Selset Reservoir Hydroelectric Scheme

harbouring an existing asset for new energy production in a restricted and remote location

by Stephen Collins BSc CEng MICE

Selset Reservoir dates back to 1960 and is located 9 miles north-west of Barnard Castle in County Durham. Sitting at an altitude of 310m in the valley of Teesdale, the reservoir gathers a significant amount of water every day, and principal contractor JN Bentley has worked closely with client RWE npower renewables, hydro plant suppliers Andritz, designers Mott MacDonald and reservoir operators Northumbrian Water, to construct a 750kW hydroelectricity scheme to exploit the flows discharged from the reservoir. The project successfully addressed a number of challenges associated with working in such a remote and environmentally-sensitive location and, now completed, provides enough electricity to supply 1,000 homes.

Progress on site at Selset - Courtesy of JN Bentley

Background

Selset Reservoir is part of the Lune/Balder reservoir system, which feeds the large water treatment works at Lartington. Because of its location high in the valley of Teesdale in the Pennines at an altitude of 310m, Selset gathers a significant amount of water every day, and Northumbrian Water and RWE npower renewables recognised the potential to harvest electricity from these flows.

Following a competitive tender process, JN Bentley was selected by RWE npower renewables to deliver the construction elements of the scheme.

The project utilises the flows from the reservoir by connecting into two of the discharge pipelines (north and south mains) to direct flow into the new 750kW Francis turbine, from where it is discharged into the Selset weir/tailbay pond. A new turbine house has been constructed, which is sympathetic to its picturesque surroundings, as has a new access track and associated M&E installations.

The turbine at Selset began generating electricity in January 2011 and feeds into the national grid, creating enough power to supply approximately 1,000 homes.

Key challenges

Although surrounded by open land, the construction site for the powerhouse was actually quite restricted – the sloping narrow strip of land on which it was constructed being bound by the dam and the dam abutment; existing reservoir infrastructure; a valve house and a pipe trench; and the weir pond. This made its construction particularly challenging.

The below-ground works to allow construction of the tailrace chamber and outfall pipe, together with the stepped building foundation slabs, required a series of excavations.

To satisfy the requirement for a positive propping reaction force and a maximum pile deflection of 3mm, a phased excavation system

The portal frame structure of the powerhouse was clad with masonry and appropriate roofing materials to give a traditionally-built barn impression - Courtesy of JN Bentley

The completed powerhouse and access track Courtesy of JN Bentley

New pipework and isolation valves connected to the existing north and south mains - Courtesy of JN Bentley

Installation of the hydro plant within the powerhouse Courtesy of JN Bentley

was designed. Ground support of excavations up to 6m deep, with interlocking steel piles and mega brace frames pressurised, ensured no movement, and daily monitoring of the network of level control points ensured compliance.

The restricted access required detailed planning of piling and excavation sequencing to allow installation and removal of temporary work with excavators. A side grip piling hammer was sourced for the installation and removal of the sheet piles, with all methodology agreed in advance with Northumbrian Water's Reservoir Engineer.

Beneath the upper slab of the powerhouse, the incoming 1,200mm diameter pipe to supply water to the turbine was installed. A construction tolerance was required on the turbine connection flange of +/- 2mm, achieved by incorporating a steel template to provide precise control when casting the pipe surrounds and thrust blocks.

Flood prevention

Temporary works to provide flood protection were also successful. Reservoir levels were lowered by 2m to establish a safe buffer against reservoir flooding, and a temporary dam was formed to allow construction of the tailrace outfall (using locally-excavated clay material and polythene sheeting to form a simple but effective temporary flood defence). The dam included a 2.5m dia. discharge pipe through the existing headwall, complete with a metal bar security screen to prevent unauthorised access into the outlet pipe and tailrace chamber.

Additionally, the reservoir wall was maintained until the new tailrace had been constructed to ensure no excavated faces were exposed should a flooding event occur – a flooding event would otherwise risk the stability of the embankment.

An Emergency Flooding Plan was agreed at the start of the works to provide further contingency, which included daily level monitoring and an early warning system if water levels reached trigger points. The plan and flood defences were put to the test during the particularly wet autumn in 2011.

