

Killinghall STW

achieving phosphorus reduction and capacity expansion

by Peter Moore

Yorkshire Water

Located approximately 5km north of Harrogate, Yorkshire Water's Killinghall Sewage Treatment Works (STW) receives flows by gravity from Killinghall, as well as pumped flows from the nearby village of Hampsthwaite, serving a total population equivalent of 3741. Built in the 1970s, the site's capacity has not kept pace with Killinghall's growing population. The existing site consisted of an inlet reception chamber, a duty-only screen, a flow measurement flume, three primary settlement tanks (PSTs) with desludge system, two mineral media filters (MMFs), three humus settlement tanks (HSTs), a sludge storage tank, as well as ancillary pumping systems for recirculation, washwater and site drainage.



Killinghall STW (August 2025) - Courtesy of MMB

Project drivers

The scheme sought to address two key issues that were the drivers for the project.

1. **Phosphorus removal:** The first driver relates to a new total phosphorus consent being established by the Environment Agency to an average annual limit of 0.7 mg/l and new total iron consent of 4mg/l (95%ile) at the consented Dry Weather Flow (DWF) discharge of 1,631m³/d. This part of the scheme falls under the Water Industry National Environment Programme (WINEP) and had a regulatory compliance date of December 2024.
2. **Flow balancing:** The second driver concerns the undersized existing works, which struggles handling peak flows caused by Killinghall's growth. This has led to hydraulic problems and frequent operator intervention during high-flow periods. Killinghall STW is designated as a treat-all-flows works, so the site does not have a storm storage or discharge permit. A flow survey established a maximum measured incoming flow of 155 l/s whilst the site itself was originally designed for 60 l/s.

In response to these requirements, Mott MacDonald Bentley (MMB) commenced work on a £15m scheme in December 2023, encompassing the comprehensive design and construction of a new inlet works, all new primary treatment facilities, expanded secondary treatment capacity, and associated ancillary works.

Solution development

The project underwent substantial modifications to its original scope, seeking environmental benefits and operations efficiencies. Numerous potential solutions were explored during the early stages of the project, with the favoured solution originally including three new 16.0m diameter primary settlement tanks (PSTs), two new 9.4m diameter plastic media filters (PMFs), and three new 17.0m diameter humus settlement tanks (HSTs).

This solution was thoroughly evaluated both in terms of buildability and assessed for its carbon cost implications. It would have involved extensive hard infrastructure, resulting in considerable embodied carbon costs. Significant construction challenges were also identified due to the restricted space within the existing site boundary.

MMB

MOTT MACDONALD
BENTLEY

DELIVERING FULLY INTEGRATED DESIGN AND CONSTRUCTION SERVICES TO THE UK WATER INDUSTRY

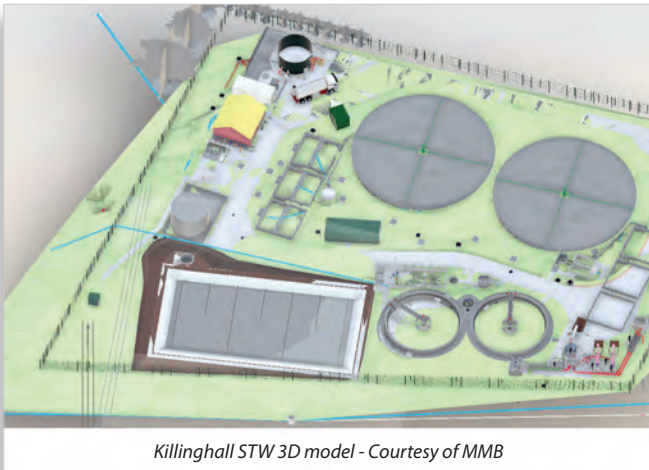
Mott MacDonald Bentley (MMB) delivers design and construction services to the UK water industry.

Our global team of experts provide integrated services in programme management, investigation, feasibility, design, construction, commissioning and handover – using innovation and digital delivery to create improved outcomes for our clients and our communities.

For exciting career opportunities, visit mottmacbentley.co.uk.



