

Hanningfield WTW

sludge treatment reed beds a world first for a water treatment works

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Hanningfield Water Treatment Works (WTW) near Chelmsford in Essex treats up to 240MI/day of drinking water for a large part of Essex. It also generates up to 3MI/day of a ferric sulphate based liquid sludge by-product. The current sludge settlement lagoon system is almost full so a new treatment system is required to enable continued water production at Hanningfield. A feasibility study investigated two main options of a mechanical centrifuge and a sludge treatment reed bed (STRB) system. In September 2009, Northumbrian Water Ltd (NWL) chose to progress with the STRB system - a world first for water treatment sludge. Construction of the reed beds began in June 2011 and is on target for completion in the autumn of 2012.



Aerial view of reed beds April 2012 - Courtesy of CA Blackwell

Introduction

Hanningfield WTW near Chelmsford in Essex treats up to 240MI/day of drinking water for a large part of the county. The site is managed by Essex & Suffolk Water as part of Northumbrian Water Limited (NWL). The works is located adjacent to a 25,000MI raw water storage reservoir. The initial part of the treatment process involves the introduction of ferric sulphate in to the pulsator clarifiers to remove silt and algae contained in the raw reservoir water.

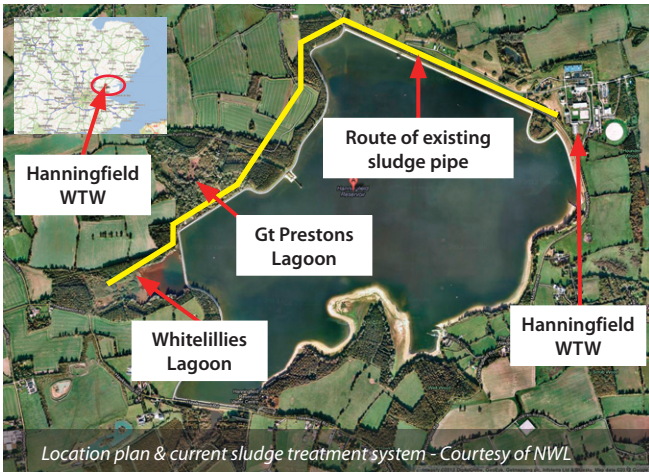
This subsequently generates up to 3MI/day of a ferric based liquid sludge by-product which must be treated. This sludge contains 99.8% of valuable water which once separated, can be returned back to the reservoir for future use.

Current sludge treatment system

Since operations began at Hanningfield in the 1950s, sludge has been discharged into Great Prestons lagoon to the north of the reservoir through an underground pipe shown on the location plan (see next page).

When it became full in 1989, flow was diverted into Whitelilies Lagoon. The lagoons act as a repository for solids whilst allowing the clear water to overflow back into the main reservoir for re-use.

Whitelilies Lagoon is now near the end of its life so an alternative, sustainable solution is required to enable Hanningfield to continue producing drinking water.



Location plan & current sludge treatment system - Courtesy of NWL

This situation led to the project entitled 'Hanningfield Long Term Sludge' with the objective to deliver a sustainable solution to manage the water treatment sludge produced at Hanningfield WTW.

Option review

Several ideas were initially discussed to resolve the situation, but following further analysis, NWL were left with two feasible solutions. These being to:

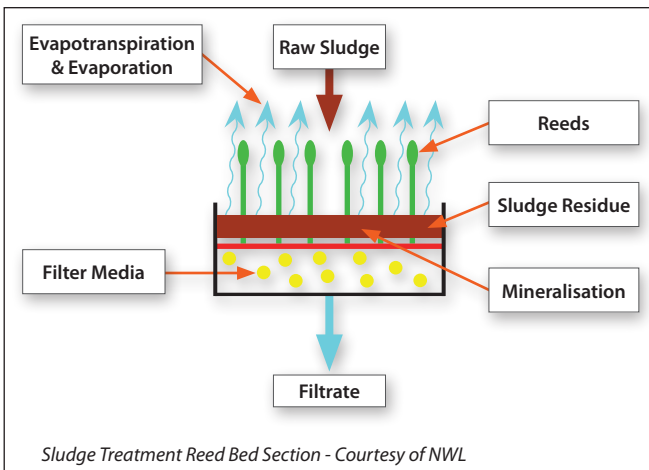
- construct an automated mechanical centrifuge system; or,
- create a managed Sludge Treatment Reed Bed system.

