Stress testing the Simcoe WWTP for higher rated capacity

By Harpreet Rai

The Simcoe Wastewater Treatment Plant was originally commissioned in the 1960s and upgraded in the mid ’70s. At the existing plant site, the facilities can be generally described as an activated sludge system with two separate process trains, called Plant 1 and Plant 2, with each plant capable of operating independently of the other. They have a common headworks and tertiary treatment facility.

Plant 1, built in 1962, is the older of the two plants, treating approximately 2,600 m^3/day. Plant 2 was completed in 1979 to meet future development needs. The two plants operated in parallel until Plant 1 was closed in 1996 because of its poor condition. Plant 2, with a design capacity of 12,729 m^3/d, operated alone until 2009.

In the Norfolk Water and Wastewater Master Plan (2006) it was established that the capacity of the Simcoe WWTP needed to be increased from the existing 12,729 m^3/d to 15,400 m^3/d to meet the development requirements for the next 20 years. A Class Environmental Assessment (EA) for capacity upgrade was completed in 2008, which recommended rehabilitation of Plant 1 to achieve the required capacity. Plant 1 was then refurbished and recommissioned and has since been running in conjunction with Plant 2.

Further, as part of the Class EA, an assimilative capacity study of the Lynn River was conducted in 2008, in order to predict the potential impact of the increased plant effluent flows on the quality of the river water. The study concluded that the plant would not be detrimental to the water quality in the river, provided the effluent loadings at the proposed rated capacity were maintained at their existing level.

This translated into not only stricter effluent criteria for carbonaceous biochemical oxygen demand (cBOD5), total suspended solids (TSS) and total phosphorus (TP) in comparison to the old Certificate of Approval, but also established limits on total ammonia nitrogen in the effluent.

Since the plant had historically been operated at relatively less stringent effluent criteria for cBOD5, TSS and TP, and with no requirement for nitrification, Norfolk County was asked by the Ministry of the Environment (MOE) to conduct a stress test of the WWTP to confirm that it could handle the increased loadings, while meeting the more stringent effluent criteria at the proposed flow.

Final clarifier and effluent sampler.

Stress-test work plan

A work plan for stress testing was developed based on the MOE’s *Guidance Manual for Sewage Treatment Plant Process Audits*, and on the proposed effluent quality parameters presented in the Lynn River assimilative capacity study. The stress test work plan was prepared by R.V. Anderson Associates and reviewed by the MOE. Calibrated BioWin models for Plant 1 and Plant 2 were developed from the historical operational and performance data for both plants.

Subsequently, the normal operating conditions of the plants were identified, and improvements in the operating strategy, with respect to consistent nitrification, were recommended, based on the calibrated BioWin model.

A test protocol was developed with plant operations staff to outline the program and solicit suggestions for improvement to overcome any potential obstacles. The recommended changes in the process were executed by operating staff before starting the stress test.

Each train was stress tested for a period of six weeks during different periods of the year. Plant 1 was tested from March to April 2010 (winter), while Plant 2 was tested from May to August 2010 (summer).

The first four weeks of stress testing for each plant consisted of steady-state operation in which the tested train was run at its respective target average day flows (Table 1) and subjected to diurnal variations proportional to the overall WWTP influent variations.

During the next two weeks of the stress test, each train was run at the same operating conditions as in steady state, except that it was also subjected to the target hydraulic peak (Table 1) by manually increasing the flow to the train for over one hour each day during these two weeks.

Plant operation was closely monitored during the entire stress test period. The recorded parameters included influent and effluent flows, return activated sludge (RAS) and waste activated sludge (WAS) flows, mixed liquor TSS and RAS TSS, and sludge volume index (SVI), on a daily basis, five days a week.

Plant	Test Period	Season	Required flows (m^3/d)		Actual flows (m^3/d)	
			Average day flow	Peak hour flow	Average day flow	Peak hour flow
Plant 1	March to April	Winter	2,671	6,700	3,276	6,700
Plant 2	May to August	Summer	12,729	32,000	14,928	32,000

Table 1 – Target flows and field operating conditions.

Parameter	Unit	Compliance limit	Design objective
BOD	mg/L	10.0	7.5
TSS	mg/L	15.0	5.0
TP	mg/L	0.45	0.15
NH_3-N	mg/L	1/5.0 Summer/winter	0.75/3.0 Summer/winter
E-Coli	CFU/100 mL	200	150

Table 2 – Effluent limits and objectives.

The performance of each train was based on regular monitoring of 24-hour composite samples of the plant influent and secondary effluent five days a week. In the case of Plant 2, the final effluent, following disinfection and tertiary filtration, was also monitored, in addition to the influent and secondary effluent.

