Derwent Valley Aqueduct

delivering resilience to Severn Trent Water's strategic grid

by Dave Bullick MEng CEng CEnv MCIWEM

A spectacular piece of Victorian/Edwardian engineering, the Derwent Valley Aqueduct is one of Severn Trent Water's most important assets and forms part of its strategic water grid. Serving more than 590,000 customers in Nottinghamshire, Derbyshire and Leicestershire, treated water flows by gravity alone, conveying 200Ml/d of drinking water from Bamford WTW in north Derbyshire to Hallgates Service Reservoir near Leicester. The aqueduct consists of 180km of large diameter pipeline (cast iron and steel pipes), 16km in 6 (No.) sections of single 6' 3" diameter tunnel. It includes 1,000 (No.) valves, 14 (No.) bridges and culverts, and 307 (No.) other structures and chambers. The planning phase of upgrade programme was featured in UK Water Projects 2011. With completion scheduled by March 2015, this article provides an update on the work carried out to date against two key projects in the overall programme, DVA Duplication and Hallgates Break Pressure Tank and Pumping Station.

Installing a close-fit liner - Courtesy Laing O'Rourke

Project need and undertakings

Part of Severn Trent Water's AMP5 programme, this major upgrade will boost achievable flowrates down the aqueduct, improve resilience to local failures, and increase the Company's operational flexibility to respond to major events without affecting customer supplies. It will also apply preventive maintenance to key individual elements such as pipe bridges, valves and air valves.

The DVA Duplication and Hallgates Break Pressure Tank and Pumping Station schemes are intended to improve hydraulic capacity and increase resilience of the aqueduct between Ambergate Reservoir near Belper in Derbyshire and the Hallgates Reservoir site.

Severn Trent Water appointed Atkins directly to carry out initial feasibility and conceptual design of the schemes, and

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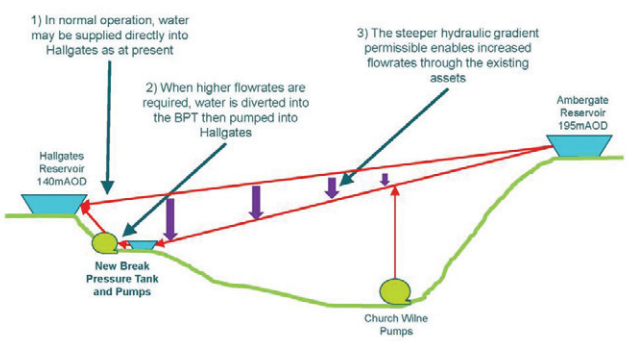
Preparing to drill a large diameter under pressure tapping
Courtesy Laing O'Rourke

Removing a section of 100 year old main
Courtesy of Atkins



The hydraulic concept makes use of pumps to increase flow through the existing aqueduct, without either increasing operating pressures or exposing the existing assets to potential transient pressures resulting from sudden pump outage - Courtesy of Atkins

Laing O'Rourke to carry out detailed design, construction and commissioning.

Laing O'Rourke subsequently appointed Atkins to provide further support to the detailed design process and also to provide ongoing operational support and advice during construction and commissioning. This includes risk and contingency planning and on-site monitoring of network data such as turbidity, flowrates and pressure during key phases of construction.

The Hallgates site and the Derwent Valley Aqueduct itself is a long lived asset that has been developed intermittently over the years. A key challenge for the project team has been to understand the existing assets and ensure that new construction is effectively integrated.

The design process involved a significant degree of site investigation, assessment of existing records and engagement with relevant stakeholders. The solution has been developed to take account of the degree of uncertainty that comes with assets of this age, and to provide sufficient operational flexibility to allow for ongoing future upgrades.

The scheme has also become the second project in the East Midlands to join the ICE *'This is Civil Engineering'* campaign.

DVA Duplication Project

The duplication project is intended to fill in a 10km 'missing link' in the aqueduct to the east of Derby that was created when a section of one of the two mains that form the aqueduct was turned over to raw water use several decades ago.

The original proposal for this scheme was to lay a new main to fill in the missing section. The feasibility process established that the raw water main was no longer required; hence it would be more economical to rehabilitate the main and return it to potable use, rather than carry out new construction.

Laing O'Rourke has carried out a roll-down pipe liner installation of a 937mm diameter PE liner pipe inserted into the 39" steel host main using the 'subline' technique. The insertion has been carried out using 18 separate pulls, with a maximum pull length of 809m. The rehabilitation work also includes open-cut sections at either end of the main, and at the approaches to an existing pipe bridge where the main crosses the currently disused Derby canal.

The length of main includes five valve houses. The original in-line valves, which were installed in 1937, were found to be of high quality and in essentially sound condition. These existing assets have therefore been removed for off-site rehabilitation and then reinstalled. Removing and reinstalling the valves safely within the tight confines of the existing valvehouses required the construction of bespoke lifting frames.

The reinstated duplication main will provide significant additional flow transfer capacity down the existing aqueduct; as a result the flowrate monitoring and control systems are also being upgraded. ABB Magmaster flow meters are being installed on both the existing main and the newly rehabilitated duplication main, together with VAG needle valves to provide accurate control of flowrate.

Constructing the scheme successfully requires significant works in close proximity to existing live, large diameter, high pressure water mains, in particular during the installation of the under pressure tappings and linestops required to complete the work. Carrying out this work safely and successfully required an integrated team approach between Severn Trent Water, Laing O'Rourke and Atkins.

Hallgates Break Pressure Tank and Pumping Station

It was originally intended to triplicate the aqueduct between

Church Wilne WTW and the Hallgates Strategic Service Reservoir site by laying 23km of new 1000mm main. However, the feasibility process established that providing this additional capacity to meet resilience flowrates would likely lead to water quality problems in normal use.

