up and downstream in three stages (black arrows). Water level increment 25 cm for each (shown for stream flow of 4 litres/sec, Q95) – jump from water up to weir crest is slightly less. At higher stream levels, water starts to flow over the high flow screen (dashed arrow). Drawing HyR_181006B.

Figure 5. Pipe route. The Geomorphology Survey provides more detailed photographs of the surroundings.

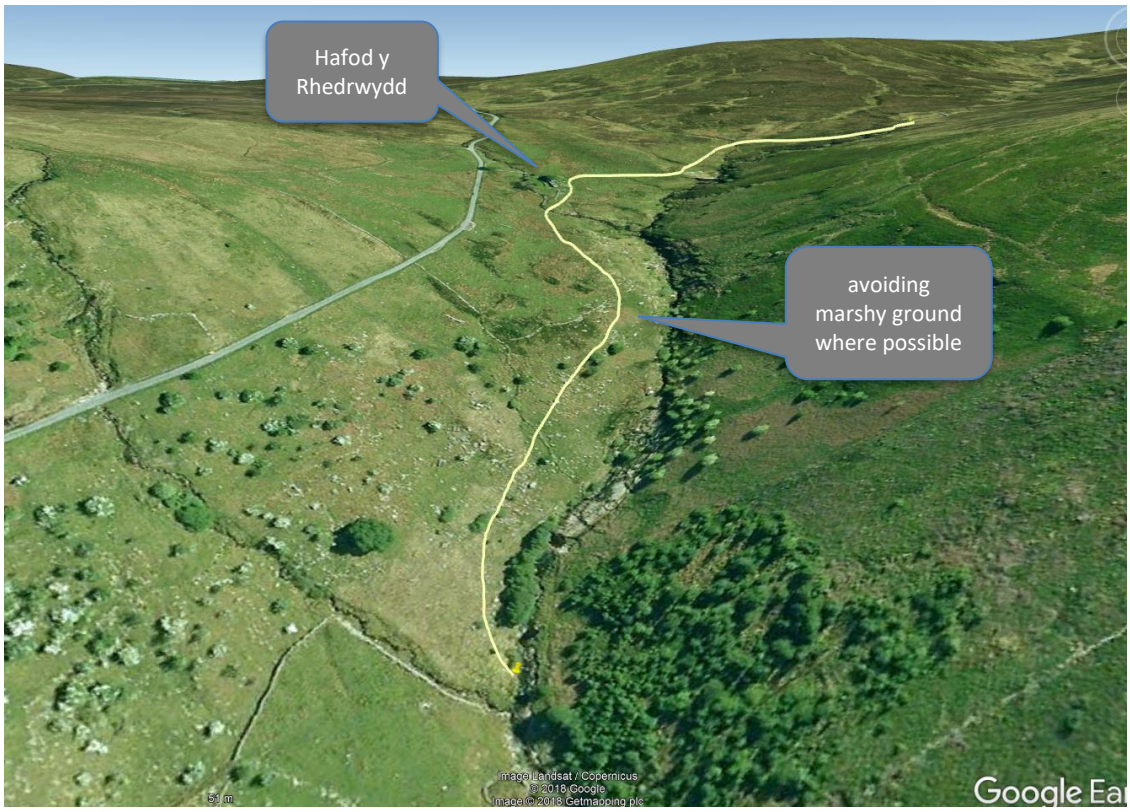

Figure 6. Pipe route below the cottage.

Figure 7. Proposed turbine hut (very roughly to scale), built into the slope & mostly hidden from the road. 3 m × 1.7 m × 1.5 m high internally, shallow-pitch turf roof, stone walls + internal insulation, 4 m × 2.7 m externally. Grey bar to show scale.

