Hydro-electricity

Gill Fenna

Quantum

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Overview

- 2009 UK Hydro capacity 1.6 GW, generating 5,300 GWh, 21% of renewable output
  - Compared to 4.4 GW wind generating 9,300 GWh
  - Excludes pumped storage for load management
- 90% of this from large (>20MW) schemes in Scotland
- Maximum capacity estimated at 3% of total demand
  - Very limited potential for more large scale hydro
- NW technical capacity 77 MW
  - 60% in Cumbria
- Proven technology, very long lifetime

Basic Principles

Power =

Head x Flow Volume x Efficiency x Gravity

Energy Generated = Power x Hours run

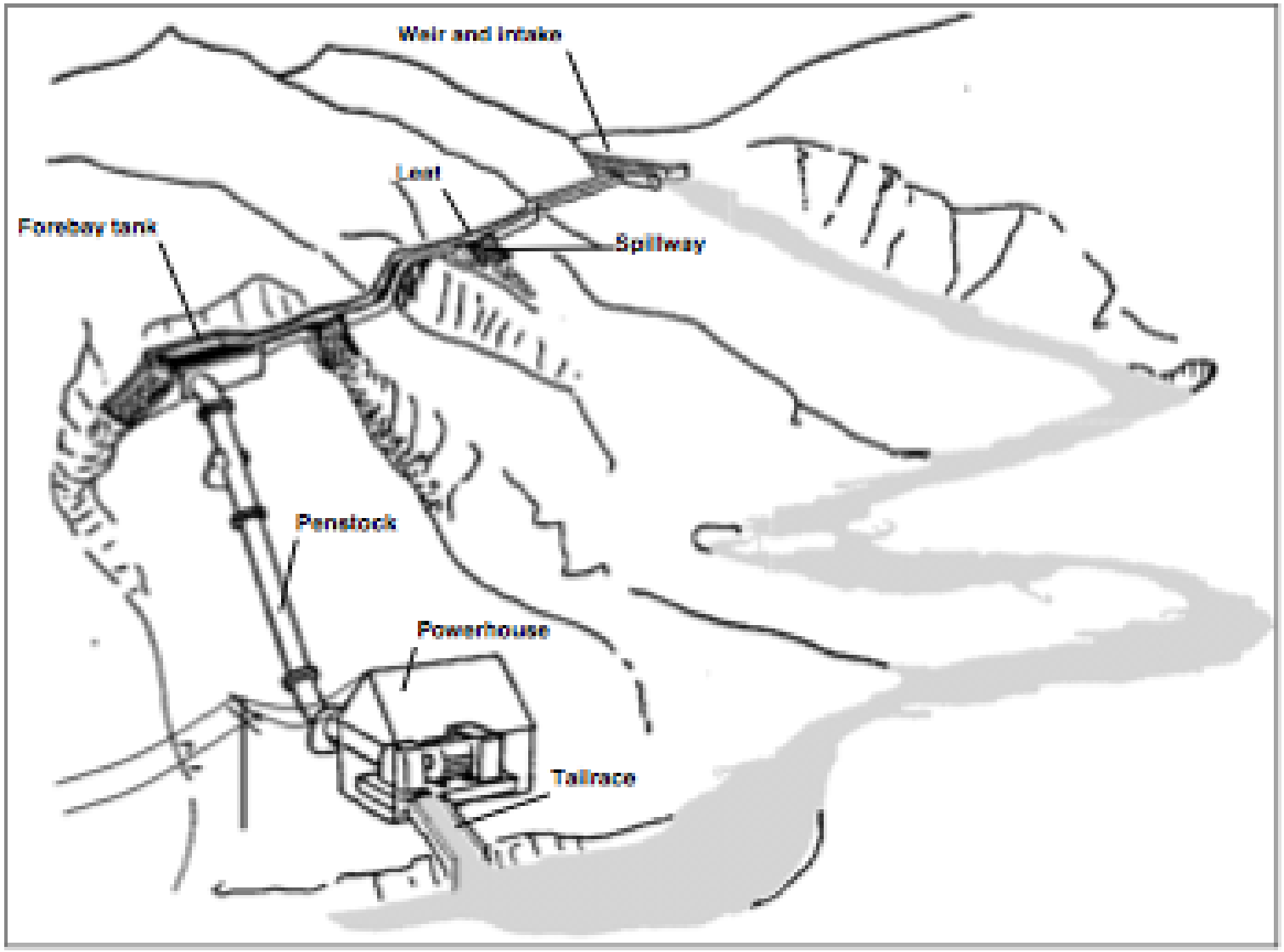
To maximise output:

- High head
- Large flow volume
- Efficient turbine
- Constant operation

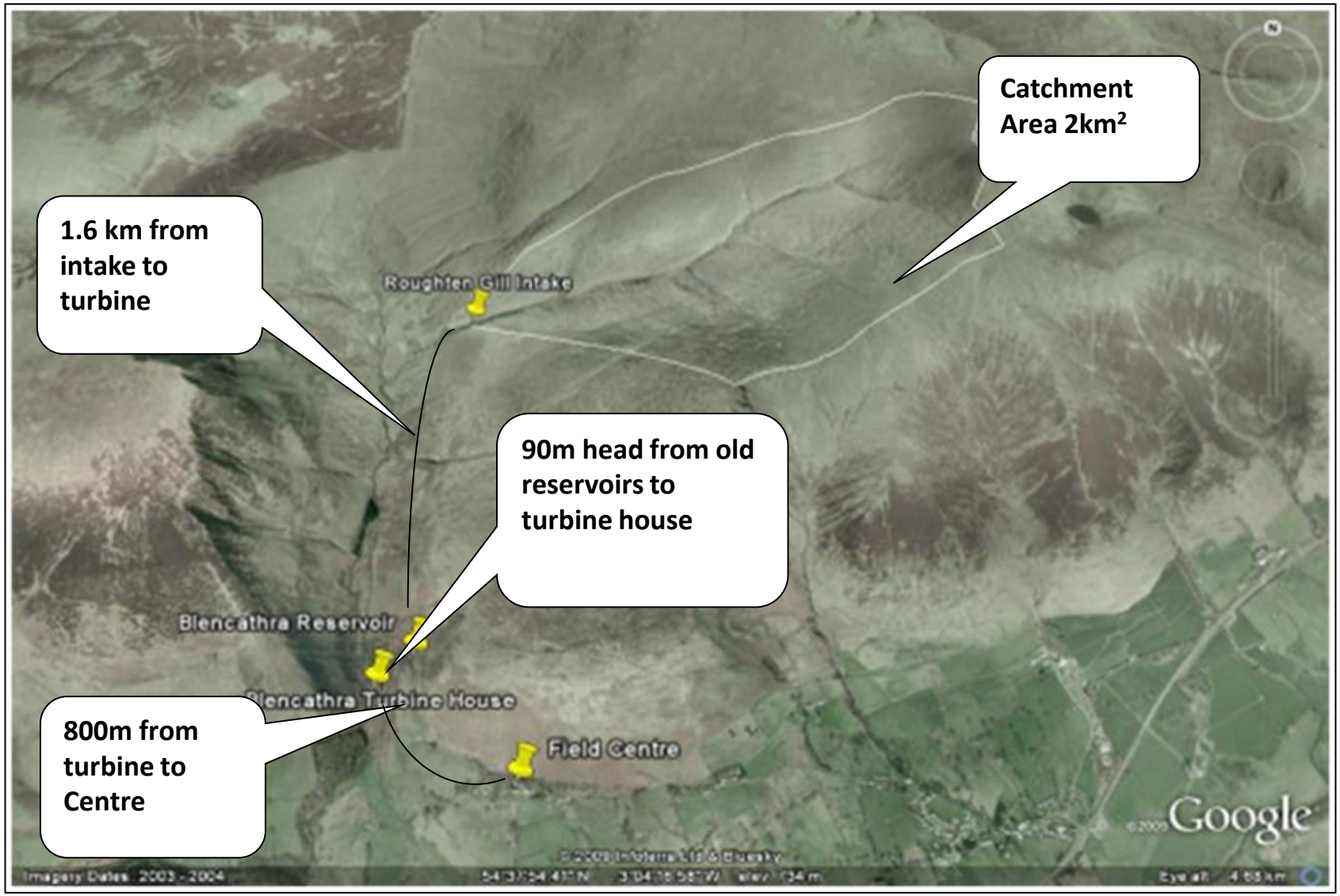
Small-scale systems:

- High/Medium Head
- Run-of-river (high flow)

High Head Scheme



Example: Cumbria



Low Head/Run of River

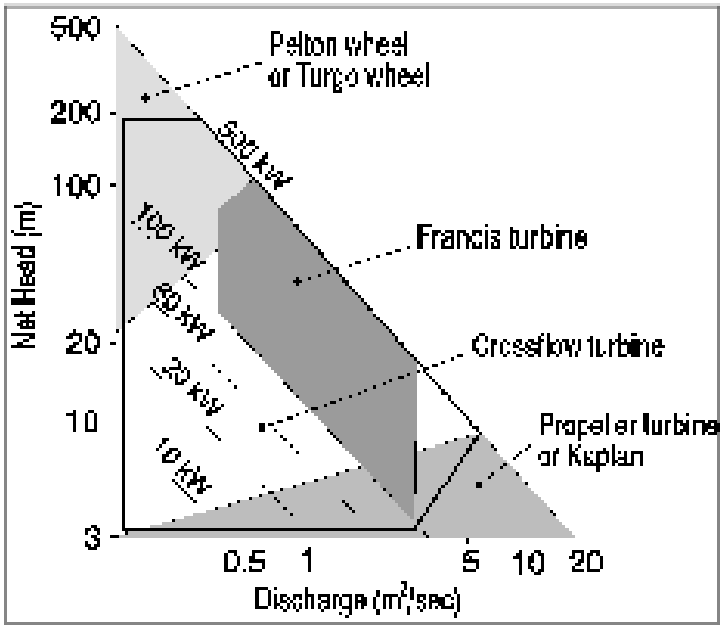
- Ideally by an existing weir
- Head height 1-4m
- No or minimal water storage
- Limited area of impact

Main Components

- Turbine
- Turbine House – turbine, inverters, controls
- Water diversion – channel, weir, holding bay, pipework, tailrace
- Fish pass
- Screening & cleaning – fish, debris
- Grid connection

Turbine Types - Housed

- Impulse turbines
  - Pelton, Turgo, Cross-flow
- Reaction turbines
  - Propellor, Francis
- Capacity: 10 – 500 kW
  - Pico-turbines to 1kW
- UK manufacturing base
  - Major suppliers in NW



Archimedes Screw

- Potentially lower environmental impact
- Visible – tourist attraction
- Lower capital cost
  - Reduced need for screening
  - May avoid fish pass
- Lower efficiency/output
  - Affects investment decision

Planning Considerations

- Visual impact
  - Powerhouse, channels, penstock etc
- Noise
- Public access
- Preservation of historic structures
  - Existing weirs, mills, turbine houses
- Construction operational & disturbance
- Environmental impact – EIA required if >500kW or in a sensitive area (SSSI etc)

