Purton & Littleton WTWs - Surface Aeration

a low cost solution to trihalomethanes (THMs) in drinking water

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Bristol Water provides water to a population of 1.1 million people in an area of 1,000 square miles, centred on Bristol. Raw water sources include both groundwater and surface water, treated in 16 (No.) WTWs producing an average daily total of 264Ml. Two of the three largest WTWs (Purton and Littleton) abstract raw surface water from the Gloucester and Sharpness canal. Purton WTW has a peak output of 165Ml/d and Littleton WTW up to 65Ml/d. Trihalomethanes (THMs), one group of disinfection by-products, are formed when chlorine reacts with natural organic matter (NOM) present in the raw water. Raw water abstracted from the Gloucester and Sharpness canal is dosed with chlorine to prevent zebra mussel colonisation of the inlet works of Purton and Littleton WTWs. Raw water chlorination has been discontinued where possible in the UK due to concerns over THM formation.

Assembly of the 5m high aerator units illustrates maintenance challenges in the future - Courtesy of Atkins

Zebra mussels Courtesy of Atkins

Background

All potable water supplied by Bristol Water must comply with the Water Supply (Water Quality) Regulations 2000 as amended 2010. The 2010 amendment to Regulation 26 requires water companies to *'design, operate and maintain the disinfection process so as to keep disinfection by-products as low as possible without compromising the effectiveness of the disinfection process'.*

The Drinking Water Inspectorate (DWI) makes an assessment of how well companies are meeting the disinfection by-product rule by reviewing the THM concentration in treated water. An annual average value of <50ug/l (50% of the maximum limit) is taken as a broad indicator that the company is minimizing disinfection by-products effectively.

Both Purton WTW and Littleton WTW were at risk of exceeding the target THM concentrations in treated water. Several options to reduce THMs were considered:

- Removing/reducing chlorination - unable to flush pipes to remove mussel colonisation, risk to water treatment process and resilience.
- Use of chlorine dioxide - creation of different disinfection by-products.
- Air stripping using surface aerators.
- Alternative air stripping such as a forced air stripping tower or submerged diffusers - high CAPEX and unable to fit with operation and cleaning of raw water tanks.

Surface aeration to reduce THMs was identified as the lowest risk and whole life cost solution. A DWI supported scheme was designed and delivered between 2010 and 2012.

Aeration for THM reduction

Due to their volatile nature, THMs are transferred to the air over time. Aeration processes exploit this volatility by increasing exposure of the water to the air; the THMs pass into the air in a process known as

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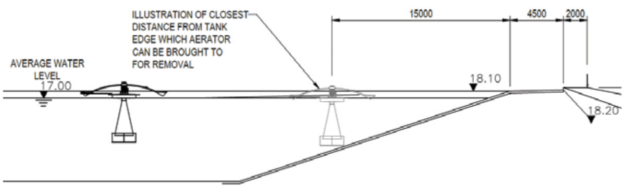


Above: section of raw water tank at Purton, showing the sloping tank sides and illustrating the closest distance from the tank edge that an aerator unit can be brought.

Below: Photograph showing tanks drained down with aerators sat on tank floor - Courtesy of Atkins

The limited vehicular access around the tanks was preventing aerator installation and future removal using a Hiab crane. Photos: Above, before and below after, improvement works - Courtesy of Atkins

air stripping. Surface aeration was chosen because it represented a straightforward, low-cost, standalone solution, which will not have a wider impact on the water treatment process. Located in the uncovered raw water tanks, the aerators would not affect the main water treatment works site at all.

There is limited experience globally of using surface aerators to remove THMs, although aeration of treated water within enclosed storage reservoirs is becoming more common. Aeration itself is a well understood and widely applied technology for wastewater applications, albeit in wastewater the dissolved oxygen is the key metric. There is a paucity of knowledge and experience of using surface aeration for THM removal, and as such, Bristol Water undertook various trials to test the proposed methods.

Surface aeration design

Historic THM levels from both Purton and Littleton WTWs were analysed and the surface aeration system was designed to achieve a 45% reduction in peak total THMs. The minimum retention time in the tanks is 2 hours, during which time the desired THM removal rate had to be achieved.

Surface aeration for THM removal was implemented at both sites:

- ***Purton WTW***: 2 (No.) raw water tanks, each with a capacity of 55,000m^3.
- ***Littleton WTW***: 3 (No.) raw water tanks, one large, 9,000m^3 capacity, and two smaller tanks each with 1,800m^3 capacity.

The total energy required for THM reduction at the two sites was calculated using published empirical formulas. A pilot trail was carried out with both a low and high-speed aerator. The high-speed type was selected for the following reasons:

- Results similar for both low and high speed type.
- Ease of maintenance: high speed unit can be removed with in situ lifting gear while low speed unit has to be dismantled into 5 pieces for removal.
- Lower capital and equal operating expenditure: high speed aerator offered 70% saving on capital cost.

Based on the pilot trial results, 15 (No.) 37kW Aquaturbo high-speed aerators were supplied by Aquasystems International NV.

Safe construction and operation

The total aerator height of 5m made it difficult to work on once it was out of the water. Dismantling the motor at the top from the 3.4m high stainless steel cone required a scaffolding tower. The aerators would have to be removed on an annual basis while the tank is cleaned, so the requirement to dismantle the aerator units and re-assemble the units two weeks later was undesirable from both a safety and a cost perspective.

An additional implication arises from the 1 in 3 slope of the tank sides; the 4m draught means the aerators can only be floated to 15m from the tank edge. A floating pontoon supplied by Airfloat was decided upon to be able to walk out to the floating aerator unit to be able to attach and detach lifting gear.

