

Rivelin WTW

ICE award winning project driven by Building Information Modelling (BIM) and innovation to deliver collaborative design and construction efficiencies

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Rivelin Water Treatment Works (WTW) has a treatment capacity of 75ML/day and serves up to 100,000 customers in south and south-west Sheffield in Yorkshire. An identified increase in raw water colour resulted in the need to enhance the existing Sirofloc treatment process to reduce final manganese levels and safeguard against the formation of trihalomethanes. The £14m project comprised two separate batches: (i) base maintenance, including the replacement of old assets with new, and (ii) new manganese contactors, incorporating the design, construction and commissioning of 6 (No.) manganese contactors. Together the two batches formed the overall scheme at Rivelin WTW and was delivered in collaboration with Yorkshire Water Services as part of their AMP5 Capital Programme.



Background

Refurbished in the early 1990s, the existing site has utilised the Sirofloc clarification process of mixing raw water with magnetite for over 20 years, with the asset life of many of the mechanical processes nearing or having expired their operational expectancy.

A number of resultant drivers therefore existed paving the way for the development of Rivelin WTW site. These included:

- **Treated Water Quality:** Manganese.
- **Other Water Quality Issues:** Deteriorating raw water quality.
- **Deterioration in upland peat sources of raw water:** Predicted to continue over next 20 years.
- **Build-up of manganese in distribution pipes:** Water discolouration.
- **Dissolved Manganese:** Taste and odour.

Managing design disciplines and interfaces

Mott MacDonald Bentley (MMB) carried out investigations into asset condition, flow and load, environmental surveys and geotechnical investigation, as well as optioneering and the development of the preferred solution. During the design development process MMB's core team benefitted from YWS input from their Operations, Land/Planning and Customer teams.

The feasibility process identified the preferred solution to be manganese contactors, as they provided the best balance of whole life cost and risk. The solution involved the construction of new manganese contactors and a treated water holding tank, installation of M&E pipework pumps and equipment, control plant, and construction of a new process plant building and associated works to integrate the new process with the existing works.

The delivery team utilised a Milestone Delivery Process to ensure that the project only progressed once it had been thoroughly explored for opportunities to innovate, reduce cost and improve safety at each stage. This is a standard approach for MMB, adapted to fit client-specific milestone delivery processes, allowing project leaders and site managers to deliver schemes through each stage of the design process from receipt of client's brief through to completion, avoiding any uncertainty on previous decisions, current positioning and required actions.

Supply chain interaction

Early supply chain engagement was carried out from the onset, driving capital efficiencies for YWS. The vehicle to deliver this approach was via the *Collaborative Working Plan*, developed by the project team with involvement from key supply chain partners as well as client interaction.

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engineering sustainable outcomes



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Installation of precast concrete elements - Courtesy of MMB



Construction of the new building at Rivelin WTW - Courtesy of MMB



Complex plant installation - Courtesy of MMB

An operational example of how this provided measurable benefits to the scheme delivery is demonstrated by the business case derived out of the investigation into the implementation of variable speed pumps, as opposed to the fixed speed alternatives for the main works transfer pump duties, (i.e. the interstage pumps between the existing process and the new manganese contactors, and the high lift treated water pumps to the service reservoir).

The business case identified whole life cost efficiencies that could be made by utilising variable speed pumps; by reducing the original design of 5 (No.) fixed high lift pumps, to 4 (No.) variable alternatives. This approach was then replicated in the selection of the 'Interstage' pumps. The business case was successfully put forward to the client and therefore implemented into the project delivery. The business case identified higher initial CAPEX outlay, but lower OPEX over the lifespan of the pumps, providing the client with greater savings over a prolonged period, compared to the CAPEX savings of using the fixed pumps. The implementation of 4 (No.) variable pumps also negated the requirements to upgrade the power supply consisting of HV works on site (which the fixed pumps would have required), offering further cost/programme savings, and equally as important, removed a high risk operation in the form of the HV works.

YWS had a number of water quality business drivers, so as part of our early supplier engagement we engaged with specialist chemical dosing subcontractor Nomenca Ltd. Engaging with them early in the design phase generated savings through better understanding of risk; creating efficiencies as we were able to develop the design into an overall composite system on site, providing improved construction implementation, site operation and maintenance.

Building Information Modelling (BIM)

The scheme utilised BIM extensively throughout its delivery; providing a high degree of collaborative design and construction, driving project efficiencies. The 3D model was developed from feasibility through to detailed design and used at each milestone review. At the time, the BIM model of Rivelin was the most advanced and detailed that MMB had ever worked with.

The development of the BIM model saved time during the installation process, as there were no clashes between components built off-site and elements provided by others were already built into the model. Full clash detection in a virtual environment was invaluable for interface management and negating expensive reworking on site.

The team initiated a 3D digital cloud point survey of the existing pipework network by sub-contractor ACWA which was integrated into the BIM model. This allowed the team to precision-thread a new 1m diameter pipe through the existing building structure and retain the use of the existing pipework. The model was utilised for the fabrication of the new pipework and to assist the installation process. As a result, no modifications were made to the pipework on site.

