Katrine Water Project

700,000 residents of Greater Glasgow delighted with new works

The residents of Glasgow maintained a keen interest in the development of the city's new water treatment works, a £120 million technically challenging project which was delivered under budget and ahead of the original time schedule. Hardly surprising, since construction on the site of the existing 150 years old works at Scottish Water's Milngavie reservoirs complex north of the city, an area treasured by residents for recreational purposes, was devised to 'shoe-in' with the uninterrupted operation of the Victorian facility which has served generations of Glaswegians. The 700,000 residents in the `Greater Glasgow area were delighted with the appearance and taste of their new water supply upgraded to European standards following the commissioning late last year.

Katrine: Aerial photo of new works and one of the covered reservoirs *photo courtesy of Scottish Water*

The £120 million replacement works receives raw water from Loch Katrine, 26 miles away, through a series of Victorian built, gravity fed aqueducts and also utilised the same distribution infrastructure which was laid down all those years ago.

The Katrine Water Project, whose management contractor was Black & Veatch, with Montgomery Watson Harza and Thames Water responsible for the civil and water treatment process design, called for the construction of the works, two covered reservoirs and a complicated formation of pumping station, tunnels and intake structures.

Gus Watt, Scottish Water's project manager said; "Each of the two pumping station tunnels have intake structures which had to be constructed within the existing Mugdock and Craigmaddie reservoirs when the levels were lowered, while the embankments and surrounding infrastructure are all of Listed building status, Therefore, client, contractor, sub-contractor and designers were required to collaborate very closely within a partnering environment to meet the challenges of delivering the difficult element of work within such demanding constraints and when the business of supplying Glasgow's daily requirements had to continue uninterrupted."

The heavily chlorinated supply from the Victorian works has now been replaced by water from the new facility, designed for a maximum plant outlet flow of 240 MLD. The raw water is treated through a direct filtration plant, utilising coagulation and dual media filtration.

Treatment processes used at Milngavie includes the following.:

Raw Water Conditioning

The untreated water is dosed with limewater to increase the pH before coagulant dosing.

The combined raw and recycle water is dosed with a 0.15 percent w/w solution of limewater in the inlet channel. The limewater dosing is controlled by flow pacing from the plant flow, trimmed by a feedback from the downstream pH meter to ensure that close control of the pH is maintained. A limewater solution has been used instead of a slurry as maintaining accurate flocculation pH control is critical to the process due to the low buffering capacity of the raw water. It also has the benefit that carrier water isn't required and the dosing lines aren't prone to blockages.

Coagulation

The conditioned stream is then dosed with coagulant in the single inlet channel. The coagulant used is Aluminium Sulphate, at an average dose of 0.8 mg/l as Al.

Pipework being submerged at Craigmaddie Reservoir *photo courtesy of Scottish Water*

Flocculation
It may be required to dose flocculation aid polymer during high colour events (>30 Hazen).

The facility to dose polyDADMAC is allowed for. The dosing point for the flocculation aid polymer (polyacrylamide) will be the same as the coagulant, into the single inlet channel.

The coagulated water then flows by gravity to two flocculation streams, (operated as duty/duty) which have a combined residence time of five minutes at the instantaneous maximum flow. In each stream the water is mixed in three-stage flocculation tanks, which are separated by perforated plate baffles.

The flocculated water flows to where the two streams combine and is then dosed with a filtration aid polymer (polyacrylamide) at an average dose of 0.08 mg/l, via a static mixer in the channel prior to the filters.

Filtration
There are 12 dual media rapid gravity filters, each containing a 600mm layer of normal cut anthracite (No.2) over 600mm of 14/25 sand.

Each filter is monitored for flow, filtered water turbidity, head loss across the filter media and flow normalised head loss across the filter media. All these are trended on the SCADA system.

Washwater Recovery
In normal operation the filters would be expected to be called to wash on time elapsed and each filter will be washed once a day. Under these circumstances only one filter will need to be out for washing at a time, though it is possible to carry out a maximum of 24 filter washes in a day.

The filter backwash consists of an air scour followed by a combined air/water wash, to ensure that the dirt is removed from the media, followed by a high rate re-grade wash. After washing is complete the filter is refilled and the filter run to waste sequence will commence. The filter will be run to waste to the Balance Tank until the filtered turbidity falls below a pre-set value (<0.1 NTU), to allow the filter to ripen and minimise the risk of cryptosporidium going into supply.

