# Northumbrian Water's Broken Scar WTW

## £22m upgrade, including GAC process stage on live plant

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**Broken Scar is one of Northumbrian Water's principal water treatment works, serving the population of Teesside and East Cleveland. The works has a nominal capacity of 180 ML/d and abstracts raw water from the River Tees. Over the last 4 years, an extensive programme of work costing £22m has been carried out to maintain compliance with future water quality standards. New chemical storage and dosing equipment systems have been provided together with sludge transfer pumping stations, sludge thickeners and a new GAC filter process stage.**

Chemical Building - new PAC plant *(courtesy Northumberland Water).*

**Background**

The treatment works abstracts water from the nearby River Tees and pumps this to a raw water storage reservoir at the head of the works. The raw water is moderately soft with an average alkalinity of 55mg/l with an average pH of 7.8. Fluctuations in raw water quality can be very sudden with variations in colour from moderate (30˚ Hazen) to highly coloured (280˚Hazen), and TOC concentrations varying from 4.9mg/l to 17mg/l, which can give rise to the formation of trihalomethanes (THMs) in distribution. Generally, the higher values of both colour and TOC occur in the autumn although sudden peaks can occur at any time. Naturally occurring manganese in soluble form is also a seasonal problem, giving rise to problems in distribution.

Most of the existing plant was in excess of 25 years old and at the end of its design life. Over recent years there was evidence of a trend towards periods of higher apparent colour of the raw water and the existing chemical plant was at risk of being unable to provide sufficient dosing to comply with water quality targets at higher works flows. The existing treatment facilities were also at risk of not being capable of meeting the DWI requirement to restrict the level of THMs to 100ug/l in the distribution system at all times.

The works itself comprises two streams. Chemicals are dosed at the head of each stream and chemically dosed water is passed to five clarifiers. One stream serves two flat-bottomed clarifiers and the other is served by three accentriflocs. Following clarification the water is filtered in twelve dual media rapid gravity filters before combining and passing to a chlorine contact tank prior to being pumped into distribution.

Sludge from the clarifiers was pumped to holding tanks where it was settled and the supernatant drawn off and discharged to the River Tees. Settled sludge is centrifuged with the resulting cake disposed of in skips off site. The existing sludge/washwater facilities

were not capable of storing and treating the quantity of sludge produced during high works output and poor raw water conditions and were at risk of failing discharge consents.

**Maintenance plan**

In 1996, an extensive series of studies were commissioned to investigate problems with the existing treatment works, to develop global solutions and to formulate a prioritised medium term capital expenditure plan. Northumbrian Water's framework consultant, *Binnie Ferguson McIlveen (BFM)* carried out individual audits of Process and Asset Conditions, and feasibility studies of the various chemical treatment systems, together with the used filter washwater, sludge and drainage facilities. In excess of two hundred problems were identified and categorised into business, maintenance and process issues. The individual studies were combined to form a Maintenance Plan for the treatment works, which was then further developed into conceptual designs for the three associated main outputs from the studies. These were:

* chemical plant refurbishment project;
* used filter washwater, sludge and drainage facilities project;
* addition of a new GAC filtration process.

Refurbishment of the chemical facilities was designed to provide adequate chemical capacity to enable the works to achieve treatment resulting in 100% compliance against anticipated future water quality targets at a maximum sustained works flow of 180 Ml/d.

**Procurement strategy**

The overall procurement strategy was designed to evolve towards an ideal model, subject to experience performance and partnership working. The Chemical Plant Refurbishment Project comprised three separate contracts, the Plant contract, the Electrical, Instrumentation and Control contract and the Civil Works contract. The Civil contract was an ECC Option B (Priced contract with bill of quantities) and both the Plant and Electrical contracts were ECC Option A (Priced Contract with activity schedule) All three contracts were tendered to NWL framework contractors. Civils was awarded to *MJ Gleeson, Plant to Meica Process Ltd and Electrical to Idec Ltd.*

Following a successful performance on the Chemical contract, NWL's strategy was to develop a partnering approach with *M J Gleeson* for the efficient and effective delivery of the Sludge and GAC projects within the overall tight timescale. Subsequently, six months into the Chemical Plant Refurbishment Project, NWL awarded a negotiated contract to *M J Gleeson* for upgrade of the Used Washwater Sludge and Drainage Facilities Project. The form of contract was ECC Option B. Both projects were progressed concurrently.

Following the Teesside THM study, it became evident that a new GAC process was required at Broken Scar. Due to the performance and the opportunity to realise efficiencies across the delivery of the overall programme, NWL chose to enter negotiations with *M J Gleeson* for delivery of the GAC contract.

A professional services contract was awarded to *M J Gleeson to* produce an Agreed Target Cost (ATC) for a new GAC plant. Members of the team charged with arriving at the ATC included representatives from NWL, the principal contractor *M J Gleeson, the process contractor Black & Veatch, Binnie Ferguson McIlveen, who were part of the Gleeson team and the cost consultant Atkins Faithfull & Gould.* Extensive value engineering studies took place, taking into account various process and operational. considerations together with civil constraints. The main GAC contract was awarded in July 2001 as an ECC Option C (Target contract with activity schedule) incorporating a separate Partnering agreement with incentives for early completion.

External view of new chemical building *(courtesy Northumberland Water).*



Following post project reviews, members of the construction team expressed a preference for ECC Option C form of contract as being the most effective in achieving delivery of a particular project. In hindsight, delivery of the Sludge and Chemical projects may have benefited under single Option C contracts with improved co-ordination and more centralised control.

