AUTOMATION SPOTLIGHT

Oakville South West Wastewater Treatment Plant Upgrade

By Graham Nasby, Mike Di Iorio, Pete Samson and Stan Spencer

The year 2011 marked the completion of the $58 million dollar "Phase 3" upgrade to the Oakville South West Wastewater Treatment Plant located in Oakville, Ontario, Canada. Operated by the wastewater division of the Halton Region Public Works department, the plant provides wastewater treatment services for a population of approximately 52,000 and has a peak capacity of 180 MLD (million litres per day).

The project included replacing the influent pumping station, a new headworks facility, the installation of additional onsite storage to accommodate higher wastewater flows during periods of wet weather, and a significant capacity increase. Also included were an upgraded electrical system and process train improvements. The project also involved the wholesale replacement of much of the plants instrumentation and a significantly expanded SCADA system.

Coordinated by Canadian engineering firm Stantec Consulting Inc., the project team involved a multitude of design and construction professionals covering a wide variety of skill sets. The plant's new SCADA system was designed and programmed by Eramosa Engineering, which has offices in Guelph, Calgary, and Detroit. Eramosa is a specialist consulting engineering firm that specializes in electrical engineering, system integration, data visualization, web-based reporting, and SCADA master planning.

The upgrade project was so large that was actually comprised of a number of distinct projects which were undertaken as a series of carefully orchestrated phases. The plant also had to remain in full operation during the entire upgrade, so all site work had to be carefully coordinated and scheduled. During the 3-year construction project, the project team was able to ensure that the plant's constant inflow of sewage was always treated before being discharged to Lake Ontario.

Aerial shot of the Oakville Southwest Wastewater Treatment Plant.

NEW BAR SCREEN BUILDING

Unlike traditional wastewater plants, the plant's bar screen is located ahead of the lift station. A new dual bar screen chamber was installed on the incoming 1350 mm gravity sewer leading into the plant. The idea is that any debris entering the plant is screened out before it has a chance to clog the plant's lift station pumps. The net result has been a significant decrease in maintenance work associated with clogged pumps. The screens are fully automated and cycled based on several operator-selectable control strategies, depending on time intervals and the characteristics of the incoming raw sewage flow. As the screen building is located in close proximity to a residential area, the building was architecturally designed to fit in with the neighborhood.

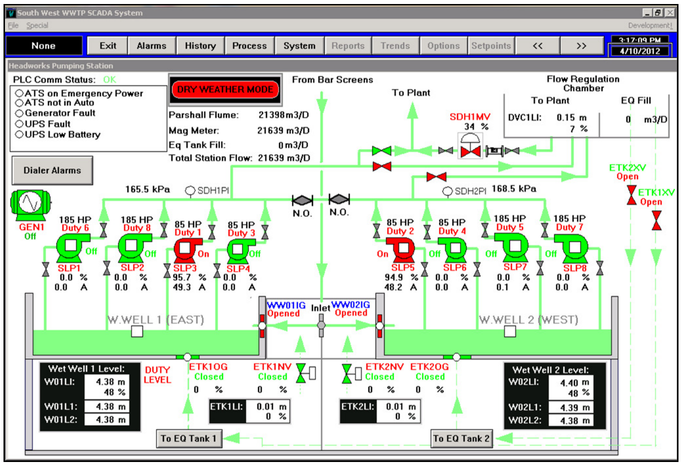
New Bar Screen Building, which is located within sight of an established lakefront residential area.

NEW LIFT STATION & EQUALIZATION TANKS

Part of the upgrades was to construct a new sewage lift station to replace the aging W18 facility which was located on the corner of the plant property. The new lift station features two large tandem wet wells, and two 4000 m^3 onsite equalization tanks. The equalization tanks are designed to reduce the effect of weather-related high flow rates on the plant by offering short-term storage. Fed by a single 1350 mm gravity sewer, giant automated sluice gates are used to feed one or both wet wells depending on service requirements.