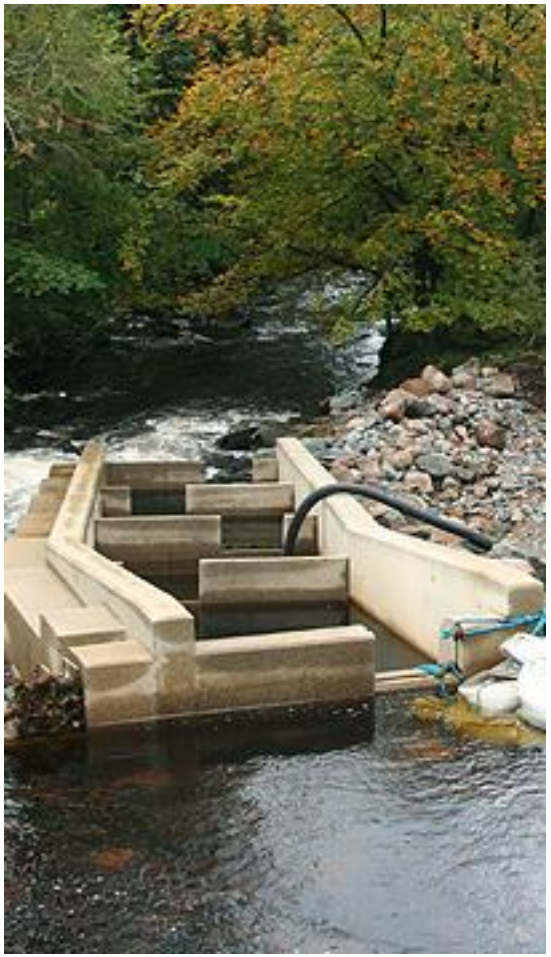
Structures – Turbine House

Forest of Dean

Lake District

Brecon Beacons

Structures – Fish pass, weir



Structures – Penstock, Trash Rack

Backbarrow: 400kW, 3 turbines

Site Selection Issues

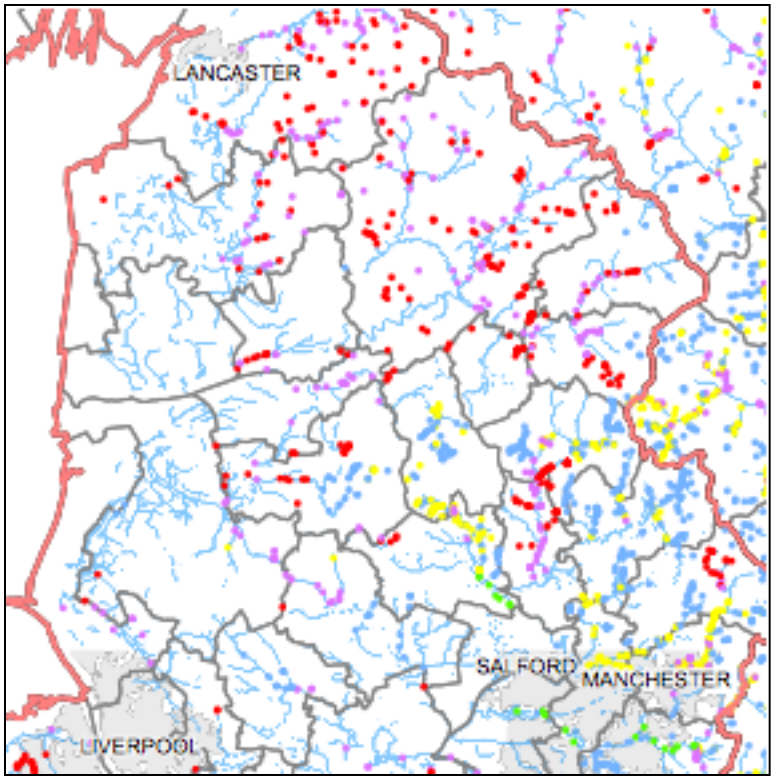
- Gross head available
- Water flow – quantity, availability, variability (seasonality, catchment area, run-off rates)
- Site for turbine house
- Proximity to grid connection
- Access for construction machinery
- Permanent access for maintenance
- Land ownership
- Environmental impact
- Fish – ladders, angling

Environment Agency Site Assessment

- Mapping Hydropower Opportunities and Sensitivities in England and Wales, Feb 2010
- National and Regional reports
- Mapped 25,935 water-course barriers to identify technical potential for small hydro
  - 17,000 weirs, 6,000 waterfalls
- Estimated head height and flow rates to assess output
- Identified areas of sensitivity for fish species & habitats
- Over 4,000 sites classed as “Win-Win”
  - Potential to generate energy and improve environment

