Strongford STW

restoring digestion efficiency and achieve phosphorus permit compliance

by Nick Cunningham MEng (Hons) Grad MICE

Strongford STW is one of Severn Trent Water's largest Activated Sludge Plant (ASP) works serving a population equivalent of approximately 350,000 from the catchments of Stoke-on-Trent and Newcastle-under-Lyme. The current facility includes primary settlement, activated sludge secondary treatment, final settlement and a tertiary ammonia removal (TAR) plant with a maximum flow to treatment of 2,738l/s. In 2014, Strongford will be required to meet a new total Phosphorus (TP) permit of 1mg/l or 80% removal. This more stringent permit is to help reduce the impacts of eutrophication in the River Trent. This was unachievable with the existing process and its ageing assets. In addition, the existing sludge handling facilities required upgrading to ensure improved sludge quality to increase the gas production and efficiency of the on-site digestion process.

New final settlement tank in operation - Courtesy of MMB Ltd

The project, valued at approximately £20M, has been delivered by D&B contractor Mott MacDonald Bentley (MMB) as part of client Severn Trent Water's e5 Major Projects Programme. The e5 alliance was formed between four framework contractors and Severn Trent Water to deliver large wastewater non-infrastructure projects, with efficiency, innovation and collaboration at its core.

Problem definition

During the preliminary design stages, a thorough survey was conducted which identified that some of the current assets needed to be rectifed in order to meet the new 1mg/l TP permit and restore maximum output from the digesters. These include:

- Poor structural condition of ASP Nos 1 and 2 which were asset life expired (constructed in 1936 and 1952 respectively) with surveys showing repairs would not economically extend the asset life.
- The FSTs had insufficient capacity and imposed a hydraulic limit on the throughput of ASP2.
- The existing ASP blowers installed in 1976 were asset life expired, and no longer supported for spares and an ever increasing risk to the works permit.
- A buried section of aeration pipeline between the blowers and ASP Nos 3, 4 and 5 was leaking.
- Poor aeration control on ASP Nos 3, 4 and 5 resulting in

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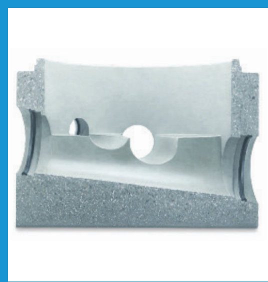

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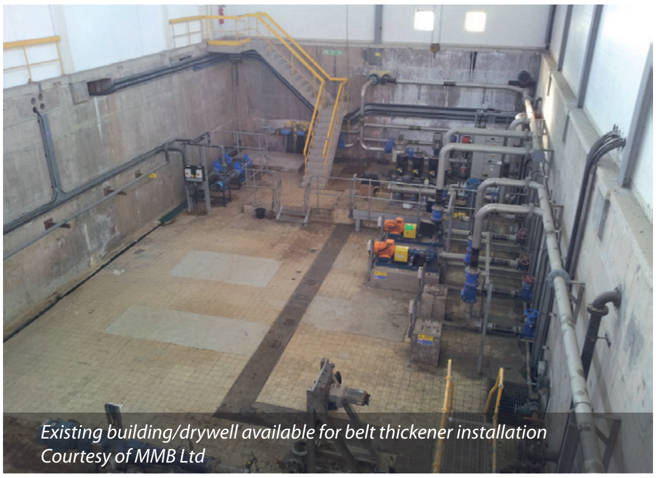
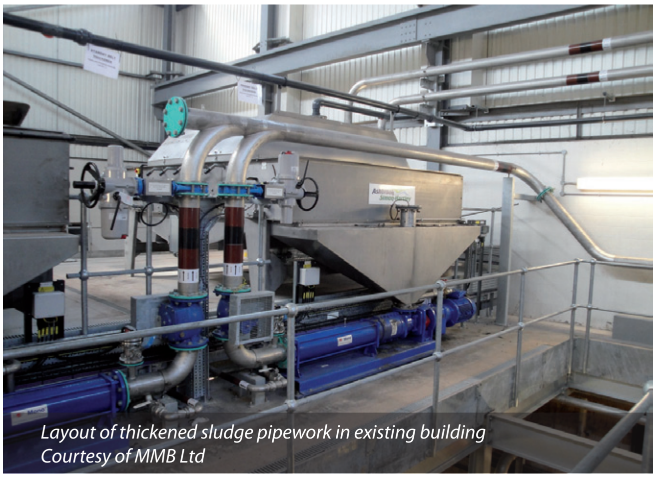


