Case Study: The Role of Optimization in Plant Re-rating

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Introduction

The Grand River Conservation Authority (GRCA) initiated a program in 2010 to optimize wastewater treatment plants (WWTPs) in the watershed to improve water quality in the Grand River and its tributaries. In addition to improving effluent quality, optimization can also be used for re-rating an existing facility to defer capital expenditures. This case study describes the background, approach and "lessons learned" from optimizing the Cayuga WWTP to tap its full capacity.

Background

Composite Correction Program

The Grand River optimization program utilizes the Composite Correction Program (CCP) to improve performance and capacity. The CCP was developed by the U.S. Environmental Protection Agency in the 1980s and demonstrated in Ontario in the 1990s (MOEE, 1994; MOEE & WTC, 1995). During the first step of the CCP, a team assesses a plant's operation, design, maintenance and administration to determine the unique combination of factors limiting performance. The design evaluation consists of preparing a Performance Potential Graph which displays the estimated capacity of the major unit processes under current loading. The second step of the CCP, a program of follow-up support, may be recommended to resolve the identified factors if the design of the facility is "capable" or "marginal". If the design is "not capable" then a plant upgrade or expansion is required. During technical assistance, facilitators support process control activities and transfer skills to operations staff and assist managers to upgrade policies. Additional details of the Composite Correction Program can be found in US EPA handbooks and an Ontario CCP Manual (US EPA 1989; WTC and PAI, 1996).

Cayuga WWTP

Assessments were conducted of Haldimand County's WWTPs, lagoons and surface water treatment plants as part of the County's optimization program. The objectives were to summarize information on the performance and capacity of each facility for planning purposes and to enhance understanding of long-term facility needs. A team consisting of County staff and a third-party advisor conducted an assessment of the Cayuga WWTP using CCP tools in 2008.

The Cayuga WWTP is an oxidation ditch with two circular secondary clarifiers. Treated effluent from the plant is discharged to the Grand River. An aerial photograph of the plant and photograph of one of the rotors used for mechanical aeration is shown in Figure 1. The facility is operated by Veolia Water under contract to the County. The 2008 assessment found that the Cayuga plant

achieved compliance for the 12-month period evaluated but was subject to high levels of inflow/infiltration (Howarth, 2014).

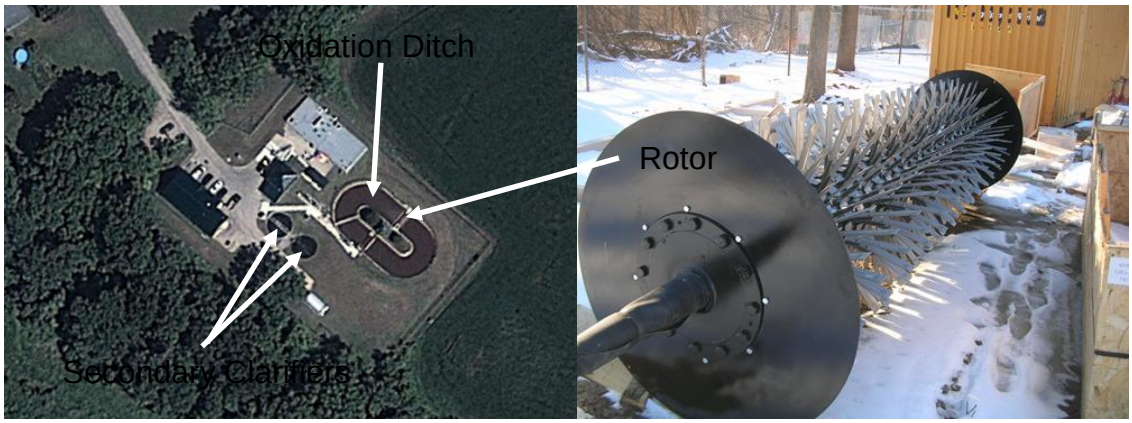

Figure 1: Aerial photo graph of Cayuga WWTP (left) with rotor for aeration (right)

