Harrogate North WwTW
tertiary treatment using nitrifying sand filters

by
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Yorkshire Water's Harrogate North WwTW, serves a population equivalent of 45,750 with a Flow to Full Treatment of 294 l/s. The works is a Three Dry Weather Flow Works comprising briefly two primary tanks, three plastic media filters and six stone media filters running in parallel, and two humus tanks. The works must comply with UWWTR and also has an RQO spot final effluent consent of 40 mg/l SS, 14 mg/l BOD and 10 mg/l Ammonia-N. The works was struggling to meet the relatively tight BOD limit and was Yorkshire Water's (YWS) only failing wastewater treatment works in 2001.

Nitrifying Sand Filter under construction *(courtesy Paques)*

A scheme was generated under the YWS AMP3 Capital Solutions Partnering Agreement with *Mott MacDonald Bentley (MMB),* a joint venture company formed by consultant *Mott MacDonald* and contractor *J N Bentley.* The solutions team comprises members from both MMB and YWS, all based in one office at Skipton, North Yorkshire.

Objective of the scheme was to achieve compliance with the BOD consent. Ongoing failing samples meant that the scheme needed to be fast-tracked in order to avoid this large works staying on the failing list for another year and, therefore, a tight time-scale of six months was set for completion. Initial feasibility work indicated that the addition of a tertiary treatment plant to the works was the preferred solution.

Options

Traditionally, a sand filter plant would be installed in this situation. This would remove suspended solids and hence remove the BOD associated with the suspended solids (particulate BOD). However, analysis of the effluent samples showed that the levels of soluble BOD might still be high enough to cause compliance concerns. The sand filter was therefore considered to be a high risk solution in this case, as it was unlikely to have a significant impact on soluble BOD levels.

A low risk solution would be provided by biological aerated flooded filter (BAFF) plant which would reduce both the soluble BOD by biological treatment, and the particulate BOD by filtration.. Estimated costs of the BAFF plant were approximately double the costs of the sand filter plant and the proposed time-scale would have been difficult, if not impossible, to meet.

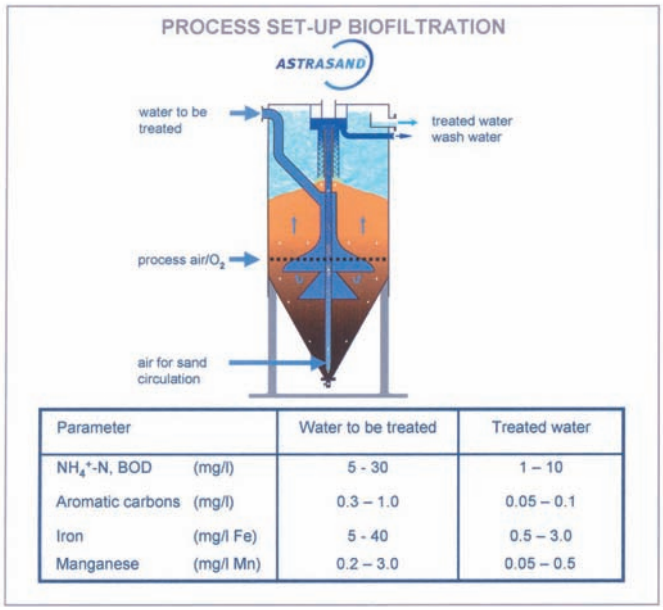
The partnership approach between YWS and MMB encourages the implementation of innovative solutions, and the recently developed technology of a nitrifying sand filter was identified as an alternative, non-traditional solution.

Nitrifying sand filter

The technology was developed by *Paques,* based in the Netherlands. They have been researching nutrient removal with the *Astrasand* continuous upflow sand filter, using process air to provide nitrification. and chemical dosing to achieve nitrogen and phosphorus removal. The nitrifying sand filter comprises a standard sand filter, modified by the addition of an air-ring within the sand filter. Addition of the air ring allows air to bubble up through the sand, providing oxygen to encourage biological growth and remove soluble BOD (and ammonia) from the influent. At the same time, filtration of the influent through the sand reduces suspended solids and therefore the particulate BOD associated with those solids.

The air ring could be added to standard sand filters at a fraction of the additional cost of a BAFF plant, whilst significantly reducing the risk of soluble BOD breakthrough associated with a traditional sand filter solution. Provision of the air does slightly reduce the effectiveness of the filtration treatment due to disturbance of the sand. However, once installed, adjustments to the airflow can be made to achieve the optimum performance, which is a balance between biological treatment to remove soluble BOD, and filtration to remove suspended solids and associated particulate BOD. This solution was, therefore, ideal for the final effluent compliance issues at Harrogate North.

This new technology had been previously installed at Foulbridge WwTW (population equivalent 1,100, under another MMB/ YWS scheme where tertiary treatment was required to meet a tight BOD consent (9 mg/l), but some ammonia polishing was also needed.



Parameter		Water to be treated	Treated water
NH_4^+-N, BOD	(mg/l)	5 - 30	1 – 10
Aromatic carbons	(mg/l)	0.3 – 1.0	0.05 – 0.1
Iron	(mg/l Fe)	5 - 40	0.5 – 3.0
Manganese	(mg/l Mn)	0.2 – 3.0	0.05 – 0.5

Process set-up Biofiltration *(courtesy Paques)*

The single nitrifying sand filter unit had shown promising results and these, plus information supplied from *Paques* on expected BOD and solids removal, meant that the solutions team had sufficient confidence in the solution to implement it.

Installation

The size of the works at Harrogate North necessitated a multiple unit installation. A set of ten continuous upflow nitrifying sand filter units was installed, each unit being 3.2m diameter and 8.2m high. A team approach from *YWS, MMB and Paques* enabled the sand filters to be successfully installed within the six months time scale.

The scheme was delivered for £1.12m. This represents a significant cost saving against the estimated cost of £2.42m for the BAFF plant alternative. In addition, the operating costs of the BAFF plant would have been approximately £23k higher per year.

Spot FE samples (mg/l)	**BOD (mg/l)**		**SS (mg/l)**		**Amm.N**	
	Ave	95%ile	Ave	95%ile	Ave	95%ile
Pre-scheme	13.2	18.9	22.3	30.00	2.7	4.6
Post-scheme	8.3	11.0	9.7	14.1	0.9	2.1

Commissioning

The sand filters were commissioned in November 2002. Sample results have shown that the works is now comfortably meeting its BOD consent with typical values of 8 mg/l, whilst also achieving a significant reduction in Ammonia-N, with the levels now being typically less than 1 mg/l. ■

Note on the authors: *Fiona Thompson is Project leader and Wendy Rostron Process Engineer both with MMB; Rob Bainbridge*