The alternative solution chosen was to harness the unused capacity of the existing assets by installing a set of booster pumps on the aqueduct, providing capability to increase the hydraulic gradient over the length of the aqueduct if required. The pumps are installed at the downstream end of the aqueduct, so when they are operated the upstream pipeline pressures are reduced rather than increased.

Furthermore, the pumps are hydraulically isolated from the aqueduct by the inclusion of a break pressure tank. This provides the capability to attenuate the impact of sudden changes to pumped flowrates on the upstream aqueduct, in particular the transient pressure surges that would occur in the event of a sudden unplanned pump outage.

In normal use, the aqueduct can continue to operate as a gravity system as at present, with the pumps offline but held in a state of readiness to operate at short notice. If a higher flowrate is required than can be delivered under gravity alone, then the pumps are started and water is diverted from the existing terminal reservoirs into the break pressure tank using twin VAG needle valves.

The break pressure tank sits only 200m upstream from the terminal reservoirs but at an elevation 30m lower. The pumps then draw water from the break pressure tank and lift it back up to the elevation of the terminal reservoirs. Twin non-return valves prevent water from the pumping station returning back up the aqueduct.

The new booster pumps and break pressure tank have been constructed on the site of a set of long disused filter beds within the Hallgates site, while control equipment is installed within an existing building. The site is in a sensitive area between twin Site of Special Scientific Interest (SSSI) areas at Swithland Wood and Bradgate Park. The final design of the scheme has eliminated the need for any significant construction within these SSSI areas.

Furthermore, while the design of the scheme required diversion of the final 2km stretch of the aqueduct for hydraulic reasons (to avoid a local high point), the diversion provided the additional benefit of removing the existing aqueduct assets from the Swithland Wood SSSI.

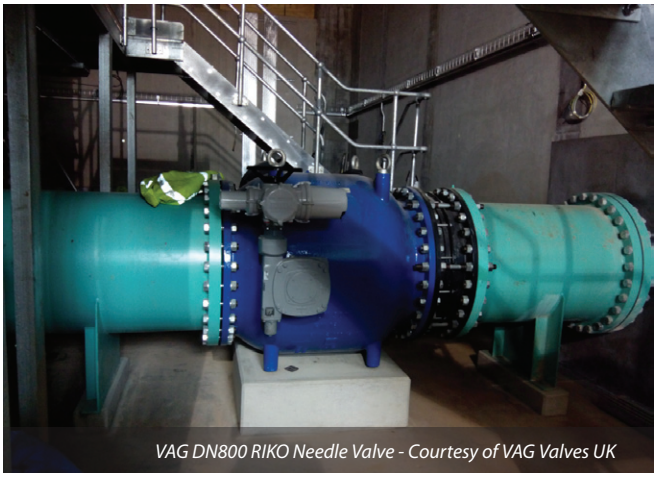
The break pressure tank has a total capacity of 5Ml and has been constructed using Laing O'Rourke's innovative design for manufacture and assembly (DfMA) methodology. Wall panels were constructed off-site in a controlled manufacturing environment, minimising the amount of in situ construction required, improving quality control and reducing the length of the construction programme.

The pumping station has been designed for a maximum flow of 120Ml/d with a lift of 30m and makes use of inline centrifugal canister pumps supplied from Bedford Pumps in a duty/assist configuration. While the efficiency of these pumps is not as high as other designs of pump, they were selected as the optimal design of pump for this application due to its resilience nature and expected intermittent use.

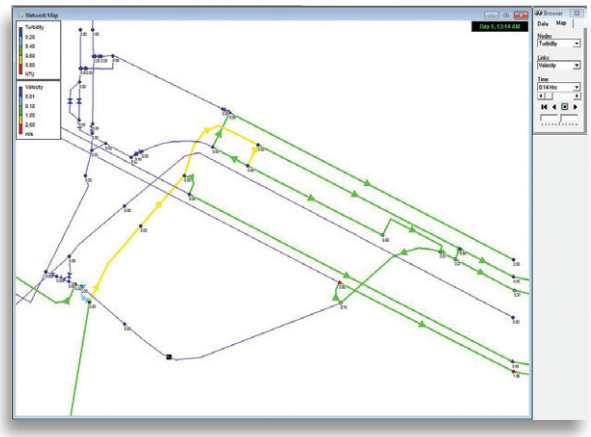
Construction is approaching completion and the commissioning process is underway in accordance with a planned completion date of March 2015.

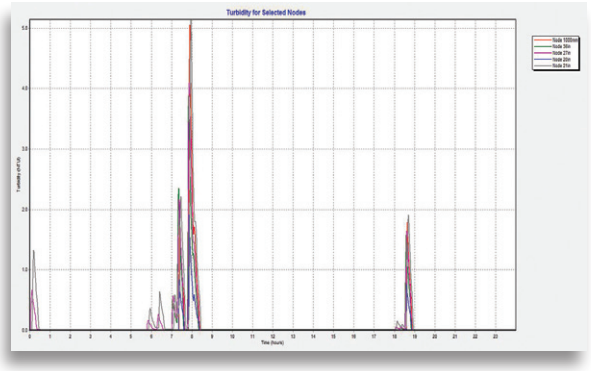
The Editor & Publishers would like to thank Dave Bullick, Principal Engineer at Atkins, for providing the above article for publication.

Construction of Hallgates Break Pressure Tank and Booster Station using DfMA techniques in October 2013 - Laing O'Rourke



VAG DN800 RIKO Needle Valve - Courtesy of VAG Valves UK





The projects are making use of innovative PODDS (prediction of discolouration in distribution systems) principles and tools developed by the University of Sheffield to help predict and manage discolouration risk Courtesy of Atkins