Mechanical centrifuge systems have been used successfully elsewhere for treating raw sludge from water and sewage applications. As such, it would be a fairly straightforward process to design a system to manage sludge from Hanningfield.

Reed beds have been used successfully for industrial sludges such as sewage and food sources but never before for water treatment sludge. NWL felt the STRB system would be the most sustainable solution for Hanningfield although this needed verification before any final decision could be made.

What is a sludge treatment reed bed system?

Very simply, an STRB system is a vertical flow filter bed which receives raw sludge and separates the solids from the clear water content. It does this by retaining the sludge residue on the surface whilst allowing the clear water to pass vertically through the filter system and away via a drainage system at the base of the bed. The system can retain up to around 1m depth of sludge residue built up over several years before it needs to be excavated. Following excavation, the system can receive raw sludge almost immediately as the filter media and reed roots are retained in-situ.



Sludge Treatment Reed Bed Section - Courtesy of NWL

In addition to filtration, organic solids in the sludge residue are mineralised, thereby minimising the residue volume. Volume is further reduced as some water content is lost through evapotranspiration through the reed plants themselves and by evaporation from the surface of the bed.

The overall reduction of sludge volume occurs without the use of chemicals. The process involves only a very low level of energy consumption for pumping the sludge to the site and valve operation within the site. The sizing and design of a reed bed system depends on the sludge production, sludge type, quality and regional climate.

Reed bed trials

Due to the innovative and untested nature of an STRB system for water treatment sludge, a small scale trial system was set up at Hanningfield in March 2008 to determine if the system worked and if so, what the optimum operating conditions were. A simple retrofit of 6 (No.) existing 5m diameter tanks created the trial system.

The purpose of the trial was to determine:

- The suitability of sludge from Hanningfield WTW for treatment in a reed bed system.
- The dimensions and number of beds required for a full scale system.
- The quality of reject water.
- The sludge residue properties to determine a final disposal route.

Loading to each bed was varied over the test period on the basis of:

- Volume of raw sludge applied (m³).
- Period of loading (days).
- Dry solid content loading (kgds/m²/year).
- Length of drying or rest period between loads (days).



Trial reed bed system - Courtesy of NWL



Sludge residue sample from a trial reed bed (ds 60%) - Courtesy of NWL

Through the trial, each bed was monitored visually against set criteria including reed health, blinding, weed growth and residue depth. Samples were taken for laboratory tests from the raw sludge input, the filtrate output and the sludge residue left on the surface. This information was used to determine the size and number of beds required for a full scale system, how it would operate and the expected life cycle between emptying.

The trials were developed, monitored and analysed by NWL and our framework reed bed consultant ARM Ltd and their partners Orbicon based in Denmark.

Trial results

- Reed growth in the trial beds was very good with reeds spreading and growing up to a height of 2m during the summer and dying back during the winter each year as expected.
- Sample analysis of the raw sludge showed a large variation in the dry solid content with the average at 0.17%.
- The pH level of the raw sludge is around pH7 and within parameters to allow good growing conditions for the reeds. The raw sludge contains nitrogen and phosphorus so there has been no need to add fertilizer.
- The raw sludge has good settlement properties which assists the separation process on the bed.
- Following a loading of raw sludge, most of the water content continues to flow vertically through the sludge residue and filter. The trials have not encountered any blinding of the surface, slow dewatering or water ponding.
- Samples of filtrate water treated in the system have shown excellent efficiency of the filtration through the beds with a normal flow turbidity of less than 1 NTU (nephelometric turbidity unit).
- Trials have shown that almost all the raw sludge passes through the bed within the first few hours of being loaded.
- Sludge residue results have shown that the system has good dewatering properties resulting in dry solid (ds) contents of up to 60% following extended rest periods.