Existing building/drywell available for belt thickener installation
Courtesy of MMB Ltd



Layout of thickened sludge pipework in existing building
Courtesy of MMB Ltd

New ASP6 showing in-situ structural walls and precast baffle walls
Courtesy of MMB Ltd

Fixed DO probe and access steelwork at the new ASP6
Courtesy of MMB Ltd

increased operational expenditure.
- Life expired SAS (surplus activated sludge) belt thickeners which required high levels of maintenance and were unable to meet future demands.
- Failures with the existing decant systems, isolation valves and in-tank mixers in the deteriorating sludge buffer tanks meant that gravity thickening of primary sludge was no longer possible.

Proposed solution

For Strongford to effectively treat the incoming flows and organic load to the permitted standard and restore the effectiveness of the digesters, the site's ageing assets would need to be partly replaced, added to and improved.

An initial pilot plant study was conducted where a number of jar tests were taken to confirm if it would be possible to remove phosphorus by chemical precipitation with Iron salts. Due to the low concentrations of ortho-phosphate in the influent at 2.4mg/l (lower than typical wastewater), only a relatively low dose of Iron salts of 8mg/l Fe on average would be required to precipitate out the phosphorus load below the required permitted limit.

A full scale trial on one ASP at Strongford was conducted in February 2011, which confirmed that a dose of 8mg/l could achieve the total phosphorus permit, reducing the effluent total phosphorus concentrations to <0.1 mg/l.

Following the results of the trial, after rigorous option evaluation and with close collaborative working, the design teams from both Severn Trent and MMB defined and developed the following solution:

- Construction of a 15,250m^3 four-lane, three-pass, carbonaceous ASP to replace existing ASP1 and ASP2 and make full use of an existing 10 (No.) cell tertiary ammonia removal plant.
- Construction of five (No.) 34.4m diameter precast final settlement tanks, a 1,200mm diameter outfall pipeline, 920l/s RAS pumping station and associated distribution chambers.
- Installation of a chemical dosing facility to feed Ferrous Chloride to the new and remaining existing ASPs to aid in the precipitation of phosphates.
- New SAS and primary sludge thickening (gravity belt thickeners) and upgrade of associated buffering and handling ancillaries.
- Improved automated control of air to ASPs 3, 4 and 5.
- Construction of a new blower house providing air to all ASPs.

Cost savings and innovations

The Strongford project was delivered £2.3m below budget. During the design and delivery of the project, the team has been continually focussed on driving innovation and harnessing it to realise significant cost savings without compromising the quality or effectiveness of the finished product and process.

Many of these innovations have been jointly developed with Severn Trent Water and since been distributed to all partners and are the focus of this article.

Fixed location of dissolved oxygen (DO) probes: Each ASP aeration lane contains a number of aeration grids through which air flow into the tank is valve controlled. The set point is derived according to a measurement obtained from a dissolved oxygen probe, which is placed two thirds of the way down the grid.

The standard design requires that the position of the DO probes need to be flexible, allowing them to be moved by +/- 10m from their design location. However, at Strongford the team agreed that the ASP aeration control could be optimised with the DO probes in a fixed location. This reduced the amount of above tank access steelwork required by approximately 120m, which had the following benefits:

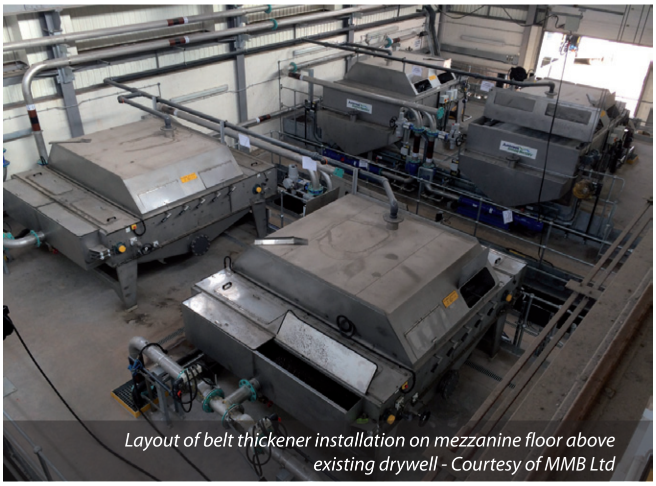
- A cost saving of £65k.
- Reduced installation time.
- Greater opportunity to use precast panels for internal walls that were not required to be load bearing.