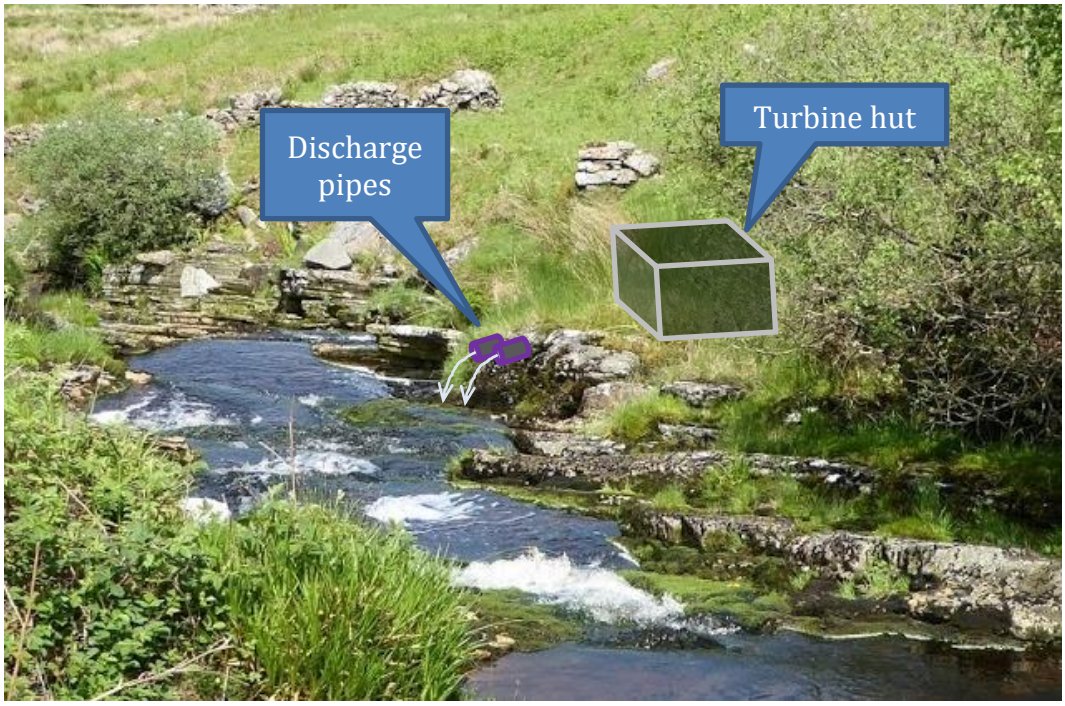

Figure 8. Each turbine will have a pipe of at least 140 mm bore discharging into the river. The diameter will be sufficient for the water to run out (like a waterfall) as opposed to squirting as a jet.

The pipes will be situated above the stream's high water level (Figure 9).

Figure 9. Discharge point after heavy rain (15th September 2017).

Since the house is off-grid and will use the electricity in part to run a UV water steriliser and refrigerator it is desirable to maintain some flow even in very dry weather - this is more important that the maximum power in wet weather. It is therefore requested that flows beyond Q95 are considered "protected" rather than completely hands-off. The extraction in this regime will be hardware-limited to 0.6 litres/sec (sufficient to provide about 350 Watts to the house, see *Justification for the extraction regime.pdf*).

The turbine control system will adjust the spear valves to vary the extraction rate in response to stream level (measured just below the screens) and power required. A small settling and de-aeration tank about 40m from the screens will contain a second level sensor to warn of any obstruction to flow due to screen blockage.

Domestic water to the cottage will be measured by a domestic water meter and is not expected to exceed 1 m^3/day (5 people, typically 150 litres/day each). For safety, 2 m^3/day is used in form WRE.

The penstock will be made from 110 mm HDPE pipe. Frictional losses in the pipe limit the maximum possible net power output to just over 9 kW at a flow rate of 14.8 litres/sec. Figure 13 shows the predicted output (as 240 V AC in the house) for a range of turbine and alternator pairings. No allowance has been made for losses cause by weld beads in the pipe, so these values may be a slight over-estimate.