Performance Potential Graphs

Figure 2 is the Performance Potential Graph generated in 2008 for the Cayuga WWTP. Each major unit process is listed along the y-axis of the graph, along with its rating criteria. The length of the associated bars displays the estimated capacity. In some cases, two rating criteria were used. For example, "Aeration HRT" in Figure 2 has an estimated rated capacity of 922 m^3/d based on a criteria of 20 hours for hydraulic retention time (HRT) and 1,229 m^3/d (the sum of 922 and 307) for a 15-hour HRT. The dashed vertical line displays the average annual flow for the most recent 12-months, with the solid line displaying the allowable capacity of 873 m^3/d under the ECA. This PPG indicated that the plant had potential liquid train capacity above 873 m^3/d but lacked sludge digestion and any on-site storage.

Acting on the assessment, the County upgraded the Cayuga plant in 2011 to improve sludge management and process operability. An automatic screening auger, an additional rotor for the oxidation ditch, ultraviolet disinfection and a new sludge digester and sludge storage tank were installed. Following completion of the upgrades, the Performance Potential Graph was re-generated in 2011 (Figure 3).

The major unit processes for the liquid train were 1,220 m^3/d or greater, as was aerobic digestion. On-site sludge storage was rated at 1,107 m^3/d based on 180 days of storage. However, this unit process was judged not to be ultimately limiting as the County had the option to haul sludge to an off-site storage at the Townsend Lagoon. The County decided to pursue re-rating the plant from 873 m^3/d to 1,230 m^3/d.

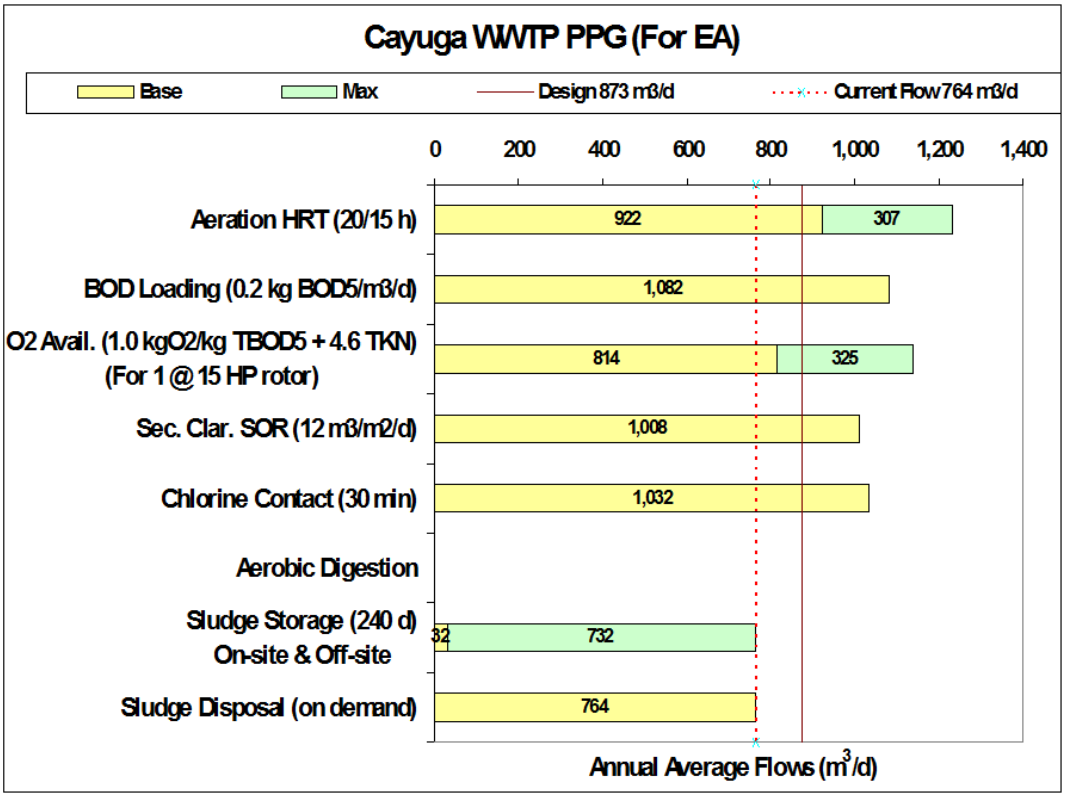

Figure 2: 2008 Cayuga WWTP Performance Potential Graph (Howarth, 2014).