**Wildllife**

Early during the design process it was discovered that the treatment works site was home to the rare Greater Crested Newt (Triturus cristatus). The newts are a protected species and were breeding in the old sludge lagoons. Following consultations with Durham Wildlife Trust, NWL had to obtain a special license from DEFRA to proceed with the projects. In order to use the lagoons the newts were translocated to specially constructed breeding ponds, which were fenced off for the duration of the site site works. In addition, a special newt fence was erected around the perimeter of the existing lagoons to stop newts returning there to breed, when the fence around the new breeding ponds is eventually removed at the end of the project.

Because other species are vital to the habitat of the Greater Crested Newt, other species were also moved to the breeding ponds. In total, some 745 Greater Crested Newts, 3,506 smooth newts, 433 frogs and 12,600 common toads were translocated to the new breeding ponds over a three year period.

**Chemical plant refurbishment**

The £7m Chemical Plant Refurbishment Project comprised three separate contracts for civil, plant and electrical/ICA installation and included the following major items of work:

* construction of a new chemical building and adjacent bund including new cross-site dedicated service ducts for chemical dosing lines;

* installation of new bulk chemical storage tanks, dosing equipment and pipework for lime, powdered activated carbon, coagulant and sulphuric acid within the new building;
* upgrading of the existing phosphoric acid and polyelectrolyte systems;
* intallation of new MCCs and electrical instrumentation and control and automatic systems to service the new chemical plant;

The new chemical systems were commissioned and sequentially brought on line to replace the existing systems, with periods of parallel running until final commissioning of the individual dosing systems.

The new new dosing equipment included pre-filter doses of lime and chlorine enabling manganese removal onto the rapid gravity filters, although this will not be implemented until the coagulant is changed from Aluminium Sulphate to Feripol XL. The changeover is currently underway one stream at a time.

**Used Filter Washwater & Sludge Project**

The £4m Sludge Project upgraded the sludge handling capacity of the works removing constraints on the main process units. The project incorporated civil, mechanical and electrical/ICA installations and included the following major items of work under a single ECC Option B contract.
* construction of a sludge transfer pumping station with an incoming gravity drain and a rising main to the existing sludge holding tanks;
* modification of four existing sludge holding tanks and associated pipework;
* construction of two WRc thickener tanks, thickener feed pumping station and a thickened sludge transfer pumping station including interconnecting pipework;
* modification of existing sludge lagoons;
* new used filter washwater pumping system, polyelectrolyte and sodium hypochlorite dosing systems and the refurbishment of gravilectric de-sludging systems to the two flat bottom clarifiers;
* new MCC and associated equipment.

**GAC process stage**

The GAC project included provision of a new GAC filter block together with a relift pumping station and associated site pipework. Footprint of the new GAC block measures 80m by 30m and contains seven GAC adsorbers, machinery room, inlet and GAC loading/removal gallery, outlet gallery and MCC room. Each adsorber has an area of 108m$^2$, bed depth of 2.5m and operates at a nominal design rate of 10m/hour. The GAC plant was designed to achieve a maximum level of THM in the treated water of 30 ug/l. Backwash water is supplied from a washwater holding tank, using two submersible type pumps in a dry arrangement, operating as duty and standby. Air scour is provided from a single blower.

GAC loading and removal is carried out automatically, using a pipework arrangement connecting from the tanker parking area, feeding into each adsorber. Motive water is provided using a single dry arrangement submersible pump. The adsorber eductor system is designed to ensure a minimum 96% removal of GAC. A new point of application for chlorine dosing has been provided in the mixing chamber in the GAC return pipe to the existing chlorine contact tank. The existing chlorine dosing point has been retained to allow bypassing of the new GAC facility should this be required. A 12m dia shaft forms the sump for the relift pumps, containing three vertical lift variable speed turbine pumps, supplied by *Flowserve Limited.* The pumps operate as duty/duty assist and standby, and are controlled by plant demand.

A dynamic model of the whole system was prepared to take into account the implications of pump operation açross the operational range, and surges in the event of pump failure and power failure.

GAC filter block inlet gallery *(courtesy Northumberland Water).*

External view of new GAC filter block *(courtesy Northumberland Water).*

It also investigated the effects of the new operating regime on the existing works under all operational conditions and actions were taken to ensure process safety.

Throughout the project, *Black & Veatch* have made extensive use of 3-D modelling. Not only did this provide a dynamic model of what was being designed, detailed general arrangement and isometric drawings are produced which prevent clashes of services within the design and fabrication of pipework. This capability was particularly useful prior to award of ATC. It provided NWL's operations and maintenance personnel with a 'picture' of the final works, and assisted greatly in the value engineering and Hazop studies. The 3-D model was also used on site during the mechanical and electrical installation.

**Summary**

**NWL, with it's suppliers, consultants and contractors, delivered £22m worth of investment on a live water treatment plant without any interruptions to supply. The works were complex and being local to population required NWL to carefully plan and consult to ensure delivery of investment was smooth and acceptable to all stakeholders.**

The strategy of evolving procurement, allowed NWL to develop on concepts of partnering, providing confidence to all parties in the chosen procurement strategy and is considered a successful benchmark programme to build NWL's investment strategy for future years.n

Note: *The author of this article Mick Abbott, is Project Manager, Northumbrian Water.*