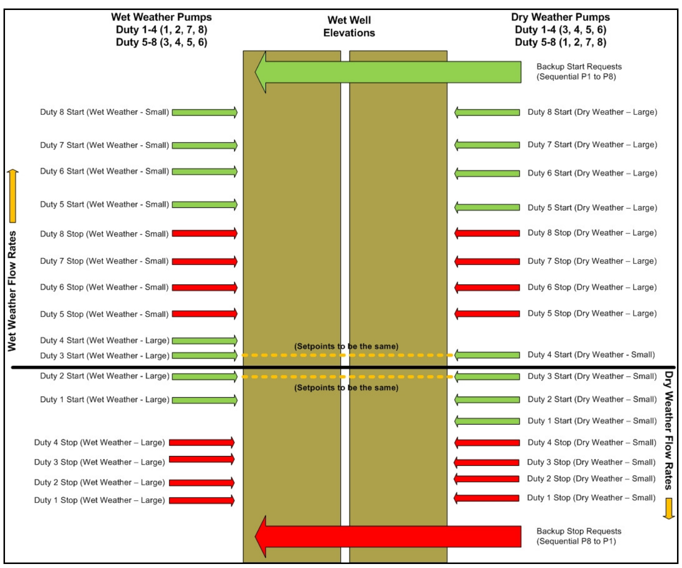
The pumping station itself features a total of 8 pumps – four rated at 17.3 MLD (million litres per day) at 13.9 mTDH (meters total dynamic head) and four rated at 56.3 MLD at 13.9 mTDH. The plant's fully automatic control system, using Allen-Bradley ControlLogix PLCs and Wonderware InTouch HMI software, controls the VFDs for the pumps in response to wet well levels and the rate at which the wet wells and equalization tanks are filling/emptying over time.

A "duty-based" approach is used for controlling the wet well pumps. Viable duty combinations for both low flow and high flow scenarios are available and the system is capable of sequentially switching between them based on influent measurements. This permits a higher resolution of control during low and high flow conditions while aiding in asset management by equalizing operating runtime across all equipment. The system also automatically handles pump failures and when pumps are taken out of service for maintenance.



The lift station has 8 independent pumps under duty-based control.

Under normal operating conditions, the "duty table" can be updated manually by the operator to set designated pumps to start in a specific order as the incoming flow of sewage increases. To ensure that pump runtime is equally shared between the pumps, pumps are automatically rotated in and out of service on an operator-adjustable time interval.



Level-based control scheme for the lift station, using different duty configurations if the plant is responding to a wet weather event or not.

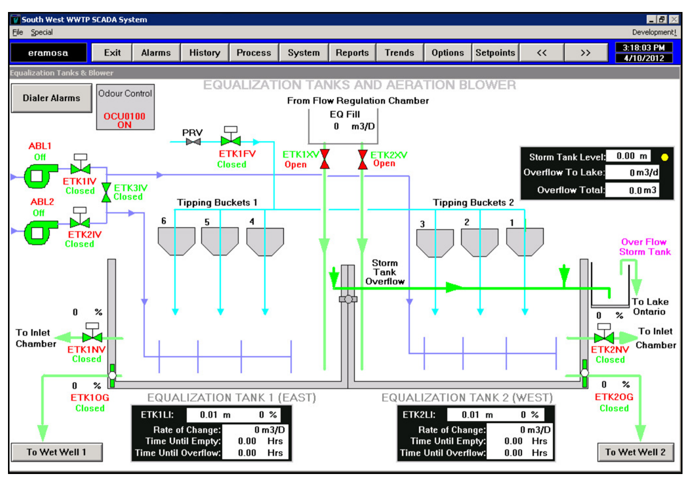
The plants eight pumps are typically set up in dry weather so the smaller pumps operate as Duty 1 through 4 and the larger capacity pumps operate as Duty 5 through 8. During a wet weather event, the duty-table is automatically switched around such that the larger pumps are assigned to duties 1 through 4.