Filter backwash can be initiated in four ways:

* manual demand for backwash from Operator;
* high filter outlet turbidity (> 0.1 NTU)
* high filter flow normalised head loss;
* time elapsed since last backwash.

The dirty washwater passes to the washwater holding tanks that feed lamella clarifiers to achieve solid liquid separation. The clarifiers are run in parallel and operated with a continuous inflow.

However, redundancy is included in the system as under normal backwashing conditions the total volume of washwater produced can be treated by one clarifier stream.

Supernatant from the lamellas returns to the Balancing Tank for recycle to the raw water pumping station and sludge passes to the sludge holding tank, from where it is discharged to sewer. The lamellas are designed to provide a sludge with a solids content, that will be a minimum of 0.8 per cent and a maximum of 2 per cent w/w.

Supernatant with turbidity above 10 NTU should not be returned to the balance tank, due to the increased risk of cryptosporidium passing into supply. The lamellas have been designed to achieve turbidity below two NTU as a 95 per centile at maximum flow and solids loading and a turbidity below 5 NTU as a maximum. The washwater supernatant recycle will vary between 2.5 and 5.0 per cent of the total plant flow in accordance with the Bouchier recommendations.

The dirty washwater is pumped and dosed with polyacrylamide before entering flocculation tanks, to improve separation in the lamellas. The lamellas consist of a series of inclined-metal plates, where the clarified liquid flows upward and over weirs into the balancing tank while the solids settle on the inclined parallel plates and slide onto the floor of the tank.

The scraper mechanism on the tank floor then moves the sludge into collection hoppers, which are desludged on a adjustable time interval into the sludge holding tank. Lamellas have been chosen for Milngavie due to their small footprint area in comparison to a conventional settlement tank, and product quality.

Orthophosphoric Acid Dosing
Orthophosphoric acid for plumbosolvency control is dosed downstream of the filters at the same point as the sodium hypochlorite addition.

Katrine: Photo showing Lamellas *courtesy Scottish Water*

Disinfection
Ten per cent Sodium hypochlorite solution is used as the disinfectant. This is delivered to the site as a 15 per cent solution and diluted on site to 10 per cent. The hypochlorite dose is flow paced with a feedback loop trim from the post dosing chlorine residual sample, to give closed loop control of the chlorine dose. Hypochlorite has been chosen as the safer alternative to chlorine gas.

Treated water stabilisation
The pH of the disinfected water is raised by the addition of limewater (0.15 per cent w/w).

The treated flows pass to a high-level water storage tank with a capacity of 80 Ml. This clearwater tank firstly feeds the high level supply zone within Glasgow. It also delivers to another similar-sized storage tank, the service reservoir, that supplies the low level zone, mainly within the city centre.

Major elements of the scope of the project included:

* construction of the main treatment works housing all the process elements. This aesthetically pleasing building is in natural stone;
* two 80 megalitres covered reservoirs;
* raw water pumping station located within a 15 metre diameter 30 metre deep shaft. This included two 2 metre wide diameter intake tunnels 300 metres long to the raw water reservoirs;
* 12 kilometres of large diameter (900mm to 1.2 metre diameter) pipelines linking the works to the existing networks.
  A further 1.5 kilometres of 1,000mm diameter pipework was submerged at the bottom of Craigmaddie Reservoir;
* a cross-connection between two of the largest water supply systems in Scotland (Loch Lomond and Loch Katrine) was constructed to allow a gravity supply to the nearby Balmore Water Treatment Works. A link main from Balmore WTW to the Glasgow network facilitated a reduction in the Milngavie WTW footprint. This cross connection is saving customers £500,000 a year in electricity pumping charges.

Mark Allan, Black & Veatch's Contract's Manager said: "From the outset, it was appreciated that developing the new works within the residential and highly sensitive Milngavie area would require careful planning, co-ordination and consultation with the local community.

One of our key objectives was to minimise the impact of construction on the local area and to strive to make as much of the complex available for continued public use while our activities went on."

A campaign to win the confidence of local residents was launched by the Katrine Water Project and since construction started in March 2004, the very few issues that have arisen have been quickly resolved.

Throughout the construction process, the project attracted a string of prestigious accolades including Gold awards from Utility Industry, Considerate Constructors and the Royal Society for the Prevention of Accidents.

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