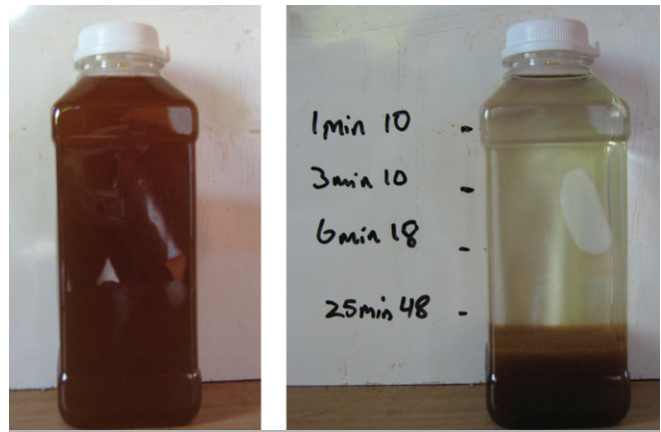
Option decision (September 2009)

By September 2009, sufficient data had been collated and analysed for both the mechanical and reed bed systems to enable a decision to be made. Based on presented data, it was agreed unanimously to progress with the reed bed option. At that time, it was also demonstrated that the project would contribute to the following strategic achievements:

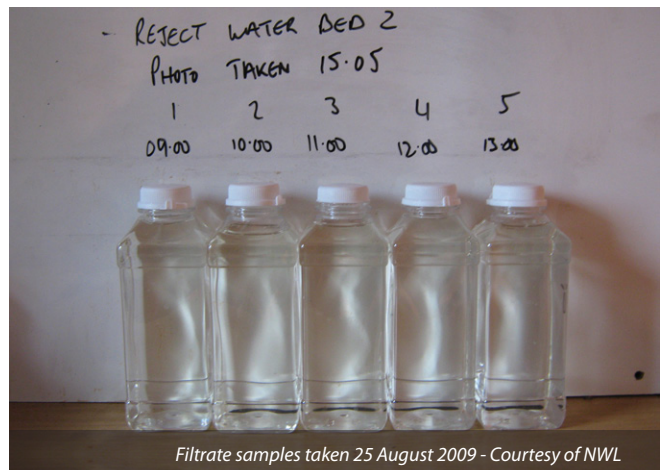
- **Saving water:** Trials produced sludge residue with up to 60% dried solids content, saving more water for re-use.
- **Sustainability:** The scheme requires minimal operation and energy resource. Cyclic emptying ensures re-usability of each reed bed into the foreseeable future.
- **Biodiversity:** The reed beds will attract insects and birdlife to the area. The filtered water will feed the adjacent wildlife habitat of Great Prestons Lagoon.
- **Carbon management:** The feasibility stage indicated a lower carbon whole life cost than a mechanical system.
- **Company efficiency:** Reed beds require minimal operational input.
- **Learning organisation:** Reed beds for WTW sludge is a world first, which shows the company as being proactive in promoting and embracing innovation.

Capital and operational cost evaluation (September 2009)

Capital and operational costs were calculated by our framework consultant MWH at September 2009 for comparison between the mechanical and reed bed systems. The capital cost for both systems were found to be fairly similar at this time. The reed bed scheme however requires far less operational and maintenance input than a mechanical system so on a whole life cost basis is the best value.



Settlement of raw sludge over time - Courtesy of NWL



Filtrate samples taken 25 August 2009 - Courtesy of NWL

The chosen location of the full scale reed bed site is ideal with regard to existing infrastructure but due to its sloping and undulating nature, required a significant amount of additional earthworks.

Also, the site's remoteness dictated the need for a new access road. These issues increased the financial and carbon costs but still remained competitive against the mechanical option.

A mechanical system would require a continuous sludge removal equating to around one 30m³ lorry per day for an average flow. This would increase at short notice when the raw sludge volume increased.

Other advantages of the STRB include:

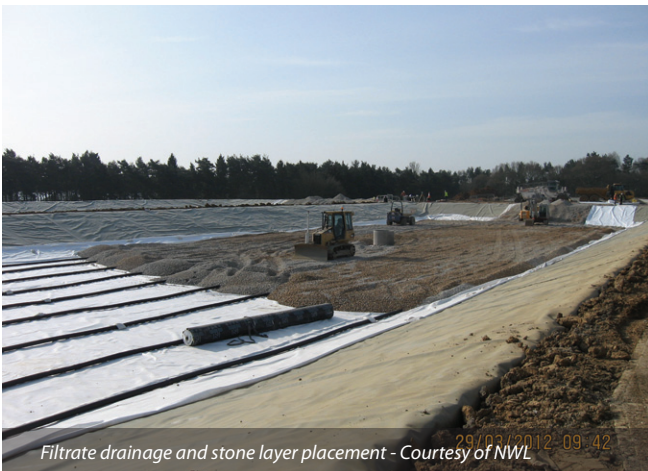
- The reed bed system will receive all raw sludge, regardless of flow rate or density and retain the residue until the bed is full. This means there are no emergencies and no reliance on third parties.
- The reed bed sludge residue has a higher dry solid content than would be produced by the mechanical system. This means we will be recovering more water from the sludge and creating fewer lorry movements overall.
- The reed bed did require an extensive Environmental Impact Assessment (EIA) due to its location but surveys indicated a very minimal construction impact and some longer term benefits.

Full scale STRB operation

The trial reed beds determined the full scale system as requiring 16 individual beds covering a total surface area of 4.3ha. The trials also determined how the full scale system is intended to operate although this will inevitably change during live operations as the beds mature and sludge production varies.



Layout of full scale reed bed system - Courtesy of NWL



Filtrate drainage and stone layer placement - Courtesy of NWL



Placement of filter media - Courtesy of NWL



Sludge loading to a finished reed bed - Courtesy of NWL

Raw sludge will be distributed over the surface of one of the reed beds for around four to five consecutive days. This bed will then rest for a period of up to two months whilst the other beds are loaded automatically on a cyclic basis. During this rest period, the retained sludge residue on the surface of the bed will dry and crack to achieve the maximum dry solid content thus releasing the maximum water for recycling.

At September 2009, the build up of sludge residue to achieve a full bed was calculated to take around 13 years, although this would depend greatly on the future quality and quantity of the liquid sludge and the performance of the beds themselves.

Of the 16 (No.) beds, 2 (No.) beds will be emptied in any emptying year meaning 8 years of the 13 year cycle will be emptying years. However, since 2009, the trial reed beds have been continued in order to fine tune future operations. Further analysis has proven that the reed beds will operate successfully at a higher loading rate than originally envisaged at the design cut off date. This means that the full scale system will be able to accept more sludge before emptying meaning a potential longer life than 13 years and an even lower operating cost than originally calculated.

During an emptying year, two beds will be taken out of operation some months in advance of emptying to obtain the maximum dry solid content and the least residue removal volume. The number of lorry movements will depend on the quality of the sludge at the time but when full, these two beds are envisaged to produce between 11 and 15 lorry removals per day, over a three to four week period. Analysis of the residue from the trial beds has shown it to be useful as an agricultural soil improver.

Once excavated, liquid sludge loading can resume almost immediately causing the reed beds to regenerate themselves naturally without artificial assistance.

Construction

Following a full planning application and OJEU tender process, the main reed bed construction work was awarded to CA Blackwell of Earls Colne in Essex under an NEC2 Option A contract. Earlier enabling contracts were successfully delivered by Aquazone Ltd of Gt Yarmouth, Norfolk.

Construction commenced in June 2011 and is on target for completion in the autumn of 2012. NWL appointed Turner and Townsend as ECCPM for the project with technical assistance and site supervision from MWH and ARM.

Following completion, raw sludge flows to the STRB will be ramped up over two years before eventually accepting all of Hanningfield's sludge. Until this time, some flow will continue to flow through the current lagoon settlement system.

Conclusion

There has been a considerable amount of research work undertaken to prove that reed beds work for WTW sludge at Hanningfield, and it may have been somewhat easier, and possibly quicker, for NWL to have specified a tried and tested mechanical system.

However, by being innovative, NWL will achieve a sustainable treatment system with competitive capital and operational costs. This STRB system will also be a world first for water treatment sludge.

This project compliments NWL's vision of being the national leader in the provision of sustainable water and waste water services.

The editor & publishers would like to thank Paul Grimwood, Project Manager with Northumbrian Water Ltd, for providing the above article for publication.

Waterworks sludge treatment



- No requirement for sludge removal from site for at least ten years
- No chemical dosing required
- Achieves sludge dry solids content of over 40%
- Applies to either alum or ferric sludges
- Low energy and OPEX costs
- Returns 99% of filtrate to water course
- Proven technology
- Flexible operation
- Fully SCADA controlled
- Environmentally friendly operation



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