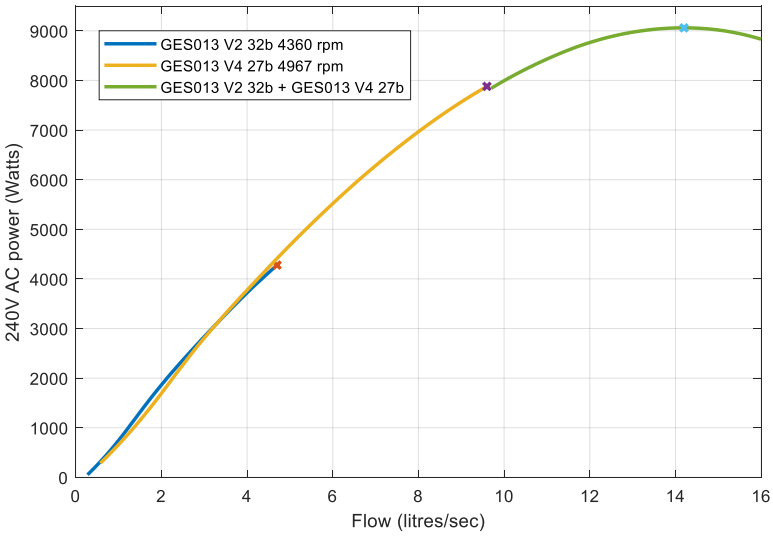

Figure 14. Net power (taking account of penstock losses, component efficiencies, windage and parasitic losses) as a function of flow rate. (*system_plot3.m*)

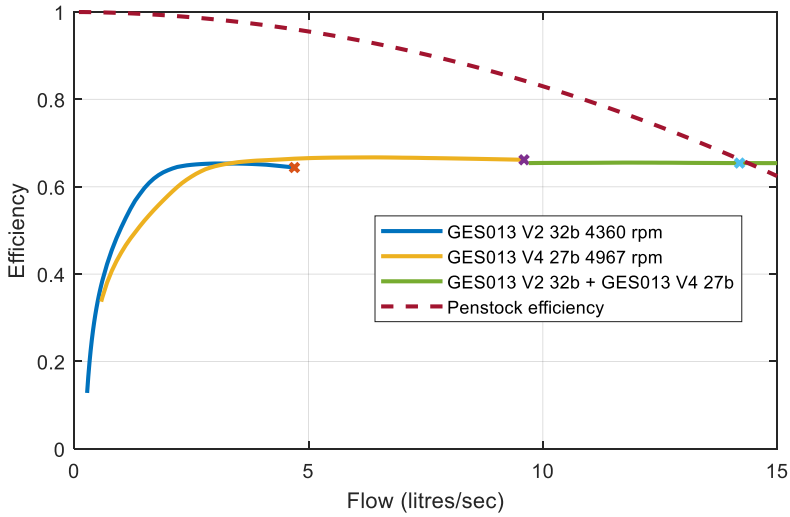

Figure 15. Efficiency curves for (a) turbine, alternator, power conversion and control system, (b) pressure drop in penstock. (*system_plot3.m*)

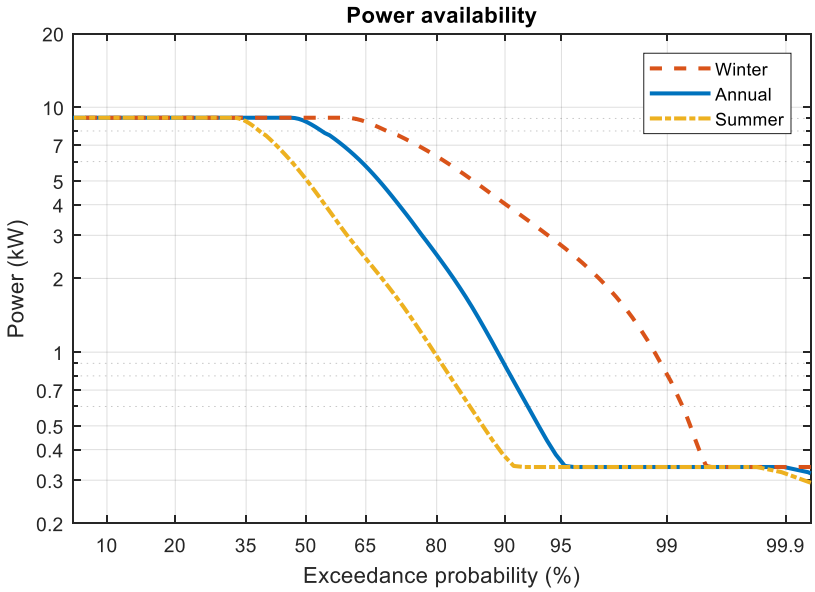

Figure 16. Power availability (see **Justification of the extraction regime v3.pdf** for further details about component efficiency assumptions).

Operation and control

To allow efficient operation at very low flows and ease maintenance there will be two turbines and alternators, one set larger than the other. They can run individually or together.

The turbine runners are made by Hartvigsen Hydro.

