Birmingham Resilience Project

securing Birmingham's water supply for future generations

by Jon Wagstaff & Mat Bingham

Frankley water treatment works (WTW) is located to the south west of Birmingham city centre. It is the primary water treatment works supplying potable water to the city of Birmingham. The Elan Valley Aqueduct (EVA) is a 118km gravity aqueduct that conveys raw water from the Elan Reservoirs in mid Wales to Frankley WTW. The Elan Reservoirs are the primary raw water source for Frankley WTW. Additional raw water can be pumped to Frankley WTW from an existing intake on the River Severn located at Trimpley. The treatment processes at Frankley WTW are capable of treating River Severn raw water as a small proportion of the total flow by blending with Elan raw water and pesticides removal using granular activated carbon (GAC) filters.

Example of an Actiflo® plant - Courtesy of Severn Trent Water

Elan Valley Aqueduct

Built in the 1890s the EVA is in need of maintenance to ensure continued reliable operation into the future. Currently the EVA can only be taken out of service for short periods with Frankley WTW relying on raw water storage local to the water treatment works during these shutdown periods. These shutdowns are limited to 5-7 day outages. Inspection of the EVA has identified that longer outages than can currently be accommodated are required to carry out repairs to some of the tunnels and conduits.

In 2013 STW undertook a needs study to look at possible alternative supplies for the city of Birmingham which would enable the EVA to be taken out of service for the needed repair work.

Over one hundred options were assessed and the selected preferred solution comprised:

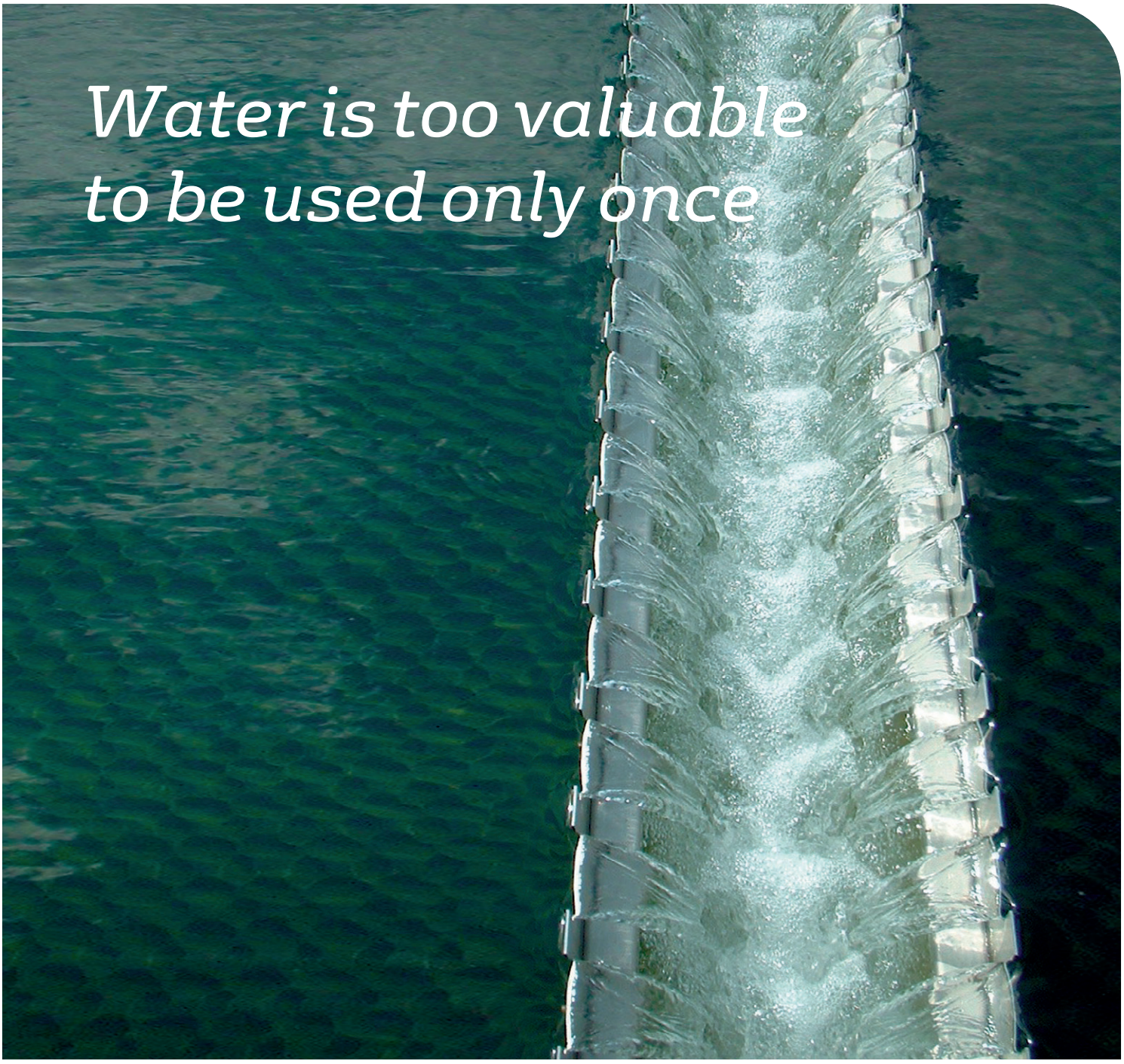
- New River Intake pumping station and screens on the River Severn near Lickhill.
- Raw water pipeline to Frankley WTW from Lickhill.
- Upgrade of Frankley WTW to enable unblended river water to be treated.