Pictured: Award-winning sewage
treatment works upgrade



Killinghall STW 3D model - Courtesy of MMB



New flow measurement channel and chemical point of application area (August 2025) - Courtesy of MMB



Bird's eye view of the new PSTs (August 2025) - Courtesy of MMB



Planting underway in the aerated reed bed (September 2024)
Courtesy of MMB

The project team established a strong working relationship with the Yorkshire Water and the Yorkshire Water's strategic planning partner Stantec UK, working collaboratively to refine the scope as the project moved towards detailed design.

The decision was made to reduce the number of new PSTs from three to two, whilst completely removing the PMFs and HSTs. In their place, an 861m² vertical flow sub-surface aerated reed bed was introduced. It was agreed that the existing humus settlement tanks would be retained, with the flow to them limited to 60 l/s, which they were originally designed for. Any flows exceeding 60 l/s would be directed to the new aerated reed bed, essentially establishing two streams for secondary treatment; one to treat typical daily flows, and another to treat flow peaks during heavy rainfall events.

The two streams then combine in the final effluent chamber, before discharging to the River Nidd via the works' outfall.

The solution

Inlet pumping station: A new inlet pumping station has been constructed at the head of the works to receive flows from the Killinghall gravity main and lift them to the new inlet reception chamber. The pumping station was introduced to prevent the gravity main from surcharging which otherwise would potentially have led to settlement in the main during low flow conditions. The pumping station consists of three submersible pumps running duty/assist/standby.

Inlet works: New duty/standby spiral screens have been installed rated for a flow capacity of 80 l/s. These are containerised units with DN300 inlet and outlet connections. To supplement the spiral screens, a new upward flow screen has been installed within the inlet reception chamber, which is located upstream of the spiral screens. Any flow exceeding 80 l/s will back up and pass through the upward flow screen up to a maximum of 75 l/s, therefore providing a combined total screening capacity of 155 l/s. Downstream of the screens is a new vortex grit removal system complete with duty/standby airlift blowers. The grit system is sized for the maximum flow of 155 l/s. A grit bypass chamber has been installed complete with manual isolation penstocks should the grit system ever need to be taken out of service for maintenance.

Primary settlement tanks: Two new 16m diameter PSTs have been constructed, together with an auto-desludge system. Each tank was constructed using 48 precast panels with an in situ hopper and floor slab, with each tank having a half bridge scraper to direct settled sludge to the hopper, and to remove scum from the surface of the effluent in the tank. A distribution chamber was installed upstream of the PSTs to split the flow evenly across the two tanks.

The chamber was constructed out of 3D-printed sections which were then assembled on site. The auto-desludge pumping station comprises two RAM pumps, drawing sludge from the hopper at the bottom of each tank, and pumping it to the new sludge export tank. The pumps can also return the contents of the tank to the distribution chamber upstream of the tanks as part of the automated drain down sequence.

Aerated reed bed: A new vertical flow sub-surface aerated reed bed receives any flows that exceed the capacity of the existing MMFs and HSTs. The aerated reed bed offers an effective, low-energy solution by combining natural biological processes with enhanced oxygenation. This made it ideal at Killinghall for supplementing the existing secondary treatment assets, receiving peak flows to allow the MMFs and HSTs to treat up to the maximum flow they were originally designed for.

A second 3D-printed chamber was installed, this time downstream of the new PSTs, to split the flow between the existing process stream (MMFs and HSTs) and the new aerated reed bed. A

Killinghall STW Supply chain - key participants

Principal contractor: Mott MacDonald Bentley
Process design: Stantec UK
Ground surveys: Dunelm Geotechnical & Environmental
Groundwater investigation: WJ Group
LV electrical installation: Circle Control & Design Systems
Mechanical installation: Alpha Plus Ltd
FRC: G&F Formwork Ltd
Metalwork: Fab-Tek Installations Ltd
MCC & software: Total Automation & Power
MCC kiosk: Quinshield Ltd
Aerated reed bed: ARM Ltd
PST precast panels: Naylor Concrete Products Ltd
PST half bridge scrapers: JBF Group Ltd
PST auto-desludge RAM pumps: EMS Industries Ltd
3D-printed chambers: Hyperion Robotics