Figure 17. Stainless steel Turgo runner.

The alternators are 3-phase permanent magnet devices made by MOOG, models GES013-V2 and GES013-V4.

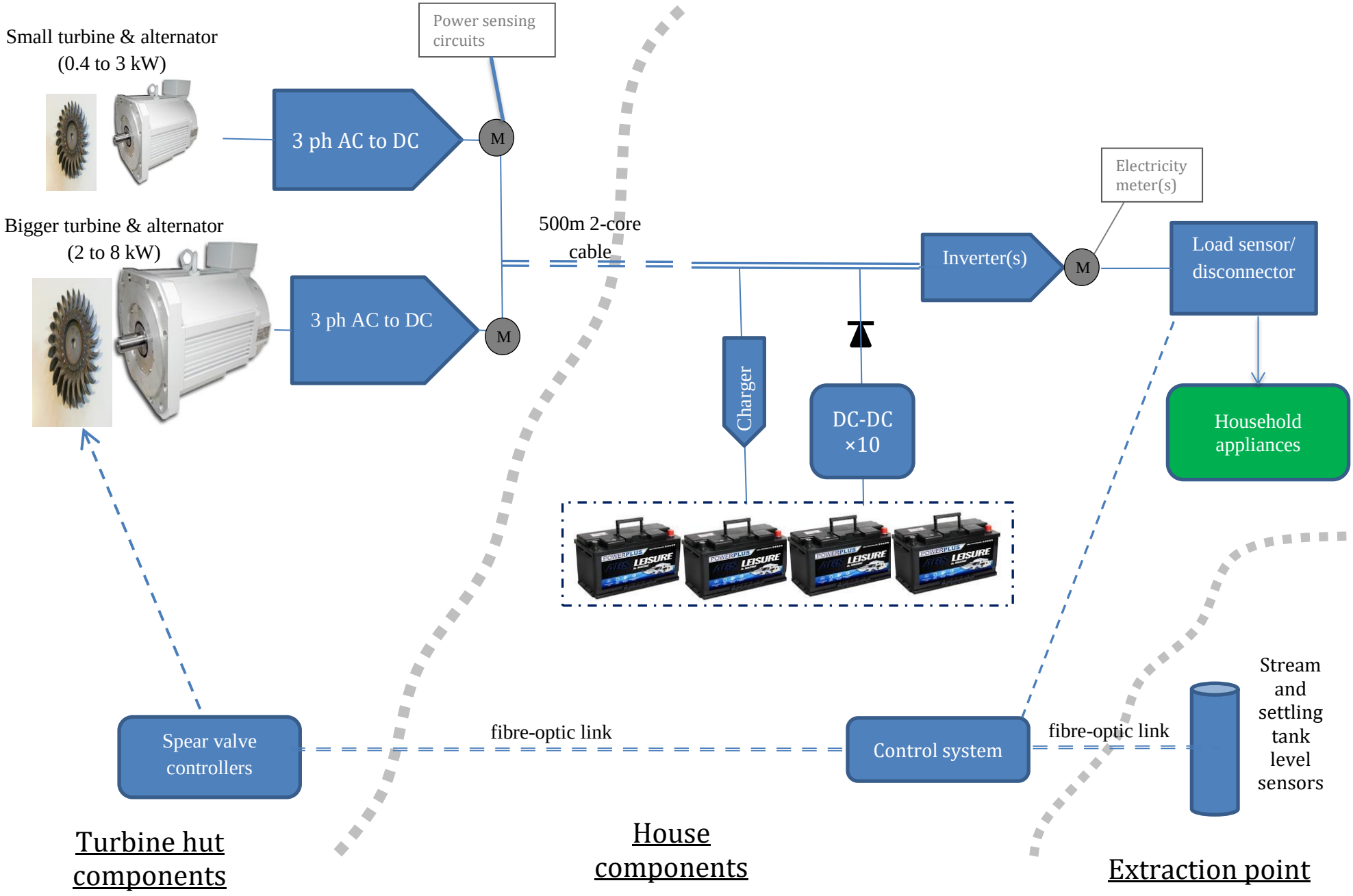

Figure 18. Schematic diagram of the turbine control system.

Ecology and construction methodology.