BIM at Rivelin WTW was used during HAZOPS, specifically for virtual tours to identify risk areas to operatives, e.g. access issues. The 3D model allowed operators to undertake virtual walk-throughs to identify potential areas of risk at the earliest stage, as well as an early understanding of how the new asset was to be operated and maintained.

Engineering sustainable outcomes

During the design process a key issue was the size of the building footprint. After extensive review with YWS, it was agreed that the manganese contactors could be located on top of the Treated Water Holding tank. This arrangement, with partially treated water being held in concrete tanks located on top of the final potable water tank allowed MMB to reduce the size of the building by a third; providing time and cost benefits.

Liaison with the local action group Rivelin Valley Conservation Group and Sheffield City Council Planning Office, also allowed the exterior of the building to be clad in sustainable timber rather than being constructed in stone as per the adjacent buildings; providing a cost saving of £300,000.

The use of precast concrete, in accordance with the Waste and Resource Action Programme (WRAP), played a significant role in the delivery of the scheme and was identified during the HAZCON process for the benefits it would bring. This was a development from MMB's work in other areas, using precast concrete for reservoir spillways and service reservoirs. Maximising off-site construction enabled a tight construction programme to be achieved in a safe and cost effective manner. The treated water holding tank and 6 (No.) contactor tanks utilised precast columns, beams, walls and slabs constructed over two levels.

Workmanship in stitching together the precast elements to create watertight structures was a critical requirement, and additional supervision resources were deployed to site to ensure programme gains were not lost through remedial works. All water retaining structures passed their drop tests first time.

Collaborative planning was used from the start of the scheme design and contributed to its successes. Attendance at Construction Lean Improvement Programme (CLIP) sessions by key subcontractors prompted the reuse of some existing assets, as well as a new form of dual contained dosing pipework which generated a cost saving of £78,000.

Engineering challenges

Creating water retaining structures from multiple components constructed off-site was not without its challenges. Learning from earlier schemes resulted in a joint design for the precast elements which included two scabbled zones, and a smooth area with bonded hydrophilic strip which was continuous along every joint. Fibre reinforced concrete was used together with traditional reinforcement to get an equivalent quality finish to the precast panels.

Stability during construction was achieved by the precast panel feet, which were incorporated into each tank's floor slab. Upper levels of external precast walls could only have feet to the internal face; these panels were temporarily tied to internal panels to provide stability.

Health & safety

With up to 40 workers on site on a daily basis, health and safety was key from the start of the scheme. The site induction was agreed during a pre-start away day which included key sub-contractors. Existing buildings on site were also refurbished to provide welfare facilities for site personnel.

144,000 hours were worked on the site and there were 554 Behavioural Discussions recorded. There were 228 near misses reported, two of which merited a full investigation by the site team. The result of this proactive approach to the management of health and safety was an AFR of zero across both phases of the scheme, with no reportable injuries and only seven minor injuries on site.

The excellent approach to safety was recognised by YWS health and safety team who stated: *"During my visits I've noted a great sense of teamwork together with a real desire to deliver the best possible outcome as far as H&S is concerned – the chemical dosing element of the work is particularly impressive"*.

Effect on the community

Rivelin WTW is located on the edge of the Peak District and the Rivelin Valley Conservation Group highlighted their initial concerns surrounding the scale of the proposed development on the site. Close liaison during the design phase led to the relocation of the building to an enclosed part of the site, which, together with the external finish of timber cladding, addressed the action groups concerns. A site visit as the works progressed confirmed their satisfaction with the final product.

Conclusion

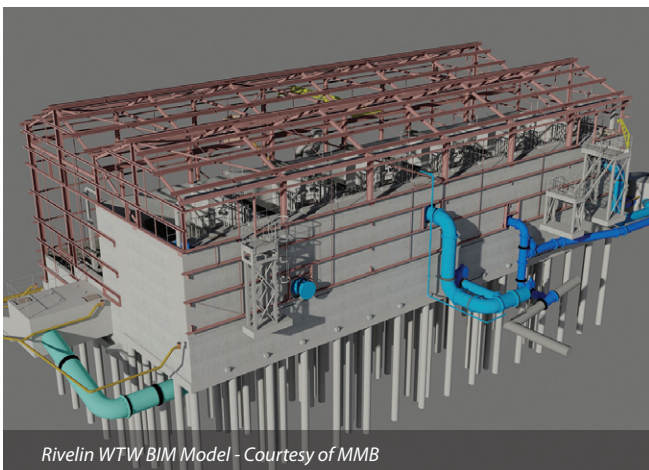
MMB successfully delivered both batches of the scheme. Batch 1 (base maintenance) was programmed to start before the second batch (new manganese contactors), allowing the project team time to develop the solutions for Batch 2 during the delivery of the initial batch. The two batches did run concurrently, leading to completion and operational use 2 weeks ahead of schedule.

Success at Rivelin WTW has been recognised with an ICE Yorkshire and Humber 2013 Centenary award for excellence in concept, design and execution of civil engineering works, due to the successful delivery of a high quality scheme, safely, on time and on budget. John Bowes, chair of the ICE Yorkshire and Humber Awards judging panel commented;

"The effective design led to considerable cost savings and the site had an exemplary safety record. The whole team committed to collaborative planning and doing what they said they would do. This approach led to the scheme finishing on time and within budget."

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