# Wanlip STW - Sludge Project

## increasing digestion capacity

by Gabriella Giuffre, Sean Lang & James Morgan

Wanlip STW is Severn Trent Water's third largest sewage works. The site is located north of the city of Leicester and serves a population equivalent (PE) of 582,800. By the year 2026 Wanlip STW will treat a dry weather flow (DWF) of 140,000m$^3$/d, a full flow to treatment (FFT) of 345,600m$^3$/d for a PE of approximately 660,000. The existing treatment works includes a sludge digestion facility treating indigenous sludge, imported sludge and trade waste sludge. The Wanlip Sludge Project is part of AMP5 investment programme and will provide Severn Trent Water and its customers with a new sludge digestion facility with an increased treatment capacity to replace the existing aged and inefficient sludge digestion plant.

*Cladding to SAS building progressing - Courtesy of Costain-MWH*

### Background

The Wanlip Sludge Project is a £32m capital investment project being delivered by Costain-MWH. Another project currently being delivered by Costain-MWH at Wanlip is the £16m Wanlip Inlet Project which will provide a new inlet works and storm route. Knowledge, resources and facilities have been shared between the two projects. *An in depth description of the Wanlip Inlet Project is featured on pages 71-73 and on www.WaterProjectsOnline.com.*

The Wanlip projects are part of the £210m e5 major projects programme being delivered for Severn Trent Water in AMP5 (The e5 partners are Severn Trent Water/MWH Treatment/North Midland Construction Nomenca(NMCN)/Costain/Mott Macdonald Bentley).

### Solution development

Working closely together Severn Trent Asset Creation, Service Delivery and Costain-MWH developed the solution identified at feasibility and defined an optimised solution consisting of a new facility providing an increased digestion capacity (average 29,386 tDS/year, peak 38,587 tDS/year).

The optimised solution comprises:

- Imported sludge reception and screening facilities.
- Indigenous primary sludge screening, storage and thickening by gravity belt thickeners.
- Pre-digestion blending tank.

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- Indigenous surplus activated sludge storage and thickening by gravity belt thickeners.
- 'Bagel' design acid phase digester.
- Gas phase digesters.
- Digested sludge transfer pumps and tanks.
- Digested sludge dewatering facilities.
- Biogas storage and management system.
- Hot water system including boilers and CHP engines.
- Chemical dosing (for hydrogen sulphide suppression in biogas, struvite control, foaming control).
- Filtrate transfer pumping station and wash water pumping station.
- Odour control plant.

The optimised solution delivers capital and operational savings by adopting innovative solutions and designs, by re-using existing assets and by adopting standardised designs developed collaboratively with other e5 project teams.

This approach enabled Costain-MWH to develop a solution that meets Severn Trent Water business plan and named outputs commitments, maximises use of existing assets whilst minimising capital cost, operating costs and whole life costs.

### Reuse of assets to deliver value

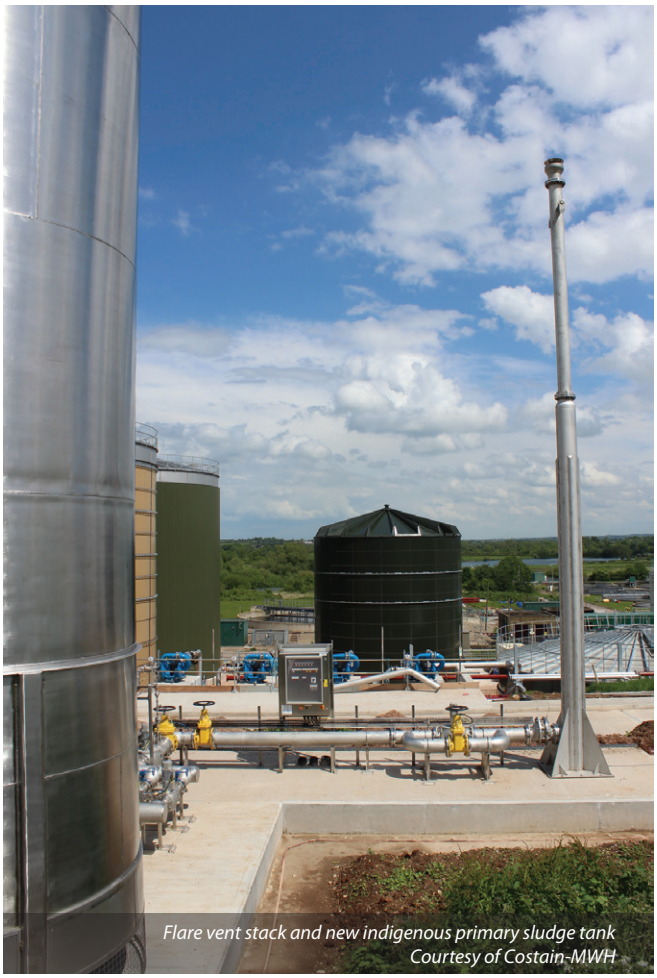
Reusing existing assets provided the Costain-MWH team with the opportunity to maximise the value delivered for Severn Trent Water by minimising asset write off value whilst reducing capital investment. The most notable examples of asset reuse in the project are:

- ***Main digestion plant location***. The entire sludge digestion facility is located within an area that used to be occupied by a tertiary filtration plant. Reusing the disused tertiary filter bed slab released space for the new digestion plant and also provided a concrete slab over which to place plant associated with the new digestion plant. The combination of these resulted in a reduction in construction and programme costs. The media from the de-commissioned tertiary plant was partly reused off site and partly reused on site thus minimising the waste generated by the project.

- ***Filtrate and wash water pumping station***. The redundant tertiary pumping station structure was modified to accommodate two pumping stations: filtrate pumping station and wash water pumping station. This enabled not only reuse of an existing structure minimising asset write off, but also a reduction of construction costs by maximising the benefits of the existing pumping station position with respect to the digestion plant slab (to collect filtrate) and the final effluent outfall (to provide a wash water supply for the new sludge works).

- ***Above ground pipeline gantry supports***. The disused treated water flow distribution culvert that runs along the full length of the tertiary filters (digestion plant slab) has been reused to support above ground pipelines. A short section of the culvert had to be stabilised to prevent slippage using augered concrete piles. However once the culvert was stabilised it provided a dedicated section along the full length of the digestion plant (circa 300m long) to install the main process pipelines.

- ***Thickeners and CHP engines***: A total of 3 (No.) SAS gravity belt thickeners, 2 (No.) centrifuges from Coleshill STW and 3 (No.) CHP engines will be reused at the new sludge digestion plant. These assets are still serviceable and their re use enables Severn Trent Water to maximise the existing assets life, minimise the assets write off whilst still delivering a low whole life cost solution.



*Flare vent stack and new indigenous primary sludge tank*
*Courtesy of Costain-MWH*

*Main process pipework on existing culvert*
*Courtesy of Costain-MWH*

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*New CDEnviro import screen*
*Courtesy of Costain-MWH*

## Collaborative design to deliver optimised solutions

Standardisation of designs and collaboration was maximised across the e5 sludge projects by the creation of the e5 sludge core team during the early stages of the sludge projects design. The e5 sludge core team included Severn Trent Water and each of the e5 delivery partners and their design teams.

The sludge core team was specifically created to collaboratively develop standardised designs, specifications and procurement strategies for plant common across the sludge projects within the e5 programme (Wanlip, Claymills, Rushmoor, Worksop). The Wanlip Sludge Costain-MWH team as member of the sludge core team was a key player in the development of optimised and standardised designs.

Some of the solutions developed collaboratively by the sludge core team are examined in this case study.

## Imported sludge reception facilities

The e5 sludge core team identified sludge screens supplier, CDEnviro Ltd, that has developed a vibrating plate sludge screen design which is capable of handling sludge volumes delivered by sludge tankers by screening throughput in line. Use of this technology removed the need for a wet well to receive and store sludge prior to transfer to sludge screens at a controlled rate (significantly lower rate than sludge tankers throughput).

At Wanlip where this solution has also been adopted for the indigenous primary sludge screens the following specific advantages were delivered:

- Removal of a deep sump and associated unscreened pumps requiring regular maintenance.
- Removal of high level access steelwork for the sludge screens.
- Reduced requirement for storage tanks to handle sludge which can be screened and transferred directly sludge buffer tanks.

## Acid phase digestion

Wanlip Sludge Project digestion plant together with other e5 projects (Claymills and Worksop) is a development of Severn Trent Water's acid phase digestion design which has been successfully used at Derby STW.

Mesophilic anaerobic digestion comprises a number of separate stages. These are hydrolysis, acidogenesis, acetogenesis and methanogenesis.

In a single-phase anaerobic digester all these stages of digestion take place in one vessel which does not provide conditions favourable to all the bacteria and enzymes present thus reducing their efficiency and biogas generation.