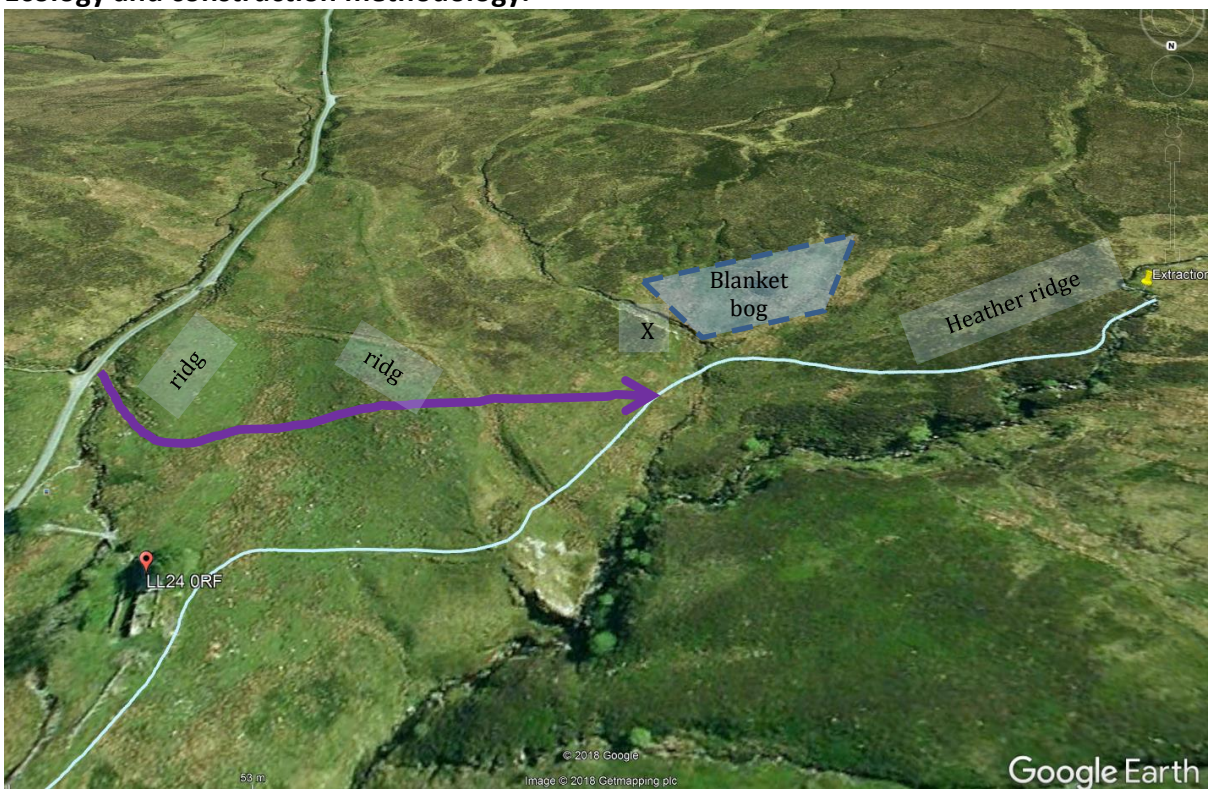

Figure 19. Access to upper section avoiding blanket bogs, for:

- 1.5 ton mini-digger
- Power barrow e.g. Belle BMD 300.

In accordance with the ecological survey, prior to any work that might continue into the bird breeding season (April-August) a brush cutter/strimmer will be used to mow a 3m wide path through heather and long grass. The path will then be raked clear to discourage ground-nesting birds from nesting along the construction route.

Also in accordance with the survey, measures will be taken to avoid any impact on otters, as follows:

- Avoid any unnecessary work or damage to vegetation along the river's edge;
- Ensure the construction site is left in a safe condition when unattended to avoid risk of injury to otters;
- Restrict construction work to daylight hours;
- Provide escape ramps from any deep excavations.

Figure 20 (Fig. 38 from the pre-application geomorphology survey, location "*x*" in Fig. 19). Soil characteristics. The pipe route will as far as possible pass through well-drained soil. (The blanket bog in the background, as marked in Figure 19, is drained at its lower edge by two small streams. The pipe route passes below the confluence of these and will thus have no impact on the blanket bog region).