NW Hydro Opportunities

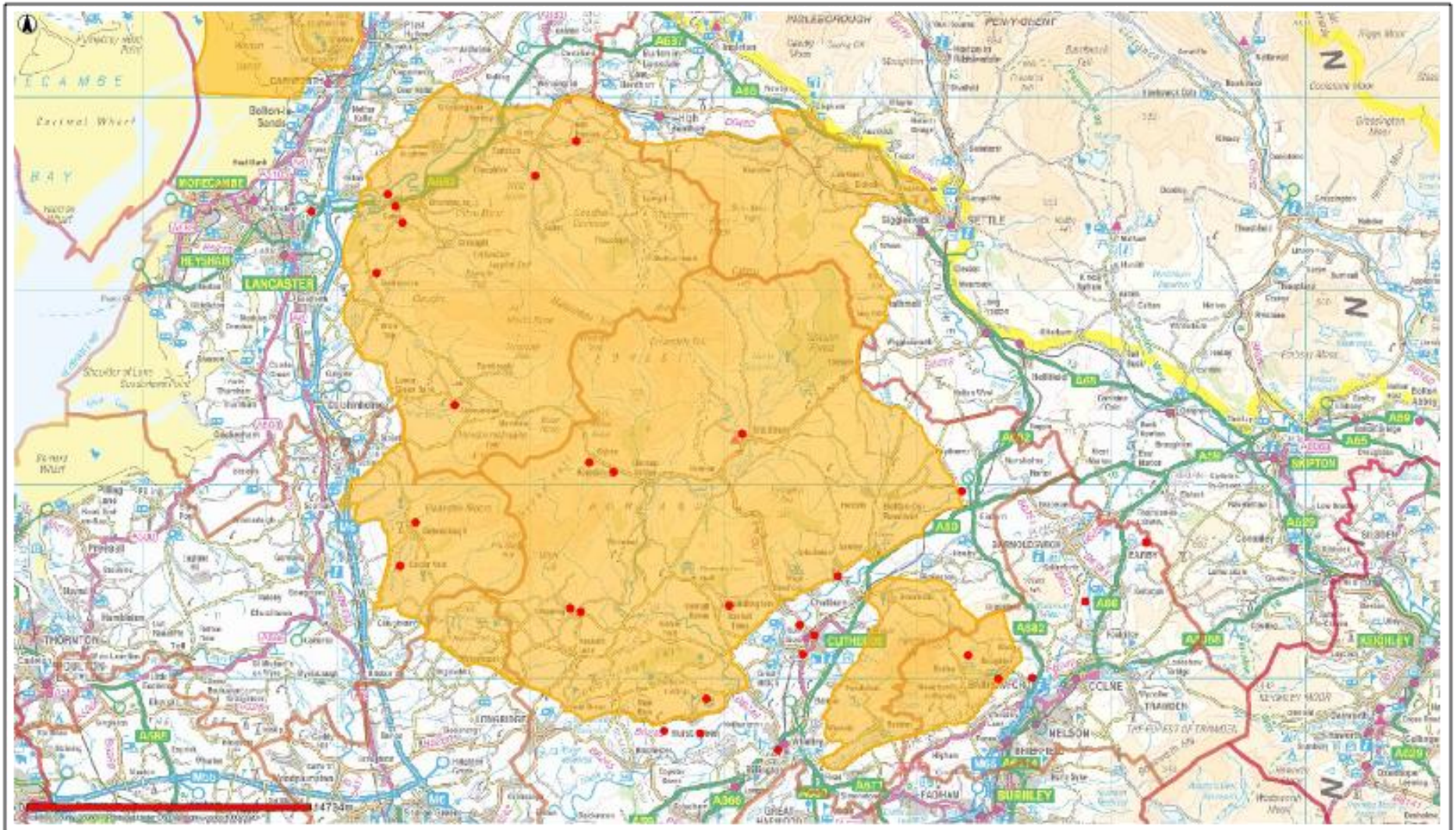
Number of barriers		4593
Combined total power potential (MW)		196
Average power potential (kW)		43
Maximum power potential (kW)		3316
High sensitivity	Number of barriers	2197
	% power potential	74%
Medium sensitivity	Number of barriers	791
	% power potential	5%
Low sensitivity	Number of barriers	145
	% power potential	3%
Win-wins	Number of barriers	896
	% power potential	39%



- High Output, Low Sensitivity
- High Output, High Sensitivity
- Medium Output, Medium Sensitivity
- Low Output, High Sensitivity
- Low Output, Low Sensitivity

