

Anglian Water's AMP4 Biosolids Programme: Whitlingham STW and Great Billing STW

a story of integration, innovation and challenge

by
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The AMP4 Biosolids Programme demonstrated Anglian Water's ability to successfully harness and integrate its contracting and consulting partners to deliver strategic programme level benefits, across a number of schemes. At the start of AMP4, Anglian Water (AW) produced approximately 520,000 tonnes of treated wet sludge per year which was largely treated by either digestion or stabilised with lime to ensure pathogen kill. Both processes create approximately 155,000 tonnes of dry solids (TDS) per annum as a biosolids 'cake' which can be safely recycled to agriculture, with its quality and use strictly controlled by Sewage Sludge (use in Agriculture) Regulations and the Safe Sludge Matrix. More than 90% of sludge produced by AW is recycled to agriculture.



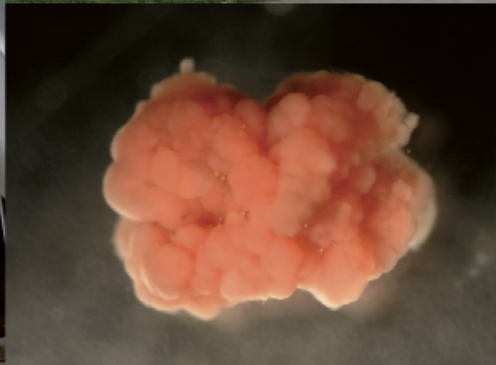
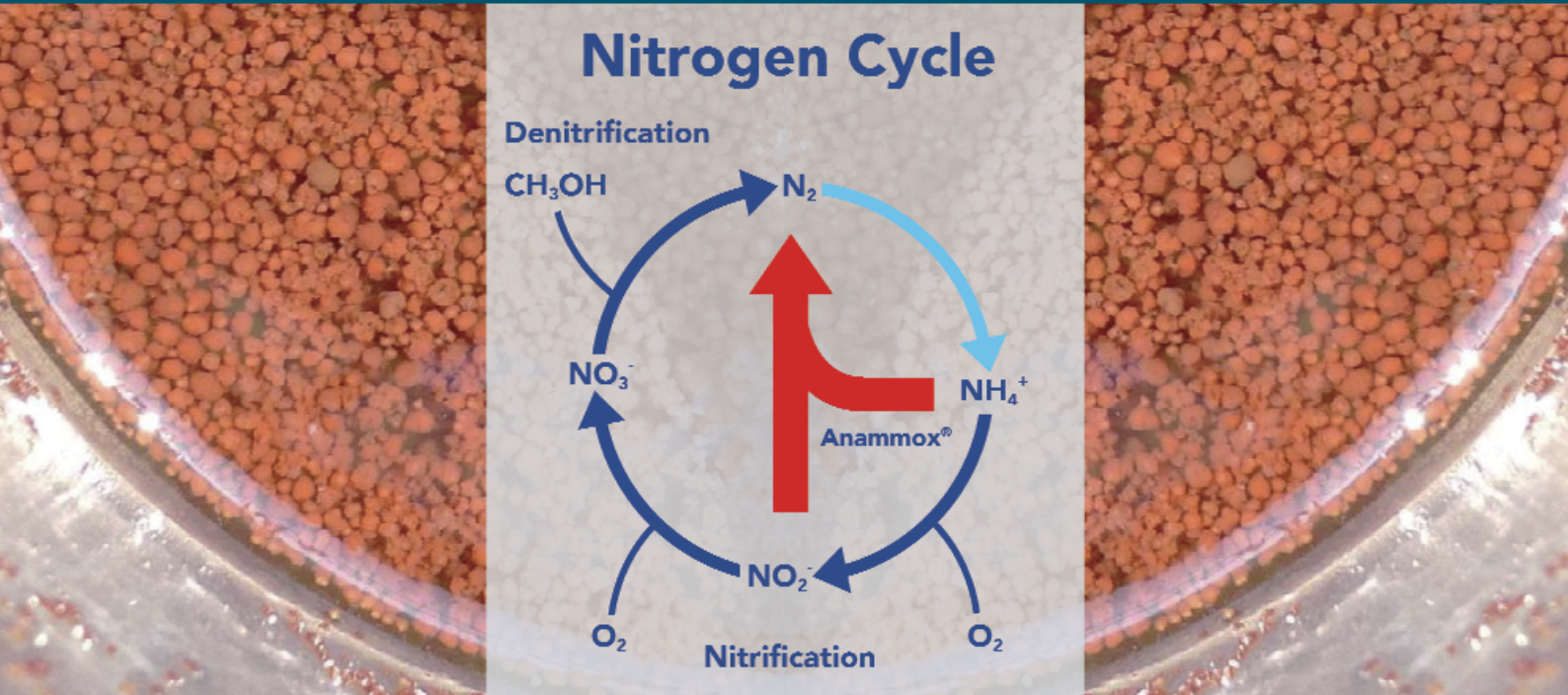
Whitlingham – Cambi thermal hydrolysis plant under construction