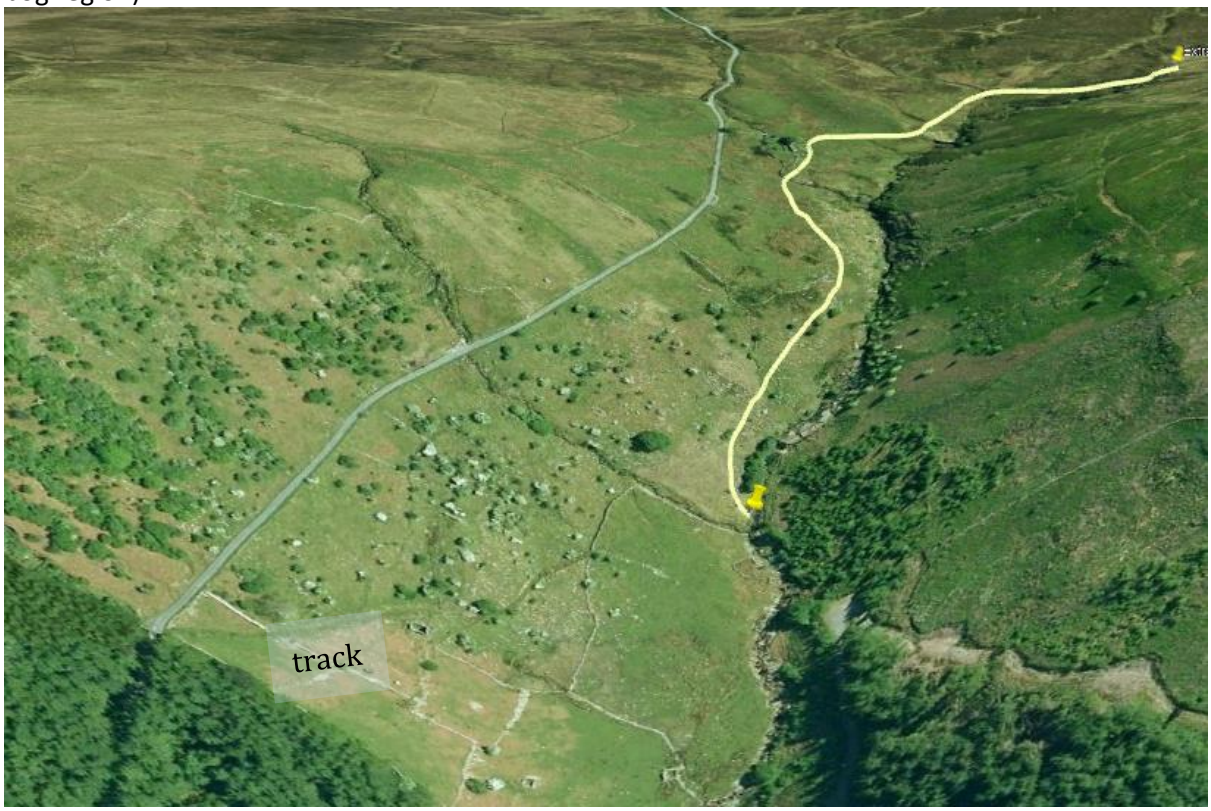

Figure 21. Access track to proposed turbine hut location.

The trench for pipe burial will be no larger than necessary:

- pipe diameter 110 mm

- cable conduit diameter 65 mm

Where possible, the top of the pipe will be 200 mm below the surface. A sheet of Terram geotextile will be laid beside the trench to separate excavated soil from the grass so that it be cleanly returned to the trench later. Turf, top soil and sub soil will each be laid out separately to facilitate the back-filling process and ensure rapid regrowth of vegetation.

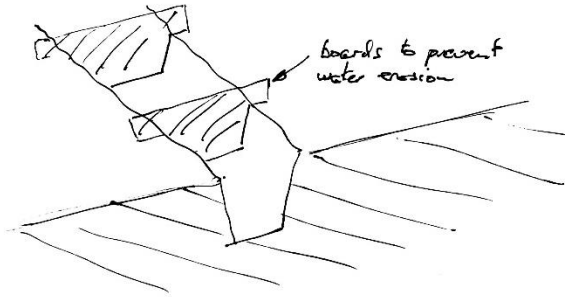

Figure 22. To avoid water erosion during construction, digging will as far as possible be done in dry weather. If there is any risk of rain, sloping sections will have boards hammered into the trench to impede water flow and prevent erosion.
When backfilling the trench, clay bands will be packed around the pipe at 30 m intervals. These will prevent water from running downhill around the pipe and causing underground erosion. The glacial till seen in Figure 20 is suitable for this purpose.