The aerators were able to sit on the tank bottom during cleaning, and maintenance to the motor was enabled by a floating pontoon.

At Littleton the narrow access track was insufficient for access by the Hiab vehicle. Autotrack modelling was used to size the required turning area, with a low-cost solution being reached following geotechnical input regarding slope stability.

The Bristol Water operations team and equipment suppliers were involved in extensive design work to come up with safe and efficient maintenance procedures.

Regulatory and third party interfaces

Surface aerators are typically used in wastewater treatment. All products and processes in contact with drinking water have to be approved for use under Regulation 31. Achieving DWI compliance involves testing to BS6920 on both leaching and support of microbial growth. This certification was not available for the selected aerators. The solution was to specify a Regulation 31 approved solvent-free polyurethane coating which was applied on site by one of Bristol Water's contractors.

The noise implications at Purton were twofold, with residential properties and a site of ecological significance close by. The Severn Estuary mudflats extend to within 400m of the raw water tanks. This estuary is classified as both a Ramsar site and a SPA (Special Protection Area, an area of international significance for migrating birds). In a situation where a protected area may be affected, environmental legislation can be complex.

Understanding any potential impacts of the scheme on animal populations can require extensive studies. In this case there was the risk that Natural England would require an environmental impact assessment (EIA), involving full surveys throughout autumn, winter and spring. This would have prevented the DWI deadline being met.

To address the noise impact on the protected overwintering birds, a restriction to the operating window was suggested. This was possible because THMs are only an issue during the summer due to higher water temperatures. By examining historical data of THM levels Bristol Water was able to agree to limit aerator operation to the period 1 April - 7 September.

Delivery of the engineering solution

The project required all parties to work closely together to deliver a successful outcome by the regulatory date. The pilot testing and overall project delivery was undertaken by Bristol Water.

The design of the full scale installation was delivered by Atkins, together with the environmental management. The surface aerators were supplied by Aquasystems International NV, with installation and electrical works provided by the main contractor Bridges (Electrical Engineers) Ltd.

10 (No.) floating aerators and the associated power supply are now in place at Purton WTW. A final noise survey was carried out while all aerators were running without any noise attenuation measures. This noise survey revealed that there would only be marginal exceedances in the allowed noise level, of 2-3dBA, at night-time only. A combination of choosing to run the units furthest from the properties, and running the aerators at a lower speed at night brings the noise level increase down to within the 3dBA agreed with the local planning authority without the need for physical noise mitigation measures.

At Littleton the 5 (No.) aerators are installed in the raw water tanks. The power supply (HV connection, transformer, LV cabling and control panel including variable speed drives for motors) and acoustic barrier were installed ready for operation in May 2012.

Performance

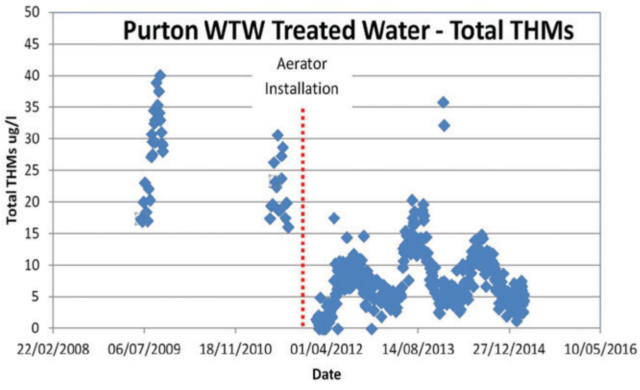
The water quality driver was to reduce THMs in treated water produced by two of Bristol Water's largest WTWs. The graph (top right) shows total THMs measured in treated water over the period 2009 to 2014. The surface aerators were operational in 2012, ensuring that the annual average value for THMs is well below the target of 50ug/l and demonstrating that disinfection by-products are minimised.

Conclusions

This project illustrates the challenges in scaling up a novel (pilot tested) solution to a full scale installation. It demonstrates how the technical solution must satisfy the needs of all project stakeholders. It also highlights the role of suppliers and third parties such as ecology and planning in ensuring that a project is successful.

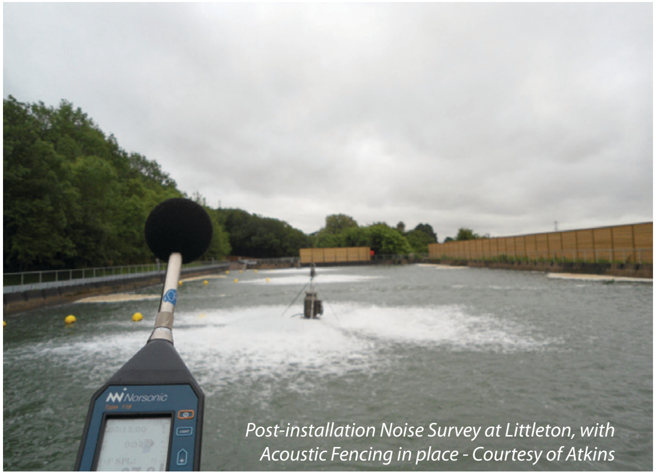
The outcome of the project is that trihalomethane compliance of up to 230Ml/d of drinking water has been safeguarded within the relatively short timescales agreed with the regulator.

This has been achieved by employing a novel process with close stakeholder liaison. Careful selection of the surface aerator type with the aid of pilot studies achieved a 70% saving in capital cost.



Comparison of total THMs before and after installation Courtesy of Atkins

Floating Pontoon to allow inspection and greasing of motors while in situ, minimising the need to remove aerator units from the tank. Pontoon also enables attaching of crane lifting hook for removal Courtesy of Atkins



Post-installation Noise Survey at Littleton, with Acoustic Fencing in place - Courtesy of Atkins

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