Courtesy of Mott MacDonald Ltd

The AW AMP4 programme sought to improve biosolids quality. The key to this was provision of an efficient pre-digestion technology, upstream of the conventional anaerobic digestion stage, which could appreciably improve the rate at which volatile solids and pathogens are destroyed.

To fulfil this goal AW's AMP4 Business Plan identified the need for five new sludge treatment centres collectively capable of treating 77,000 TDS per annum to an 'enhanced treated' standard. To meet this challenge AW developed a collaborative project team incentivised to drive best value across the programme with the necessary expertise to manage large complex projects comprising new or emerging technologies.

Following an extensive challenge by the project team, the final delivered programme comprised of four sludge treatment sites all using advanced digestion technologies; the first two constructed were a biological hydrolysis plant at King's Lynn and a thermal hydrolysis plant at Cottonvalley, Milton Keynes (UK Water Projects, 2008). The two remaining sludge treatment centres constructed were at Great Billing STW (Northampton) and Whitlingham STW (Norwich). The Great Billing project replaced two envisaged centres at Flag Fen STW (Peterborough) and Broadholme STW (Wellingborough) and optimised available digestion capacity, with the latter sites becoming satellite dewatering centres for the larger Great Billing site. This article describes the integration, innovation and challenge involved with the Whitlingham and Great Billing projects.



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A Philosophy of Collaboration

Anglian Water's project partners comprised consultant Mott MacDonald and contracting partners GTM, (a GallifordTry and Imtech Process joint venture) and Black & Veatch. AW saw the selection of its partners as critical to the success of delivering the programme. It was essential that they had a proven ability to collaborate, challenge and innovate within a team environment whilst adding cutting edge knowledge and expertise of the biosolids treatment industry. The contractor partners provided integrated in-house process, MEICA, construction and commissioning capability and, importantly, the expertise to understand, quantify, manage, and mitigate risks associated with a complex and technically challenging programme of work.

Anglian Water integrated the partners through a common incentivised commercial model, driving collaborative behaviour into the heart of the teams. All the partners played a major role in shaping how the programme was to be delivered. The collaborative pooling of skills and resources created a dynamic team environment. The team engaged with Anglian Water's operators, asset managers and technical experts, focusing on programme requirements and rigorous design challenges. This approach created innovative opportunities that improved quality and significantly reduced costs.

Challenge and Innovation – Programme Delivery and Cost Saving

Attaining best value was the main programme challenge: one key innovation was reducing the number of 'enhanced' sludge treatment sites from five to four, while increasing treatment capacity from 77,000 to 100,000 TDS/year. This made maximum use of existing assets and increased capacity for a lower £/TDS relative capital expenditure (CAPEX).

The use of emerging advanced digestion technology provided a number of advantages that contributed toward AW targets for renewable power generation and reduced operational carbon

emissions. Under this programme, 10 MW of renewable generation capacity was installed. This is well in excess of the capacity had conventional treatments been used. This benefit derived from an approximate 40% higher conversion rate of volatile matter by using hydrolysis technologies. Other benefits included the reduction in sludge cake quantities produced and reduced fuel consumption and carbon emissions from transport and agricultural recycling.

To further facilitate collaboration and drive the best Whole Life Cost (WLC) solution for AW, a Sub-programme OPEX Optimisation Plan (SOOP) was devised. This incentivisation scheme, believed to be a water industry first, enabled all partners to benefit from future OPEX savings. The plan committed the team to a two year period after handover working with the Operators to optimise performance of the plant. By outperforming thresholds, the contractors shared the operational gains achieved. The SOOP model delivered programme solutions with the lowest WLC, including investment in high-efficiency Combined Heat and Power (CHP) engines and reverse osmosis plants to treat boiler water.