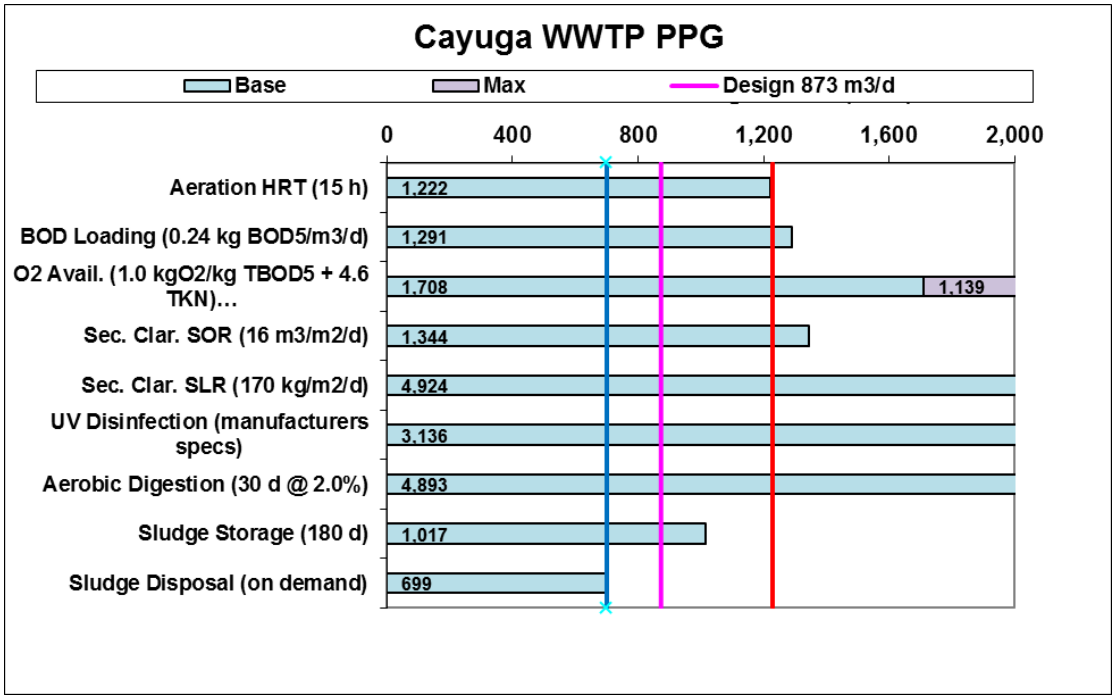

Figure 3: 2011 Cayuga WWTP Performance Potential Graph (Howarth, 2014).

Re-rating Approach

The re-rating approach for the Cayuga WWTP consisted of three major components described in the following sections.

Assimilative Capacity Study

In 2012, the County issued contracts for assimilative capacity studies to help identify acceptable effluent criteria at the re-rated plant flows. Following discussions with the Ministry of Environment and Climate Change (MOECC), a dye tracer study and river monitoring were conducted. The work included summaries of plant performance and Grand River water quality and flows and modelling of the river's response to increased plant flows. The assimilative capacity work continued in 2013. A dye tracer study (see Figure 3) was completed to better define how the discharge plume assimilated with the river and to properly define sampling locations for water monitoring. Field monitoring of the river was continued for a second year in 2013.