Sustainability and environmental issues

Environmental management at Selset took on added significance as it is situated within the North Pennines Area of Outstanding Natural Beauty, with its dam wall and north-eastern sections within the Lune Forest Site of Special Scientific Interest (SSSI), North Pennine Moors Special Protection Area and Pennine Dales Environmentally Sensitive Area. Environmental measures implemented by the team included:

- Liaising with local farmer for disposal of excavated material on their land - minimising traffic on the narrow lane.
- Groundwater treatment provided via a settlement tank and silt sock - avoiding - contamination of the reservoir.
- Use of an oil boom across the watercourse for the duration of the works.
- Access road redesigned to incorporate the use of geogrid - reducing the use of primary aggregates required on site.
- Reacting quickly and responsibly to the discovery of a wagtail on site, which was nesting within a valve that was due for removal. The works were stopped and reprogrammed to allow the eggs to hatch and the fledglings to mature and safely fly their nest. Producing a protected species report.

Given the picturesque surroundings, it was also important that the powerhouse was constructed sympathetically to its environment. It has been deliberately built to resemble a local barn using a steel portal frame clad with masonry and appropriate roofing materials to give a traditionally-built impression.

Minimum disruption to community and existing infrastructure

The development of the site at Selset was made all the more complex because of its remote location. A winding single-track road (including a narrow culvert) leads to the reservoir, which prevents large vehicle access. Close liaison with suppliers and subcontractors, prevented deliveries on articulated trucks, and works were planned and executed with small plant to prevent the need for major alterations to the road. Even the welfare cabins had to be transhipped onto smaller vehicles to get them to site.

Additionally, to ensure minimal disruption to the small number of residents on the road leading to site, they were consulted early, and a meeting was held and letters circulated to provide information about the works, answer any queries and provide contact details. Acoustic Louvres were incorporated into the design to minimise any potential noise pollution, and the sympathetic design of the powerhouse itself ensured minimal impact on the scenic landscape.

The project also benefited the community economy in that it utilised local labour, plant hire and a stone supplier. Following completion of the works, the client, contractor and local Highways Agency assessed the condition of the road, with necessary repairs to the road surface carried out and verges reinstated.

Health & Safety: An exemplary record, involving everyone on site

Active involvement and personal responsibility – evidenced by the statistics and positive behavioural discussions – were vital given restricted site access and narrow footprint. The team achieved an exemplary record and there were no reportable injuries whilst on site; 58 near misses reported (highlighting the team's desire to report events from which we can learn and prevent potential incidents from occurring); and 79 Behavioural Discussions held (observations held to praise safe behaviours and correct unsafe behaviours).

Site-specific approaches to Health and Safety included:

- Double-stacked high-spec 'plug-and-play' cabins were used to minimise land usage on site – achieving a safer welfare area.
- Material deliveries were scheduled to avoid excessive storage.
- Traffic congestion was avoided by constructing temporary passing places on the lane to site, with a 'stop and phone' point used to advise of imminent deliveries.
- Additional works incorporated also ensured safer (and improved) access for Northumbrian Water to the pipe corridor and valves.
- Designated walkways were constructed and maintained, secure fuel storage provided over and above the requirements of Pollution Prevention Guidelines, and an Emergency Flooding Plan implemented.

Budget and programme: Added value

Despite challenging weather conditions – including low temperatures and heavy snow – the turbine began generating and works were fully completed on time. Proactive use of the NEC ECC Option A contract programme ensured all changes were rapidly evaluated to ensure their impact on the project programme – and costs – were carefully managed. This meant that the additional work incorporated added real value and was still delivered within client expectations. Changes included:

- Improved roof construction details and improved instrumentation and monitoring equipment.
- Improved (and safer) access for Northumbrian Water to the pipe corridor and valves.
- Improved automation of reservoir valves and improved surface water drainage system.

Summary

By recognising the potential to harvest the flows from this existing Northumbrian Water asset, it has been possible to install a 750kW Francis turbine powerful enough to supply 1,000 homes. In recognition of "good team work and planning used to overcome technical difficulties and logistical problems at an isolated and difficult to access location," the project was recently awarded the ICE NE Robert Stephenson Award (under £4m) with the judges also noting that the "scheme was completed to the highest standards of dimensional control and monitoring of adjacent structures."

The editor and publishers wish to thank the following for their help in preparing the above article:

Tim James, Project Manager with RWE Npower Renewables; Andrew Downer, Project Manager at Northumbrian Water; Andrew Kelly, Lead Designer at Mott MacDonald; Stephen Collins, Contracts Manager, Grant Crawford, Site Agent, Peter Bell, Designer (Temporary Works); and Rob Dunn, Communications and CR, with JN Bentley.

Installation of 1,200mm dia. delivery pipework into the powerhouse - Courtesy of JN Bentley