The Programme Technology

The advantages of advanced digestion are now well documented. However, the success of the AMP4 Biosolids Programme was due to previous development and continual refinement of these new cost effective hydrolysis technologies. These technologies pre-treat sludge by increasing the Volatile Solids (VS) destruction from a current 'conventional' digestion rate of approximately 40% to between 53% and 68% for hydrolysed sludge (advanced) digestion. This increases gas production and the potential for associated power generation. The process also pasteurises sludge upstream of the digestion, ensuring the final product is of an 'enhanced treated' quality.

An integral part of the programme development was an in-depth review of 'enhanced treated' sludge processes being pioneered worldwide, together with a critique of process risk and potential for



Great Billing – Monsal EEH biological hydrolysis plant under construction

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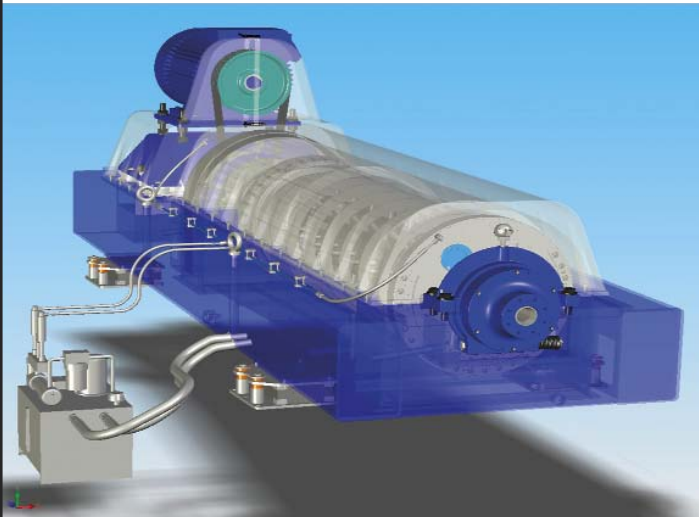


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Andritz Ltd are pleased to continue their association with Anglian Water via Black and Veatch in a series of projects for Centrifuges on new sludge treatment centres.

Whitlingham STW installed and commissioned 3 X Andritz D5LL High Performance Scroll Centrifuges with a combined maximum flow of approx 180m³/h and the capability to handle nearly 4,500 kg per hour of solids.

Andritz are working on a number of forward projects with Centrifuges varying in size up to the D7LL for use with emerging advanced digestion technology.

There are additional plans on the drawing board to extend this series of Centrifuges yet further as the Andritz team continue to increase their process knowledge and push the boundaries of sludge dewatering.

development. In 2005 such sludge treatment technologies were relatively new to the UK water industry. Areas of uncertainty remained, e.g. whether the enhanced VS destruction achieved in test conditions would be sustainable in the 'in service' condition. A benefit of selecting hydrolysis processes over other sludge treatment methods was the substantial biogas yield increase, which greatly increased the potential OPEX savings generated. In the early stages of the programme, collaborative working to drive out process uncertainty brought together the combined knowledge, experience and delivery skills of the project partners and revealed areas for further process innovation and whole life cost benefits.

The technology reviews led to the selection of both biological and thermal hydrolysis, procured through Monsal and Cambi respectively. Biological hydrolysis uses heat to stimulate bacteria to break down molecules whilst thermal hydrolysis involves "pressure cooking" the biosolids to 165°C and 8 bar of pressure. Both technologies make the sludge cellular material easier to digest. Waste heat boilers in combination with conventional fired boilers produce steam to heat the sludge. The boilers were selected to run on biogas, natural gas or fuel oil, with high efficiency CHP units used as part of the heating installation, maximising the conversion of biogas to electrical power to run the new sludge treatment centres. As a result all four sludge treatment sites were electrically self-sufficient, with surplus electricity made available to power the adjacent STW or exported to the national grid.

By working together in a trusting and co-operative manner, the technical team were able to overcome a number of challenges described below.

Treatment of Dewatering Liquors

At the beginning of the programme in 2005, few advanced sludge

treatment technologies were in operation in the UK and Ireland. The plants that were in operation included two Monsal EEH (biological) hydrolysis and three Cambi (thermal) hydrolysis plants. It was known that liquors produced from dewatering this sludge had significantly higher concentrations of phosphorus and nitrogen than liquors from conventional digestion plants. The ability of the existing wastewater treatment process streams to treat higher strength liquors is a function of their process type, chemistry and the final effluent discharge consent for the receiving waters.