Networking of ASP process instruments: In total the new ASP required twelve DO monitors and three ammonia monitors. In collaboration with the suppliers, instruments were networked in bundles to a single controller handling up to eight signals each. A single hand-held plug-in visual display unit automatically shows multiple instrument information for maintenance duties and calibration assistance.

This avoids the investment associated with a display unit for each instrument. All instrument readings are constantly displayed on a HMI in an adjacent MCC and on the site wide SCADA terminals. Benefits realised include:

- Significant savings on instrument, cabling and power supply costs.
- Reduced installation time.
- Reduced maintenance and replacement costs of displays.
- Display is not exposed to the external environment so does not deteriorate.
- CAPEX saving of approximately £50k.

Interlinking gravity belt thickener (GBT) streams: Improvements were made to both the SAS and primary sludge thickening streams. Gravity belt thickeners (GBT) were the desired thickening method for both sludges and this provided the team with a unique opportunity to interlink the two requirements. Initially, it was thought each stream required its own processing building, and each a standby belt. To reduce equipment costs and allow the installation to be accommodated within an existing building the design team proposed the use of a common standby belt. This concept was accepted by Severn Trent Water subject to the agreement that completely automatic changeover of the belts was obtained.



Layout of belt thickener installation on mezzanine floor above existing drywell - Courtesy of MMB Ltd

Through collaboration with manufacturers an actuated ramp was developed for the standby belt enabling it to process both SAS and primary sludge. By then automating the ramp position and polymer source by manipulating the control software so that the standby belt received the control settings as for the failed belt it was replacing, it was possible to fully automate the changeover procedure.

This had the following benefits:

- Approximately £117k saving on the additional belt, pumps, pipework and MCC.
- At least £435k saving on the civil and M&E infrastructure for a new building, versus that required for the new mezzanine floor.
- Single sludge thickening and distribution solution under a single control set.

Single standby blower for two aeration systems: Due to the varying water depth in ASP6 and the remaining ASPs and differing aeration requirements of the new and existing ASPs, two sets of blowers were required. The design team were able to position the blowers so that they were contained within a single building.

As a result, a single standby blower for both systems could be installed. Blower duties were carefully selected to allow the common standby to operate with both systems and the set-point range for the same blower operating in the different systems was built into the control software. CAPEX savings of up to £120k and reduced maintenance are expected.

Process trials to remove the need for back-end ASP mixing: Once the new ASP6 is commissioned, the process load onto the existing ASPs will be reduced. As a consequence the minimum air requirement to maintain mixing would possibly over aerate the activated sludge.

Discussion with STW highlighted the need for mechanical mixing in the final zone of each existing ASP, if the design dissolved oxygen levels were to be maintained. Challenge by the project team instead led to the agreement of a trial to simulate the future load and aeration conditions over a three month period. By setting the air control valves to provide minimum mixing and by reducing the flow using additional weir plates the team was able to demonstrate by constant monitoring of the ASP and FSTs that no process issues would be expected. Significant CAPEX savings of approximately £400k and OPEX savings associated with installing and running mixers was realised coupled with up to six months reduction in construction programme.