This paper focuses on the work required at Frankley WTW to enable treatment of a larger volume of River Severn raw water than can currently be accommodated.

Existing Frankley WTW

The Elan Valley Aqueduct and Frankley WTW were both inaugurated in 1904 to provide drinking water to the population of Birmingham. The treatment process at Frankley WTW originally utilised slow sand filters which have long since been replaced with more modern technology. Since 1904 the water treatment works has been continually upgraded to meet improving water quality standards.

Frankley WTW today comprises two parallel process streams, Stream 1 and 2; the process streams are supplied from Frankley and Bartley Reservoirs. Both Frankley and Bartley Reservoirs are supplied with upland Elan Valley raw water via the EVA. The maximum flow through the EVA is constrained in order to keep the water level in



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the free surface flow tunnel and conduit sections below springing level. Frankley WTW can also be supplied with River Severn raw water from Trimpley which is blended in Frankley Reservoir with the raw water from Elan.

The two parallel process streams at Frankley WTW comprise of dissolved air floatation (DAF), rapid gravity filters (RGFs), pH correction and disinfection with contact time being provided by three contact tanks (the Severn, Elan and Third). Stream 1 also has a granular activated carbon (GAC) plant downstream of the RGFs which is brought in and out of service depending on the volume of River Severn raw water supplied to Frankley WTW.

Future process

The upgrade to Frankley WTW comprises a new process stream for which the capacity takes into account maximising the existing imports into the Birmingham distribution system; however the treatment capacity of the new process stream will be greater than either of the existing streams. The new process stream will operate when supply is from either the EVA or the River Severn. Once the project is complete STW will operate Frankley WTTW as a three stream water treatment works which will provide improved resilience to its customers.

Pesticides

The levels of the pesticide metaldehyde have been increasing in the River Severn and STW require a means of pesticide treatment which will remove metaldehyde. The re-use of the GAC was investigated as an option but rejected on the basis that the existing GAC did not have the treatment capacity and there were also issues around its response time to an unplanned outage of the EVA.

Powdered activated carbon (PAC) was selected as the preferred option for pesticides removal. PAC storage and dosing systems are to be constructed at both the existing river abstraction site at Trimpley and also at the new river abstraction site at Lickhill.

Clarification

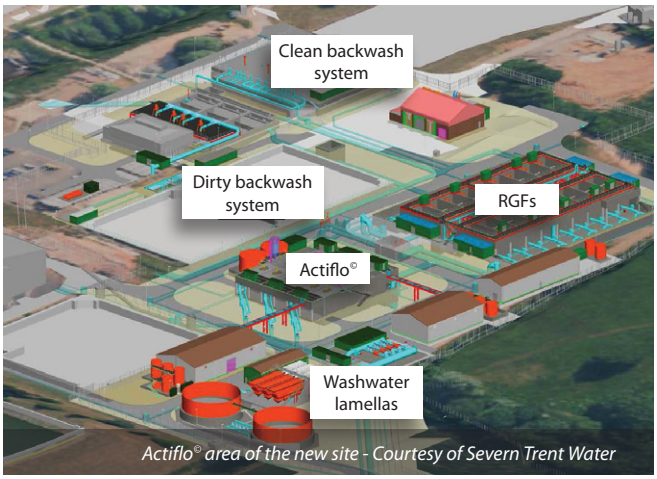
Frankley WTW has historically been designed for treatment of Elan upland raw water, a high quality raw water source from upland reservoirs in Wales. It is low in organics, solids, pollutants and alkalinity. The DAFs at Frankley WTW were designed for the Elan raw water source, not River Severn raw water.

Actiflo© was selected for the new clarification stage to treat the River Severn raw water. The Actiflo© is a patented process sand ballasted lamella which uses sand to add ballast and aid floc formation. This is a new treatment process to STW and in order to gain confidence in the process pilot trials were carried out using a trailer mounted Actiflo© located at Trimpley WTW. To replicate the new process as far as possible new RGF pilot columns were constructed to operate downstream of the Actiflo© pilot plant trailer.