*Evolution of gas phase digesters - Courtesy of Costain-MWH*

An acid phase digester separates the acidic phase (primarily hydrolysis, acidogenesis, acetogenesis) from the methanogenic phase thus providing optimum conditions for enhanced biogas production. The acid phase digester is characterized by low hydraulic retention time (1-3 days), acidic pH (5-5.5), and high volatile acids concentration. The second stage is the gas phase digestion; this phase is characterised by 7.5 pH, low volatile acid concentrations and 7+ days retention time.

The e5 sludge core team working in close collaboration with Severn Trent Water developed an optimised design for the acid phase and introduced the innovative concept of 'Bagel' design which combines two discrete tanks into two concentric tanks. This design provides not only an innovative solution but also a reduced footprint, reduced heat loss, optimised pumping thus providing a solution with reduced capital and operating costs.

A complex computational fluid dynamics model demonstrated the process security and structural integrity of both the outer and inner tanks could be constructed from epoxy coated steel. This resulted in further reductions in the construction programme compared to concrete tanks. The optimised acid phase digester design has been adopted at Clay Mills, Worksop and Wanlip.

### Gas phase digestion

The optimised design for Wanlip gas phase digesters comprises 6 (No.) epoxy coated steel digesters (4,000m$^3$ capacity each) with stainless steel roof and reinforced concrete floors with a 1 in 7 digester floor gradient. These design principles and digester materials have been adopted for all e5 sludge projects.

The optimised digester solution was a significant change to Severn Trent Water digester design standards and its implementation required extensive consultation. The business case for adopting steel digesters with stainless steel roof and flatter digester floors

*Main distribution pipework (hot water, biogas and sludge)*
*Courtesy of Costain-MWH*

was formulated by Severn Trent Water, the e5 companies and their design partners, who based on evidence and experience gained in United Kingdom and the United States, demonstrated the viability of the proposed solution.

Following extensive studies, the proposed digester solution was endorsed by Severn Trent Water and the digesters are currently in varying stages of construction across the e5 projects. This standardised solution developed by the sludge core team provided significant advantages which with specific reference to Wanlip are:

- The construction of steel digesters reduced construction costs and programme and improved construction safety. Use of steel for the digesters instead of concrete means that the programme can be modified to allow other elements of the build to progress at the same time due to reduced site constraints.

The construction period is reduced as there were no concrete pours or requirement for complex rebar to build the 20m tall structures. Moreover epoxy coated steel digesters assembly work is undertaken at ground level with the roof assembled first, and jacked up as other rings were added, improving the buildability, reducing working at height, shortening construction time and reducing health and safety risks.

- The operation of epoxy coated steel digesters increased efficiency by reducing inspection times and providing improved and safer access. Severn Trent Water digesters are currently inspected internally every ten years. To undertake the inspection the digesters are emptied and a scaffold access is provided. Scaffolding takes several weeks to erect and to remove.

  The epoxy coated steel digesters have been provided with sufficiently large openings to allow mechanical access plant to be used. This will reduce digester down time and it will also provide safer access.

- Shallower digester floors resulted in reduced ground dewatering costs due the relatively high water table level at Wanlip. Shallower floors also significantly improve access during digester inspections by facilitating use of mobile elevating working platforms which would have been unsafe with steeper floors. This will also result in dramatically reduced periodic inspection by reducing the need for scaffolding.

- The atmosphere in the gas space of a digester is very corrosive and concerns existed with use of a steel structure. To significantly reduce the risk of corrosion within this area it was agreed to adopt stainless steel bolted roofs and sections of the wall in the gas space. The inherently robust material will receive regular Non-Destructive Testing to ensure continuing structural integrity thus providing Severn Trent Water with a robust roof system in an area where the risk of failure is increased due to the environmental conditions.

## Awards

In 2014, the project has won a Bronze Considerate Constructors Award and a Gold award from ROSPA for Occupational H&S.

## Summary

Throughout feasibility, design and construction there has been engaged collaboration and innovation between STW, Costain-MWH, MWHT and the wider supply chain. Construction is expected to be substantially complete and for commissioning to start in late October 2014.

The Costain-MWH team anticipate delivering the project to programme. By 31 March 2015, 2 (No.) of the gas phase digesters are planned to be commissioned and in service. The remaining 4 (No.) digesters and acid phase digester (and associated plant) will be commissioned once the first two digesters are put into service. It is expected for the project to be completed by November 2015.

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*Gas compressor station - Courtesy of Costain-MWH*

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