Unlike many plants with onsite storage, the equalization tanks (EQ tanks) at Oakville South West are actually located at a higher elevation than the wet wells. This was done to accommodate the plant's small foot print, and to allow the EQ tanks to drain back into the wet wells using gravity flow alone. During a high flow event, a pinch valve is modulated such that incoming sewage is diverted from the wet wells into the EQ tanks through a metered regulation chamber. (The wet wells themselves are sized so that they can accommodate any incoming influent surges from the gravity sewer as needed.)

After a high incoming flow event has passed, the contents of the EQ tanks are then automatically drained back into the wet wells in a controlled manner. This is done using two large hydraulically-actuated sluice gates located in the bottom of each equalization tank.

Photo of the new wet wells and equalization tanks during construction. Note the size of the car on the bottom left of the photo.

In order to prevent the equalization tanks from going septic (and developing odours), the plant employs a small automated aeration blower system and water-fed tipping buckets. Under PLC-based control, the local aeration helps mitigate possible odours arising from septic conditions in the EQ tanks, and the water flushing system cleans the tanks after each EQ thank fill/empty operation. The Oakville South West plant is located in close proximity of a residential area so minimizing potential odours was an important design consideration.



Equalization tanks use tipping buckets and local aeration to help ensure retained sewage does not develop odours from going septic.

FLOW REGULATION CHAMBER

Another aspect of the lift station which is unique is that the lift pumps do not pump directly into the plant's grit removal system. Instead, they pump into an elevated flow regulation chamber. This chamber, by maintaining a constant head, ensures a constant flow into grit removal building. In addition to precisely controlling the speed of the lift pumps, a large pinch valve is also used to finely control the flow from the flow regulation chamber to the grit building.

Andrew Sachs, one of the project's SCADA integrators, standing beside the pinch valve which controls flow from the flow regulation chamber to the plant's grit removal system.

After passing through the grit removal system, a second flow splitting box is used to feed the plant's seven rectangular primary clarifiers. The primary clarifiers then use a series of sluice gates to distribute incoming flow to the aeration basins. A complex iterative control algorithm is used to constantly adjust the position of the gates. The net result is that each treatment train is fed at a rate to ensure maximum process efficiency.

SEVEN PARALLEL TREATMENT TRAINS

The treatment portion of the Oakville Southwest plant comprises of four separate "plants" which, in total, consist of seven parallel treatment process trains. A major component of the upgrade project was to build three completely new process trains for Plants 1 & 2, and upgrade the other four existing trains in Plants 3 & 4. (The original plants 1 & 2 which dated from the 1950s were demolished as part of the project.)

Each train consists of a square primary clarifier (with flights, scrapers and chains), an activated sludge aeration chamber, and a secondary clarifier (also with flights, scrapers and chains). Four of the existing treatment trains were upgraded, and three brand-new trains were added, bringing the total number of trains in the plant as whole up to seven.

During construction, the upgrades to the existing process trains were carefully sequenced so that the plant could remain in operations at all times.

Photo during construction showing 6 of the plant's 7 process trains.

ACTIVATED SLUDGE PROCESS

Referred to as an "activated sludge process," each treatment train uses an aeration chamber coupled with a secondary clarifier to break down the sewage. In the aeration chambers, aeration blowers are used to provide air (which contains oxygen) to the aerobic bacteria that break down the sewage. After the sewage has passed through the aeration chambers, it is then settled out in the secondary clarifiers.

At the bottom of each secondary clarifier, sludge collects which is then pumped by RAS/WAS pumps to two different destinations. The RAS (Return Activated Sludge) pumps transport part of the sludge back to the front aeration basin of the process in order to keep the bacteria healthy and active. The other portion of the sludge, the WAS (Waste Activated Sludge), is pumped to the digesters as a by-product of the process.

The key to a well-run activated sludge process is the precise control of aeration blowers and the RAS/WAS pumping system.