Forest of Bowland AONB

- Study of potential hydro sites in 3 districts: Lancaster, Ribble Valley & Pendle
- 130+ sites initially proposed
- Local sifting of sites to identify the most likely:
  - Local knowledge, “pins in maps” event, visits to sites
  - Saved time & money
- 30 sites investigated
  - Rated capacity, annual output, revenue from FITs, carbon savings, installation costs and simple payback time
  - Mostly < 50kW capacity, 3 sites >100kW
  - Discussions with landowners: interest, likely to progress
- 5 sites to have detailed investigation to help turn into a project
- Worked closely with EA and Fisheries from the start



Lancashire County Council

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EA Permissions

- **Abstraction Licence** - to agree the amount of water that a scheme can take from a river through the turbine
- **Impoundment Licence** – for any new or raised weir that will change the water levels and flows in the river
- **Flood Defence Consent**– to ensure the project does not have the potential to increase flood risk.
- **Fish Pass Approval** – to ensure fish can pass safely up and down the river and are not harmed in the turbine: fish ladder/ screens/ Archimedes screw turbine

EA Permission Checks

- Effects on ecology, biodiversity, hydrology, fisheries of any stretch of reduced flow (depleted reach) including weirs
- Assessment in changes of turbidity and impact on sediment & suspended solids
- Right of access to land
- Environmental Impact Assessment for schemes in a sensitive area (SSSI etc) or all over 500kW
- Ecological impact for designated rivers, species or habitats
- Land contamination – whether construction or operation poses a risk of polluting the waterway
- Impact on navigation and recreational users

EA Permission Streamlining

- Good Practice Guidelines for developers and EA staff
- Simplified management process with a single account manager for each application and local specialist teams
- Comprehensive pre-application checklist
- Unified set of application documents
- Single final permit
- Support for developers and other interested parties e.g. community groups, anglers

Developing a Hydro Scheme

- Finance: £100,000 - £500,000
- Development time: 2-5 years
- Requires considerable technical knowledge and management time
- Regular operations – cleaning, flow monitoring, maintenance 1-5% of capital cost
- Income:
  - Feed in Tariff (15-100kW, from 4/11) 18.7 p/kWh
  - Electricity Savings 10-15 p/kWh
  - Electricity Sales 3.1 p/kWh
- Payback: 4-8 years
  - Depends on size and amount used vs sold

Heron Mill, Beetham

- Grade II listed 18th C water mill
- Operated as a grain mill till 1950s
- Restored as operational mill/visitor/education centre since 1970s
- New hydro project proposed 2005
  - Originally Archimedes screw
- Initial planning application 2006
- 100kW Kaplan turbine installed 2010

Heron Mill: Environment Agency

- Worked closely with EA throughout
- Contractors had experience of dealing with EA issues
- Water abstraction: minimum flow over weir
- Salmon run: smolt screen to be put in place during spring & autumn
- Noise: initial concerns but not a problem
- Improved fish pass as part of civil works (although not required)

Heron Mill – Planning Issues

- Planning:
  - Blending turbine house with surroundings
  - Impact on listed building
  - Concrete surfaces
- Neighbours
  - Billerud Paper Mill: water abstraction requirements
  - Residents concerned about noise, flood risk, wildlife disturbance

Heron Mill – Project Issues

- Funding: grants & loans – took over 3 years
- Project management
  - Communications problems with/between contractors
  - Insufficient in-house technical knowledge
  - Very time-consuming
- Operating issues
  - Not yet fully commissioned
  - Automatic controls not working
  - River level monitoring: shutting down paper mill
  - Smolt screen blocked with leaves/reducing flow
  - Cleaning trash rack: should have been automated

Heron Mill - Viability

- Project cost approx £500,000 – grant and loan funded
- Output when fully operational 450-500 MWh/yr
- Income from Feed in Tariff: ~ £90,000 /yr
  - Pay off loan
  - Support Trust's educational activities

Benefits of Hydro

- High efficiencies (70-90%) and high capacity (over 50%)
- Fairly predictable output
- Seasonal peak output usually coincides with peak demand (autumn – spring)
- Robust technology – older systems have run for over 50 years
- Good financial model
- Very suitable for community schemes

Constraints

- Technical limit on capacity significantly lower than for wind
- Limits on capacity of individual systems
- Environmental and leisure concerns

Questions