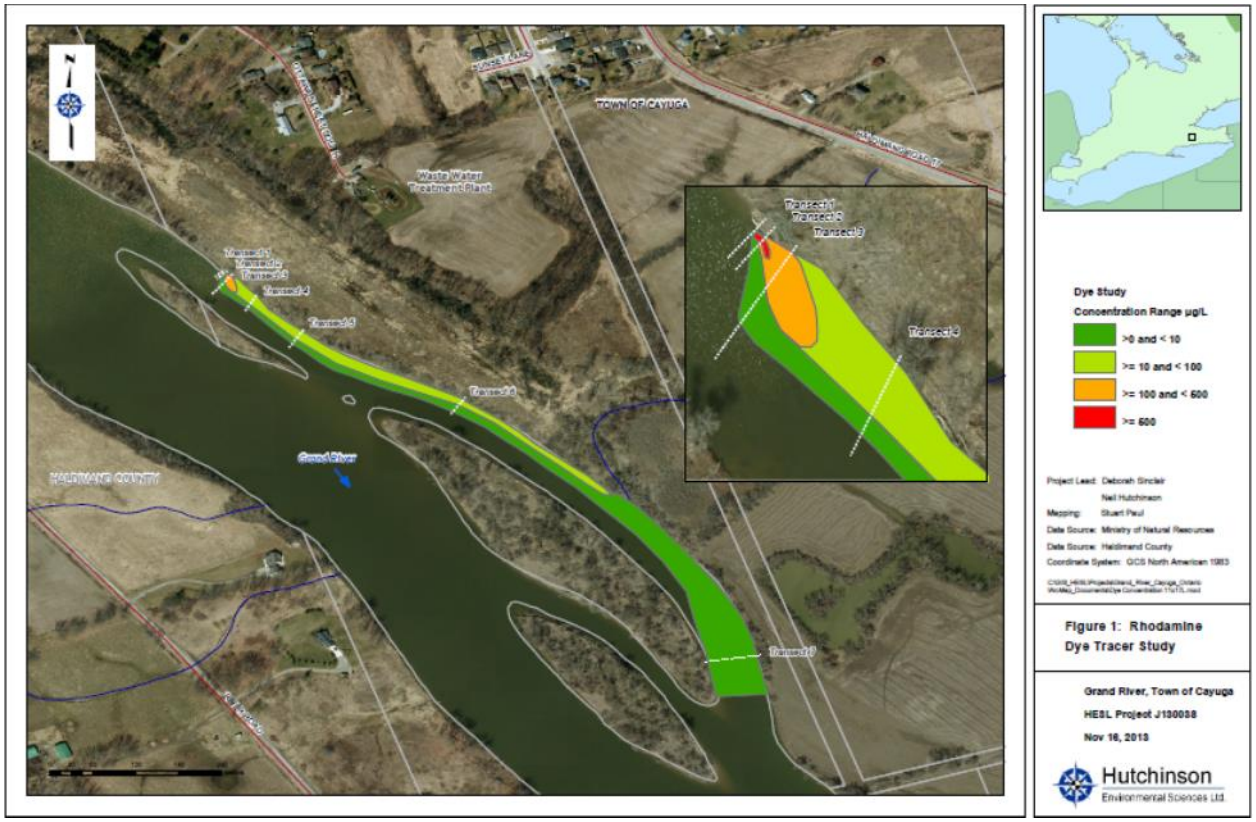

Figure 3: Results of Rhodamine Tracer Study showing dye concentrations in the Grand River from Hutchinson Environmental Services.

Capacity Demonstration & Technical Assistance

From May 2012 to September 2014, a capacity demonstration was conducted at the Cayuga plant to support re-rating. One of the two secondary clarifiers was

placed in standby mode with the total plant flow directed to the in-service clarifier. With one clarifier in service, monthly effluent concentrations were targeted which would maintain the existing approved effluent loadings at the re-rated flows. That is for $CBOD_5$, TSS and TP, an increase in the nominal design flow from 873 m^3/d to 1,230 m^3/d required a corresponding decrease in monthly average concentrations of these parameters to maintain the approved loadings in the Environmental Compliance Approval (ECA), as shown in Table 1.