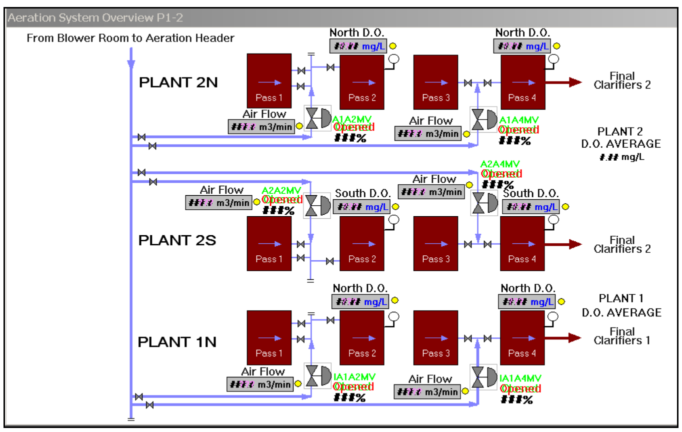
Photo of the plant's new control building under construction.

NEW AERATION CONTROL

As part of the upgrade, the automated logic to control the plant's aeration control valves and four blowers was completely rewritten.

Blower piping was rerouted and the existing aeration control valves were replaced with more appropriately sized units. A new strategy of using a common aeration header for the entire plant was also employed. In total, the blower system now uses a series of PLC-controlled blower and aeration-basin control valves, which allows the output of the blowers to be easily scaled/distributed to meet varying aeration demands.

Coupled with these mechanical/electrical changes, a modified form of the "most-open-valve" aeration control strategy was deployed with great success. The result was better DO (dissolved oxygen) control and reduced energy costs.



Screen shot of the common aeration header with control valves.

IMPROVED RAS/WAS CONTROL

In each process train, after the wastewater has been thoroughly aerated, it then flows by gravity into the secondary clarifiers. In the secondary clarifiers, the clarified treated effluent drains off at the surface and heavier sludge sinks to the bottom. The sludge is then gathered up by the each clarifier's chain/flights system.

Each clarifier is equipped with a pit at one end. This is where the chain/flights systems continuously gather the sludge as part of each clarifier's normal operation. From these pits, the sludge is then split into return and waste streams by the plant's RAS and WAS pumps.

For a clarifier to work well, the depth of the sludge at the bottom has to be carefully controlled. If there is too much sludge in the bottom of the clarifiers, the sludge could go septic which disrupts the process in the aeration tanks. If there is too little sludge, the sludge tends not to settle out properly and too much WAS is generated. A careful balance must be maintained.

As part of the upgrade, the control of the plant's RAS/WAS pumping system was fully automated. RAS pumping now uses VFD-controlled pumps and can automatically scale up and down in response to changing incoming flows to the individual treatment train. PID control is used in conjunction with magnetic flow meters to control pump speed.

Chain and flight system at end of the one of the new secondary clarifiers, showing how the flights are used to scrape up the sludge on the bottom and to gather up scum from the surface.

One nice feature of the plant's new RAS pumping system was the installation of new piping that pours RAS flow back into the head of the aeration basins from a nozzle mounted at waist level above grade. This allows the operators to visually check the color and consistency of the RAS flow as it re-enters the aeration tanks.

WAS pumping is now fully automated with several control schemes that the operator can select from. WAS pumps can be set to do most of their pumping during set times of the day, or WAS pumping can be automatically spread out into a user-selectable number of pump runs during each a 24 hour period. Overall, the WAS pumps can be controlled based on a total target WAS volume per day, a target total WAS pump runtime, or a target sludge blanket level in the secondary clarifier that is being serviced.

For the two new process trains that were added to the plant, a single bank of pumps is used to do both RAS and WAS pumping. On the outlet of the discharge header a series of motorized pinch valves are used to split the pumped sludge flow between RAS and WAS. The result is more fine control of the RAS and WAS ratio.

All seven treatment trains are controlled using standardized ladder logic code running on Allen-Bradley ControlLogix and CompactLogix PLCs. These PLCs in turn are interfaced with the plant's centralized SCADA system allowing operators to control the plant's treatment trains in both automatic and manual, as well as local, control as needed to meet operational targets. The entire system is designed to work entirely in automatic mode with minimal operator intervention required.

One of the maintenance tunnels below the plant's treatment trains.