Submersible pumps: Xylem Water Solutions
Valves: Affco Flow Control (UK) Ltd
Spiral screens: Jacopa Ltd
Grit removal: Tuke and Bell Ltd
Upward flow screen: Huber Technology
Sludge tank: Goodwin Tanks Ltd
Sludge tank mixer pump: Xylem Water Solutions
Penstocks: Waterfront Fluid Controls Ltd
Syphon chamber stoplogs: IBS Engineered Products Ltd
Ferric storage & dosing, washwater kiosk: NPS Engineering Group
Trace heating & lagging: Waste Water Manufacturing (WWM)
Fabricated chambers: George Green (Keighley) Ltd
Temporary treatment: Siltbuster Ltd
Automatic filter: Bollfilter UK Ltd
Lifting equipment: Peter Cassidy (Leeds) Ltd

modulating penstock in the chamber ensures that the first 60 l/s is directed to the existing process stream. Any flow above this spills to the aerated reed bed. An intermittent wetting flow ensures the contents of the reed bed are turned over periodically. The ability for the reed bed to blend into the local landscape adds ecological and aesthetic value, supporting biodiversity whilst providing sustainable wastewater management.

Ferric storage & dosing: To achieve compliance with the new phosphorus discharge consent limit of 0.7 mg/l, ferric sulphate is dosed downstream of the inlet works. As such, a new ferric storage and dosing kiosk has been installed. The kiosk houses a 5m³ chemical storage tank as well as a dosing rig that consists of duty / standby dosing pumps.

Sludge export tank: Sludge from the PSTs is pumped to a new 175m³ sludge export tank, which is a cylindrical sectional steel tank. The tank is equipped with a decant tree plus a duty-only mixing pump located external to the tank, connected to an ejector within the tank.

Recirculation pumping station: The existing final effluent chamber has been modified to accommodate the installation of two new recirculation pumps. The pumps deliver flows upstream of the primary settlement tanks to ensure the maximum retention time in the PSTs is not exceeded.

Washwater kiosk: A new kiosk has been installed housing a 1.5m³ break tank together with a skid-mounted set of booster pumps. A feed from the new recirculation pumping station passes through a new automatic filter located within the existing pump house, before discharging into the new break tank.

The booster pumps deliver washwater to the new spiral screens at the inlet works, as well as to various hose points around site.

MCC: To provide power and control for all new equipment, a new MCC has been installed within a new GRP kiosk. This is fed from a new 115 kVA pole-mounted transformer, replacing the previous transformer that was removed to create additional space for new assets on site.

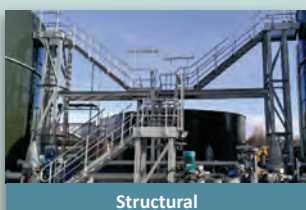


Specialists in Design, Manufacture & Assembly

Quality fabrication and installation of pipework, structural steelwork and mechanical plant for Utility, Waste Management, Waste to Energy, Industrial/Commercial and Manufacturing sectors



Pipework



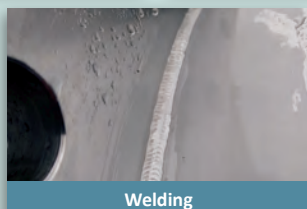
Structural



Installation



Offsite Manufacture



Welding



3D Point Cloud Scanning

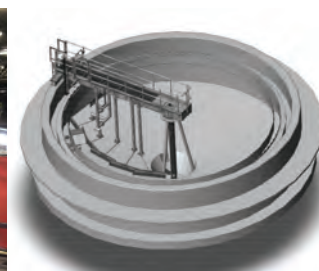


Design & Project Management



Engineering experience & innovation

As one of the UK's leading designers, suppliers & installers of pipework and fabricated metal products, George Green can meet your exact engineering needs, quickly and innovatively. Over the past 20 years, George Green has worked with many clean & wastewater industry clients, helping them successfully deliver major projects.