Plant 2 is made up of four trains, with each train consisting of a primary clarifier, an aeration tank and secondary clarifier. Since the average raw sewage coming to the overall plant during stress testing of Plant 2 was 6,400 m^3/d, Plant 1 and two trains of Plant 2 were shut down in order to create effective stress loads. Further, the required hydraulic peaks dur-

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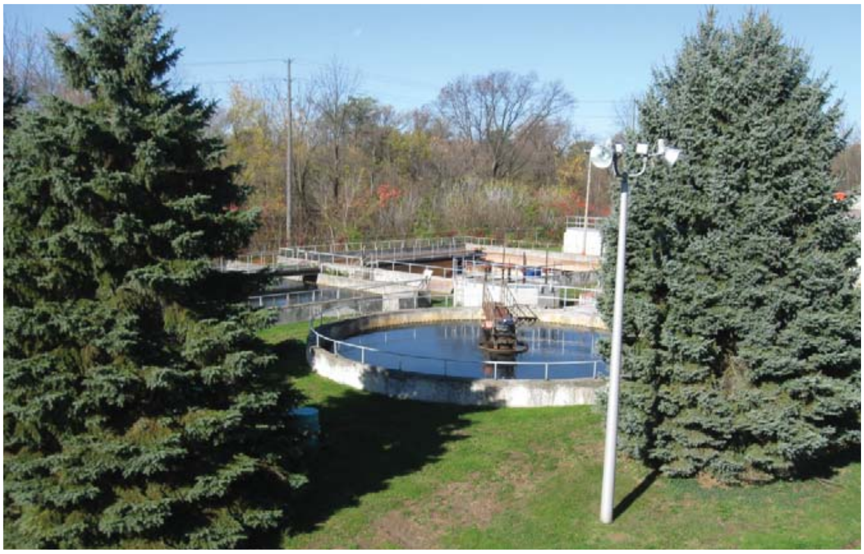

Plant two's secondary clarifiers.

ing the hydraulic peak testing phase were achieved by shutting down one of the two operating trains in Plant 2 for a period of more than one hour every day during this phase of testing.

The effluent limits and objectives for the increased rated capacity of the Simcoe WWTP are given in Table 2.

Performance of Plant 1

The calibrated BioWin model was generated from actual field operating and performance data for Plant 1, which was used to predict the performance of the plant under a minimum winter temperature of 10°C and average summer temperature of 16°C, in order to check the plant's ability to meet the effluent criteria of ammonia nitrogen (NH_3-N) under these conditions.

The discrepancy in the actual and modeled effluent NH_3-N values is because the actual field data includes some inconsistently high effluent NH_3-N values on certain days, caused by shock loads received at the plant during stress testing, whereas the modeled performance is based on consistent and steady loads with no fluctuations in influent loadings and, therefore, consistently low effluent NH_3-N.

Average secondary effluent characteristics from Plant 1 for the five weeks of stress testing are well below effluent limits for all parameters, including BOD5, TSS, NH_3-N, TP and CFU (colony forming units). Further, the average effluent NH_3-N even meets the winter objective of 3.0 mg/L, even though the plant was operated at an average flow of 3,276 m^3/d, or 23% more than the required stress flow of 2,671 m^3/d.

The simulation shows that Plant 1 has enough capacity to handle the required stress loads, as secondary effluent meets final effluent objectives for BOD and NH_3-N, and meets effluent limits for TSS and TP under both winter (10°C) and summer (16°C) conditions.

Performance of Plant 2

Using actual field operating and performance data, the calibrated BioWin model predicted the performance of Plant 2 under a worst winter temperature of 10°C and a target flow of 12,729 m^3/d.

Average secondary effluent BOD5 and TP from Plant 2 are well below the effluent limits. Tertiary filters captured the solids in secondary effluent, bringing the final effluent TSS to 3 mg/L which is below the effluent objective for TSS.

Average effluent NH_3-N of 1.25 mg/L was observed to be higher than the effluent limit of 1.0 mg/L for summer. The main reason for this was the operating flow of 14,600 m^3/d, which is 15% higher than the target stress test flow of 12,729 m^3/d for Plant 2.

On the other hand, simulated performance of Plant 2 at 12,729 m^3/d showed that the plant can be operated at a higher SRT of 10d at these loadings, thereby achieving effluent NH_3-N of 0.49 mg/L, which is 0.31 mg/L lower than the 0.8 mg/L achieved at 14,600 m^3/d. Based on this observation, average effluent NH_3-N concentration under field conditions would be 0.94 mg/L (lower by 0.31 mg/L) at 12,729 m^3/d, compared to 1.25 mg/L observed at 14,600 m^3/d. Therefore, it will meet the effluent limit for summer conditions.

The simulation also shows that Plant 2 has enough capacity to handle the required stress loads under winter conditions, as secondary effluent from Plant 2 meets effluent limits for all parameters, including cBOD5, TSS, NH_3-N and TP, at 10°C.

The capacities of the sludge handling facilities, chlorine contact chamber and tertiary disc filters were analyzed theoretically and were shown to be adequate to handle the proposed rated flow of 15,400 m^3/d.

Lessons learned

Operating conditions, including influent flows and characteristics during field stress testing, may differ widely from the expected target average flows and characteristics because of extraneous flows and/or flow control limitations within the plant. Under such conditions, maintaining average flows higher than target flows is desirable, as it precludes any uncertainty about the plant's ability to treat the target loadings.

A calibrated model of the plant is a useful and acceptable tool to demonstrate performance for conditions not encountered during field testing, such as peak cold or hot weather conditions. For example, since nitrification criteria are different for summer and winter conditions, the model can be used to predict the performance for the condition not encountered in field testing, thereby saving both time and resources.

The successful demonstration of the plant's ability to treat target flows and loading, through field testing and calibrated model simulations, led to MOE approval for the desired capacity of 15,400 m^3/d for the Simcoe WWTP.

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