PHOSPHOROUS CONTROL

Phosphorous in wastewater is a leading cause of poor surface water quality and algae blooms. Thus, Ontario Ministry of the Environment regulations require the Oakville South West Plant to remove phosphorous before any effluent is discharged into Lake Ontario.

At the plant ferric chloride is used for phosphorous control. A modified flow-based algorithm is used to add the ferric chloride to the wastewater as it travels through the plant. A large dose is added to the front end of the primary clarifiers to promote both coagulation and setting of sludge, as well as control free phosphorous. A second dose of ferric is also added at the tail end of each aeration basin to provide trim control of phosphates exiting the plant. The trim control is flow-paced based on the individual process train's effluent output.

Photo in one of the plant's new PLC Control Panels. Notice the extra space that has been allocated for future expansion.

UV TREATMENT

The Oakville South West plant uses UV as its final treatment stage to meet the stringent Canadian discharge requirements associated with Lake Ontario. Three parallel trains of UV lamps, running at 254 nm wavelength, ensure that any potential bacteria or microbes in the plant's effluent are inactivated prior to being discharged into Lake Ontario. The system is relatively maintenance free with the bulbs being equipped with automatic cleaning systems and UV intensity monitored by several fibre-optic intensity monitors.

The plant has one kilometer underwater outfall pipeline equipped with underwater diffusers to ensure that the plant's discharge does not interfere with shoreline activities.

DIGESTER BIOGAS USED FOR HEATING

For sludge treatment, the plant uses a pair of anaerobic sludge digesters. Biogas from the digesters is used to heat the digesters and to supplement heating at the plant's buildings, galleries and tunnels. The digesters use radar level transmitters and contain a full complement of instrumentation which allows the plant operations team to keep a close eye on digester performance. Mixing of the digester contents is accomplished by re-circulation pumps which can run 24 hours a day.

Sludge thickening is done off-site at a separate facility owned by the Region. Digested sludge is hauled using tanker trucks which are filled from a dedicated sludge hopper. Prior to a tanker trucks arriving the sludge hopper is slowly filled over a four hour period using positive-displacement transfer pumps. This intermediate sludge loading step prevents truck filling operations from creating negative pressure in the digesters themselves.

The sludge hopper also loads the trucks by gravity, which allows the trucks to be filled faster than by using the traditional pump-based approach. A radar level probe in the sludge hopper is used to calculate the volume of sludge that is loaded into each truck. When the plant is in full operation, digested sludge is trucked away from the plant several times a day.

One of the new Motor Control Centers (MCCs) at the plant.

NEW CONTROL ROOM

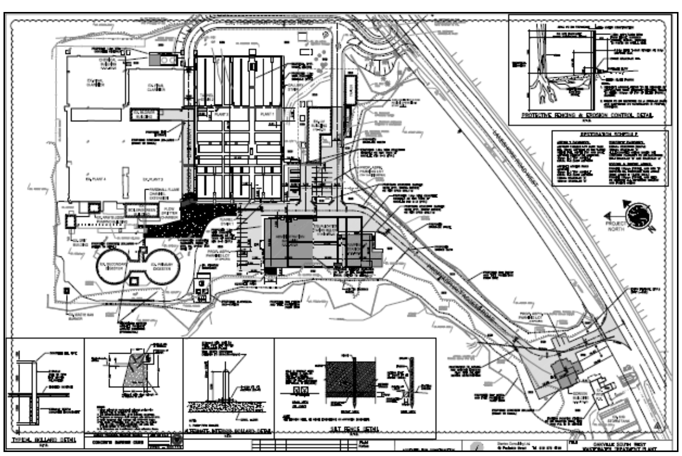
Part of the upgrade was building new plant control room located in the new centralized control and administration building. With the plant being fully-automated there is no need for a constant operator presence in the control room, but careful thought was put into the design of the control room to give operators the information they need during both normal and abnormal situations.

New control room complete with a large overview LCD display.

A large heads up display was installed so that additional personnel would not need to crowd around the operator workstations. Ample floor space was provided and the control room was placed so the operators have view of the entire plant via a window. Screens on the HMI were also developed with both normal and abnormal situations in mind.