Stream work will be carried out in very dry weather. A sheet of EPDM roofing rubber, held down by sandbags, will be placed across the stream immediately above the work location and will funnel the water into a twin-wall drainage pipe (n.b. not a dam – will not raise the level), Figure 23. This temporary pipe will carry the water and return it to the streambed immediately below the workings.

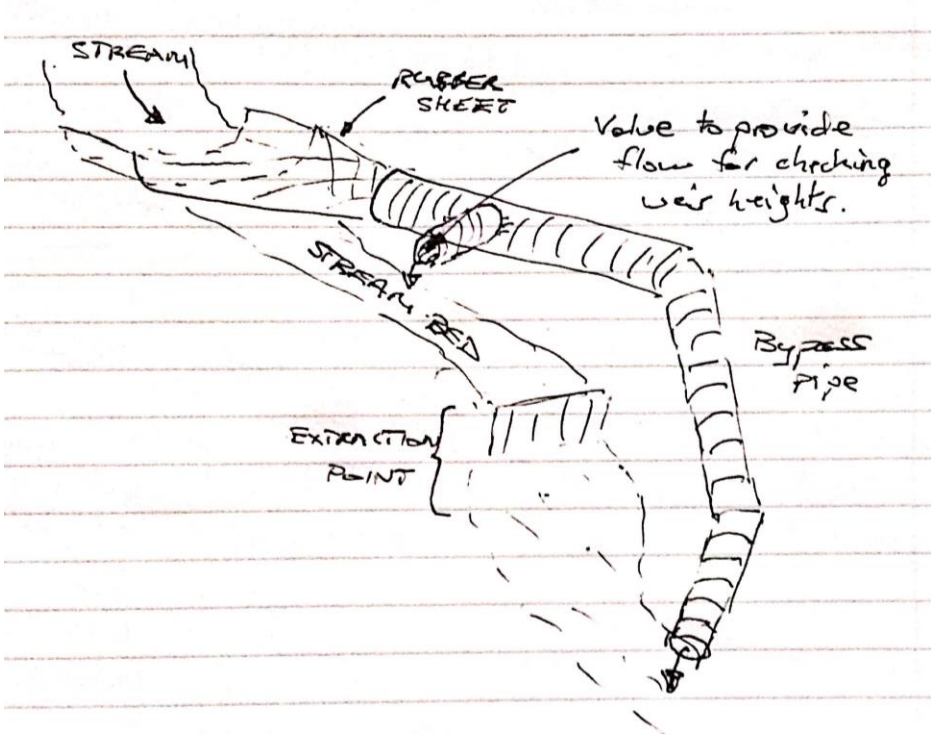

Figure 23. General arrangement of a temporary pipe to divert stream flow while building the two stream crossings. A similar arrangement working as a syphon between two pools will bypass the extraction point during construction.

Stream crossings will be cut by hand, using a stone saw (petrol or electric) to make a series of grooves and breaking out the tongues using an SDS drill, Figure 21. Where possible the rock chippings will be used in the concrete to preserve colour and appearance when filling this groove.

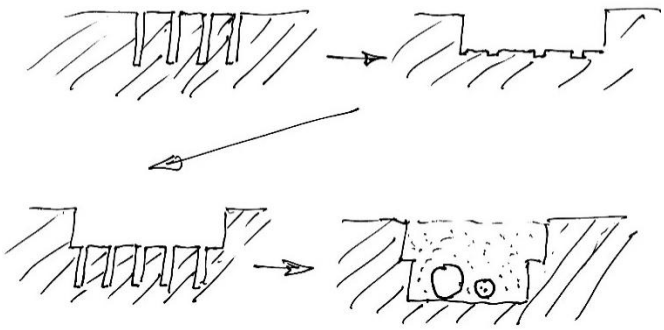

Figure 24. Construction technique for stream crossing trenches.

To avoid introducing invasive species, no soil or plants will be brought into the construction site. Digging implements and machinery will be cleaned before coming on site to avoid any risk of importing seeds and rhizomes.

RWM
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