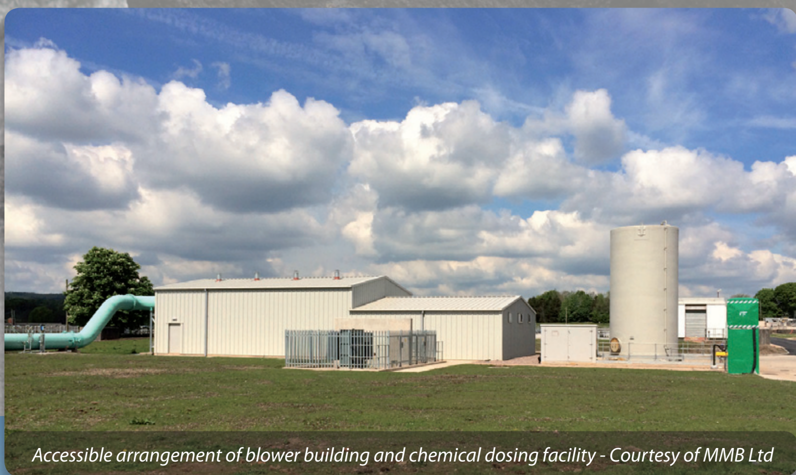
Centrate dosing to enable constant tertiary ammonia removal (TAR) performance: The flows from the new ASP6 will pass to an existing 10 (No.) cell tertiary ammonia removal plant. Although carbonaceous, it is feasible that in certain circumstances the new ASP will nitrify influent to varying levels and pose a threat to the performance of the TAR plant which requires a relatively constant ammonia concentration as 'food' source. To safeguard the site permit by ensuring plant process performance, centrate from the on-site centrifuges will be dosed to the effluent of the new ASP.

Concentration is monitored and dose rate automatically adjusted to ensure optimum performance of the TAR. If for any reason the TAR is offline, safeguards ensure dosing of ammonia is prohibited.

Solution optimised by flow control measures: A review of process design combined with a thorough understanding of the existing works identified significant savings by allowing the omission of one FST from the project scope. This was achieved by limiting the peak flows to the new ASP and diverting extra flows to existing ASPs which were proven to have increased hydraulic capacity.

Flow to treatment is controlled and split two ways via flow meters and penstocks. One stream will feed the new ASP6 and the other feeds the existing ASPs 3, 4 & 5. CAPEX savings of up to £1.2M by the removal of a FST and reduced maintenance are anticipated.

Extensive use of precast elements and holistic approach to groundwater: Precast design was selected for the FSTs early on after optioneering and efficient procurement lead by the e5 alliance



Accessible arrangement of blower building and chemical dosing facility - Courtesy of MMB Ltd

Precast walls of FSTs being positioned - Courtesy of MMB Ltd demonstrated great cost and programme savings. It was also realised that by using precast concrete for the non-load bearing internal baffle walls of the ASP, cost savings of approximately £130k could be achieved when compared to the in situ equivalent.

The design team took a holistic approach when dealing with the effects of groundwater pressure on the deep tank structures. In similar previous installations, tension piles were required to ensure the tanks did not 'float' when emptied for maintenance procedures.

By close collaboration with the structural designers and specialist assistance, the team was able to design a groundwater management system that maintained a groundwater level in the area of the tanks that would not cause tank movements upon emptying. This was done using a network of geotextile drainage layers, non-return valves and linkage pipes to remove groundwater before pumping it to the head of the works via an existing site returns pumping station. This holistic approach saved approximately £350k when compared to pile installation.

Conclusion

The solution delivered as part of this project was to remove the phosphorus load using chemical precipitation, replace the activated sludge plant (ASP) 1 & 2 with a carbonaceous ASP and produce consistent thickened sludge for the digesters. All these enhancements to the works have combined to help meet the new phosphorus permit and enhance the efficiency of on-site biogas production.

The design of the new ASP6 has been primarily based on a sludge age below the point at which nitrification occurs. This ensures that only the carbonaceous load is removed and that a constant ammonia load is available to guarantee the effectiveness of the tertiary ammonia removal plant. The TAR is then used to 'polish' the final effluent to remove the remaining ammonia load to meet the existing 3mg/l ammonia permit. Early indications are that the plant is performing well and meeting the permit within the predicted chemical usage.

From initial conception the project at Strongford has been heavily focussed on innovation, collaboration and communication and utilising all to ensure efficient, effective and successful project delivery. From a design perspective, the lessons learnt and shared knowledge available via the transparency of the e5 partnership ensured that the correct solution was provided first time.

Although some of the cost savings and innovations discussed above are specific to Strongford, many of them could be applied to other projects to realise similar savings.

The team of designers worked together to ensure interfaces were not overlooked and were able to provide information ahead of target. These have contributed to the ability to effectively plan the work and procure equipment efficiently, leading to exemplary execution of the project.

During the execution of this project, the site delivery team has developed an outstanding on-site relationship with Client Operations personnel. This level of trust has enabled timely shutdowns and the commissioning and monitoring of the plant in February 2014, with optimisation of the plant still on-going. The scheme continues to move forward positively and will be handed over in June 2014.

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