The pilot plant was operated for 6 months during which time various trials were undertaken to understand the new process performance on a range of River Severn and EVA water qualities and temperatures. A PAC dosing system was installed upstream of the Actiflo© to assess the impact of PAC on the process and inform the design of the sludge waste stream.

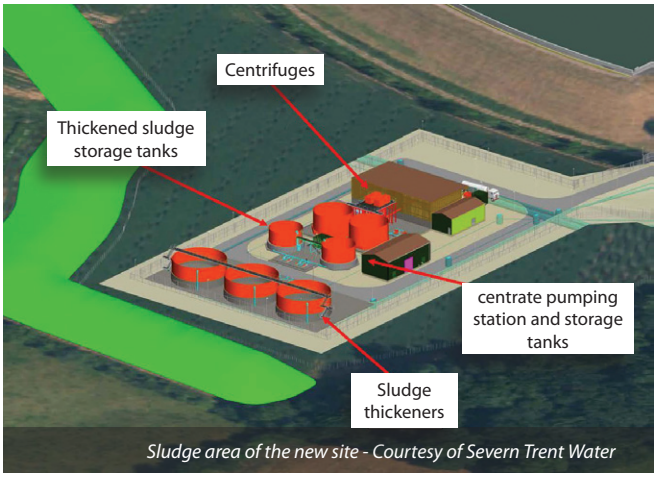
RGFs

New rapid gravity filters are to be constructed for the new process stream with associated clean and dirty backwash systems. The new clean and dirty backwash systems will also service the existing RGFs, enabling the old clean backwash tanks, which are at the end of their asset life, to be demolished. The existing overflow lagoons are to be converted to the new dirty backwash tanks reusing the existing structures. This philosophy of reuse of existing structures was adopted by STW where possible to minimise construction on surrounding greenbelt land and make cost efficiency savings.



Actiflo© area of the new site - Courtesy of Severn Trent Water


Frankley WTW - Courtesy of Severn Trent Water



Sludge area of the new site - Courtesy of Severn Trent Water


Pilot plant - chemical dosing pipelines - Courtesy of Severn Trent Water

Chemicals

A key part of the pilot plant trials was to assess the performance of different coagulants and confirm that ferric sulphate, which is the coagulant used with the existing DAFs, would give acceptable performance with the Actiflo©. These trials were successfully carried out and included tests at different water temperatures by installing chillers on the incoming raw water.

A new lime water plant was constructed and commissioned as a separate project in 2015-2016. As part of a wider strategy for the site STW ensured that the lime water plant has sufficient capacity for the new process stream. Lime water will be pumped across site and stored locally to the new structures at one of the two new chemical buildings.

All other chemicals required will be provided local to the new process stream housed in two new chemical buildings.

Sludge treatment

Currently the dirty backwash water from the existing RGFs is discharged to, and treated in a partitioned fill, settle and decant washwater recovery tank, which receives a polymer dose in transit. The washwater supernatant is pumped to Frankley Reservoir once settled. The settled sludge is pumped to sewer. There is an overflow from the fill, settle and decant (washwater recovery tank) to the existing adjacent overflow lagoon. The DAF sludge gravitates to sewer and has 2 (No.) buffer tanks to accommodate several hours of DAF sludge flow if the site sewer is surcharged, such as during a storm. Storage is required as the existing sewer capacity is limited.

Increasing sewer capacity was investigated but determined not to be viable based on programme and cost. To take account of the limited existing sewer capacity a new sludge treatment process will be provided as part of this project which maximises water recovery whilst minimizing sludge discharge to sewer.

The first stage of the sludge treatment will be recovery of the dirty backwash water from the new RGFs. The dirty backwash water will be pumped to lamella clarifier units which will return clarified water to the head of works and pass sludge forward to a set of sludge buffer tanks where it will be mixed with sludge from the Actiflo©.

The mixed sludge will then be thickened to approximately 4% dry solids (DS) content via WRc thickener units. At this point supernatant will flow back to the lamella units for further recovery with the sludge passing to a second set of buffer tanks.

The final stage of sludge treatment will be dependent on the raw water source:

- When the raw water source is the River Severn water, the sludge will be pumped to dewatering centrifuges in order to produce a sludge cake suitable for disposal to local landbank with only the remaining centrate passing to the local sewer network.
- When the raw water source is water from the EVA, the thickened sludge will be diluted with the mixed sludge from the sludge buffer tanks in order to produce a Newtonian fluid which will flow within the local sewer network, from where it passes to Minworth STW for further treatment and energy recovery.

Looking ahead

Severn Trent Water plan to have a contractor appointed by the end of the summer in 2016 with construction starting soon afterwards. Commissioning of the new works is to be complete by December 2019.

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Existing lime water plant - Courtesy of Severn Trent Water