PLANT FOOTPRINT

The Oakville South West Plant has been on the same site since the 1950s and a residential neighbourhood has grown up around it. This meant for the upgrade that the plant had stay within its existing footprint. As part of the project, the older less efficient "Plant 1 & 2" sections of the plant were removed and replaced with new state of-the-art Plant 1 & 2 sections.



Site plan for the upgrades to the Oakville South West Plant.

PROJECT CHALLENGES

Due the project's size and the cramped quarters of the site, there were numerous challenges associated with Phase 3 upgrade at the Oakville Southwest plant.
The project required a large number of design firms, contractors, vendors, and specialist personnel to be involved during the project's multi-year timeline. This meant that site activities had to be carefully coordinated and care taken so that long-lead items would be ready when it came for installation. Regular coordination meetings and detailed schedules were used throughout the entire construction effort. Both chain-of-command and direct lines of communication, including cell phones, were set up so that if unexpected site conditions arose, the project team could quickly and effectively respond to them.

Process design and SCADA design were made flexible so that improvements could be realized throughout the project. An open line of communication was used between the process design firm, system integrator, general contractor and the Region to ensure that any opportunities identified during the construction process could be effectively harnessed and put to positive use.

The plant's operations team was also extensively consulted during both the design and construction phases of the project to ensure they would be able to effectively control and operate the plant after construction was complete. The result was a finished plant that is easier to operate and maintain.

Photo of the plant during construction.

A NIGHT TO REMEMBER

One of the more time critical parts of the plant upgrade was cut-over of the main sewer to the newly installed plant bar screen and lift station. Though the actual cut-over task itself took only 8 hours to complete, the entire operation took many months of planning and preparation. The challenge was how to successfully take a portion of a fully-operating 1350 mm main gravity sewer out of service, cut out a 20 foot section of the pipe, and replace it with a new piping configuration. The ultimate challenge was to be able to do it with minimal impact to the city's residents and to the surrounding environment.

To make the cut-over possible, temporary diesel-driven pumps were used to pump the incoming sewage around the section of pipe that was to be rerouted. A total of six diesel-driven pumps, along with three more waiting on standby, were used as part of the operation. The cut-over had to go smoothly with no leaks, as Oakville also gets its drinking water from Lake Ontario.

Timing-wise, the cut-over was scheduled to take place during the middle of the night when the plant has the lowest incoming flow. Preparations began months before with trenching being put in place and the new sewer piping all being installed except for the final 20 feet piping needed for the cut-over. The cut-over itself involved cutting into the old sewer, removing old sewer pipe, and installing the new rerouted 20 section of pipe.

Some of the preparations for the cut-over of new sewage line.

As the cut-over area was also beside a major street, the street was cordoned off by police the two days before so that all the hoisting equipment and temporary pumps could be brought to the site and setup beforehand. Temporary lighting was installed so that work could carry on throughout the night.

The actual cut-over activity took just under 8 hours, and then the control system tuning began. For the next 6 hours, the plant's operators, the project's lead process engineer, and the system integrator worked together to tune the new bar screens and new plant lift station to effectively handle the new incoming sewage feed. (Prior to the cutover, the plant's old soon-to-be-demolished lift station was still being used.)

The cut-over of the main 1350 mm sewer to the new bar screens and new lift station was done at 2:00 AM during the "low flow" period.

Careful attention was paid to "what if scenarios" and making sure that the plant could continue operating even if there were multiple pump failures, ensured the cutover was a success. After full day of testing, control of the plant was handed over to operations staff.

PROJECT OUTCOME

As a result of the upgrades, the Town of Oakville now has a modern wastewater treatment plant that can now effectively handle wet weather events and handle the growing population of West Oakville. The plant is also now considerably easier to operate and is considered a flagship facility for Halton Region's wastewater services department.

Funding for the project was jointly supplied by the Region of Halton infrastructure fund, the Ontario Provincial Government and the Government of Canada's Infrastructure Stimulus Fund.

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