Product range

- Steel water pipeline fittings
- Pipework fabrication
- Rotor storage containers
- Half bridge scrapers
- Structural steel fabrication
- Stainless steel pipework & fabrications

Recent & ongoing projects

- Strategic Pipeline Alliance – Anglian Water
- Stillorgan Reservoir – Irish Water
- Tees & Central Strategic Pipeline Ph 1 | Springwell – Northumbrian Water
- Bishop Middleham | Carlton & Redmarshall – Northumbrian Water
- Melton Mowbray STW | Birmingham Resilience Project – Severn Trent
- Faringdon to Blunsdon Pipeline – Thames Water
- Sluvald WTW – Welsh Water
- Lower/Upper Barden Reservoir | Boston Park – Yorkshire Water



Parkwood Works, Parkwood St,
Keighley, West Yorkshire BD21 4PN

01535 603728 | georgegreen-uk.com

George Green Ltd has and continues to supply DWI Reg 31 Approved Products to water companies and contractors throughout the UK & Ireland.



3D-printed chamber sections awaiting installation (September 2024)
Courtesy of MMB



3D-printed chamber sections assembled (January 2025) - Courtesy of MMB



New ferric kiosk, sludge export tank & delivery bay (July 2025) and
(inset) 3D model - Courtesy of MMB



New aerated reed bed in service (August 2025) - Courtesy of MMB

Carbon reduction through 3D-printed concrete

During the development of the solution and through detailed design, reducing carbon was at the forefront of the project.

Significant carbon savings have been achieved through challenging the scope and replacing hard infrastructure with the aerated reed bed, but further to that opportunities were also realised through alternative manufacture, assembly and construction techniques. The project team wanted to explore the capabilities of 3D-printed concrete and elected to use it for constructing the distribution chambers either side of the PSTs. The chambers were 3D-printed in sections by Hyperion Robotics within a factory-controlled environment before being delivered to site for installation.

Due to the nature of 3D-printing, it allowed for more flexibility with regards to the geometry of the chamber, allowing the corners of the chambers to be rounded off. This in turn meant that the wall thickness of the chambers could be reduced from 300mm to 200mm. Compared to a conventional square chamber with 300mm thick walls, the 3D-printed alternatives represented a 53% carbon saving. By 3D-printing the chambers, it streamlined the installation process, which contributed to a leaner and more sustainable construction phase.

Reducing on-site construction through DfMA

To reduce on-site activity, the Design for Manufacture and Assembly (DfMA) engineering methodology was used extensively. By taking a lot of what would ordinarily be on-site construction activities and placing them in controlled factory environments, less machine time was required on site and less waste was produced.

This can be seen at the inlet works where instead of more conventional concrete channels and chambers, the inlet reception chamber, grit bypass chamber and flow measurement channel were all fabricated off site. With containerised screens also being used, it meant that to complete the installation of the inlet works, the various chambers and screens would be connected by pipework.

Furthermore, the grit tank was also fabricated off-site, rather than cast in concrete in situ. To allow this to be done, and for the system to work hydraulically, a chamber was formed using precast rings to partially bury the tank below slab level.

Another area where the principals of DfMA were employed was at the PSTs, where each tank was constructed using 48 precast panels. The project team selected a standard panel size from the supplier to best suit the required volume according to the process calculations. Compared to casting the tanks in situ this dramatically shortened the construction duration for each tank, shaving weeks off the programme and contributing to a lean construction phase.

Meeting the compliance date

Despite very tight timescales and a condensed construction programme, the regulatory phosphorus compliance of 0.7 mg/l was successfully achieved ahead of schedule in December 2024, successfully addressing the phosphorus removal project driver.

Construction continued into 2025, and in May flows were turned to the new inlet works and PSTs, increasing the site's capacity and addressing the second project driver; flow balancing.

At the time of writing (August 2025) the project is in its final stages following demolition of the existing inlet works and PSTs, allowing for new site access roads to be constructed.

The editor and publishers would like to thank Peter Moore, Project Leader with Mott MacDonald Bentley, for providing the above article for publication. The author would like to thank Andy Wilmer, Project Manager with Yorkshire Water Services, for permission to produce this article.