Of the two Monsal EEH sites, (King's Lynn and Great Billing); the Great Billing site has a stringent final effluent discharge consent standard and in addition to the new hydrolysis plant, had a significantly increased sludge throughput. Of the two Cambi hydrolysis sites; work was being undertaken at the Cottonvalley STW site to refurbish the existing wastewater treatment streams, however at Whitlingham STW, the treatment of the liquors proved to be a technical challenge.

Liquor Treatment R&D at Whitlingham

The Whitlingham STW is unique in the UK, combining an existing Enhanced Biological Phosphate Removal (EBPR) wastewater plant with thermal hydrolysis and anaerobic digestion. Work focused upon establishing a better understanding of the process chemistry related to the fate of phosphorus within the EBPR plant and within the hydrolysed blended sludge during anaerobic digestion. The current discharge consent includes Ammoniacal Nitrogen and Total Phosphorus but does not include a Total Nitrogen standard. As the EBPR is a nitrifying plant, it removes phosphorous by establishing a high degree of denitrification (i.e. Total Nitrogen removal) to minimise the presence of nitrates and nitrites within the wastewater stream. If this is not achieved, their presence would inhibit the biological phosphorus removal process.

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The phosphorus composition of the EBPR plant was a key factor in understanding the mechanism of how to treat these nutrients and needed to be better understood, as did the synthesis of the phosphate compounds within the digestion process. Literature and water industry reviews and investigative pilot plant trials were conducted to evaluate process options for treating these nutrients. Options focused upon potential treatment processes being used both within and outside of the water industry worldwide.

The findings of the pilot plant trials and modelling work verified the desk studies and confirmed our understanding of fixation and precipitation mechanisms of released phosphorus, during anaerobic digestion. The mechanisms proved more complex, with levels of reaction, fixation and precipitation being dependent upon the availability of chemical compounds such as manganese for struvite, calcium and the presence of aluminium and iron for precipitation. Natural struvite production was limited by the presence of polyphosphate and manganese ions. Due to the limited potential for struvite production and current technology availability, this was not seen as a viable option for phosphorus treatment, with preference given to an iron dosing system.

It was proposed to achieve the biological nitrogen removal at Whitlingham through the provision of a nitrification/denitrification process using a Stable High rate Ammonia Removal Over Nitrite (SHARON) reactor system, which is currently being constructed.

Great Billing, Knowledge Gained

The valuable data and knowledge gained from the Whitlingham pilot study was used to inform and develop the Great Billing liquor treatment solution. The original solution was to use a Phospaq recovery system, which was later revised following the Whitlingham pilot study work. The solution was modified to allow liquors to be treated via the main works with residual phosphate locked into the sludge during primary settlement by additional Ferric Sulphate dosing.

Vivianite Scaling, a Call for Adaptation

Another area of process development came from the risk of vivianite scaling on critical equipment. As the process design progressed it became apparent that an area for improvement was the risk of vivianite scaling within the hot water / sludge heat exchangers. The delivery partners adapted the original Monsal EEH design by replacing the second stage heating with steam injection to increase temperatures to 55°C (to achieve pasteurisation) instead of the original design using a



Great Billing – Monsal EEH plant, heating building, CHP's and waste heat boilers Courtesy of Galliford Try Meica JV Ltd

conventional heat exchanger. This approach eliminated the risk of vivianite scaling that would otherwise have been present in the second stage heat exchanger.

Summary

The Great Billing STC is AW's largest sludge treatment centre and designed to treat up to 38,700 TDS/annum. Commissioning commenced in June 2009 with the site receiving cake imports from Flag Fen and Broadholm by January 2010. The plant at Whitlingham was designed to treat 21,000 TDS/yr. Commissioning started in August 2009 and was operational by November 2009. Both plants provide a combined CHP capacity of approximately 6 MW, 60% of the total programme capacity, a significant contribution to AW's carbon reduction targets.

The challenges presented by these two distinct sites required innovation, integration and a collaboration of ideas that delivered the optimum solution and project cost benefits. The spirit of co-operation, innovation integration, shown by the project partners, characterised this delivery process and proved key to the successful delivery of each of the schemes and the programme as a whole.

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Great Billing - Heating building, gas holders, waste heat boilers and digesters from the top of the Monsal EEH plant

Courtesy of Mott MacDonald Ltd



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