Table 1: Summary of ECA Effluent Quality Limits and Capacity Demonstration Targets

Parameter	**ECA Load (kg/d)**	**ECA Concentration (mg/L)**	**Re-rating Target (mg/L)**
cBOD5	22	25*	18*
TSS	22	25*	18*
TP	0.9	1.0*	0.75*
E.Coli	N/A	200/100 mL**	200/100 mL**
pH	To be maintained within the range of 6.0-9.5 inclusive, at all times.		

* based on monthly averages, ** based on monthly geometric mean

Using Comprehensive Technical Assistance (the second step of the Composite Correction Program), guidance was provided to improve monitoring and process control. A kick-off meeting was held to discuss the rationale for the demonstration and identify operator concerns. Enhanced process and performance monitoring was implemented and the operator trained in applying total mass control. Total mass control consists of determining the mass in the oxidation ditch and the in-service clarifier and adjusting the wasting rate to achieve a target total mass. In addition, the rate at which sludge is recycled from the clarifier to the oxidation ditch is monitored and adjusted to ensure that the majority of the mass resides in the oxidation ditch. Process and performance data were trended using an Excel spreadsheet and routine meetings held with the operator and supervisor to review trends, troubleshoot process issues, and develop follow-up action items. As required, additional on-site meetings were held to focus on specific process and performance issues. Operators were encouraged to document plant studies and procedures “in their own words”.

During the 17 months of the demonstration period with one clarifier in service, the flow to the plant averaged 699 m^3/d. Effluent concentrations for cBOD5, TSS and TP averaged 3.2, 11.5 and 0.47 mg/L with corresponding maximum monthly concentrations of 7, 25 and 0.75 mg/L.

Liaison with MOECC

The County recognized the need to develop an effective consultative process with the MOECC to communicate the rationale, approach and findings from the studies and clarify re-rating requirements. Both the MOECC District and Regional Office and the Approvals Branch were involved in the re-rating. Four meetings were held with MOECC between May 2012 and October 2013. Initially, discussions involved the proposed work plan for the assimilative capacity study, the roles and responsibilities of the County and Veolia staff during re-rating and preliminary data which supported re-rating. A tour was conducted of the Cayuga WWTP by the County and Veolia for MOECC staff.

At a final meeting in October 2013, MOECC staff were updated on the re-rating demonstration, the 2013 field monitoring and river water quality. The next steps were discussed for bringing the re-rating initiative to closure. In January 2014, a technical memo was prepared by County staff for Approvals Branch to summarize and document the rationale, approach, and data from the capacity demonstration (Howarth, 2014). The memo was submitted to the Environmental Approvals Branch with the ECA amendment application. As the effluent load limits remained the same at the re-rated flow, the ECA application requested a Schedule A Class amendment which did not require public consultation.

Outcome

A new ECA for the Cayuga WWTP was issued by the Approvals Branch in December 2014 for an average daily flow of 1,200 m^3/d and a peak flow of 3,136 m^3/d. The ECA contained effluent and loading limits as per Table 1 with the addition of limits on Total Ammonia Nitrogen (4.0 mg/L for October 1 to May 31 and 2.0 mg/L for June 1 to September 30) and total chlorine residual (0.2 mg/L). The allowable capacity of the Cayuga plant was therefore increased by 37% as a result of successful re-rating. An additional 320 homes can be built in the community without requiring costly expansion of the liquid train. As reducing peak flows will further enhance the capability of the liquid train, the County is continuing efforts to remediate inflow and infiltration into the sewer system.

Lessons Learned

The “lessons learned” from the Cayuga WWTP re-rating were as follows:

- From start to finish, the re-rating process required 32 months, a period longer than originally anticipated. Regular communication with County managers, planners and Council on the status and next steps was required to maintain internal support.
- On-site assessment of plant performance and capacity using the Composite Correction program helped County staff to enhance their understanding of facility needs.

- The Performance Potential Graph has proven to be a valuable planning tool for Haldimand County to support allocation of limited financial resources. Periodic updating and review of the Performance Potential Graphs is effective for identify required upgrades and opportunities for re-rating.
- Successful re-rating of the Cayuga WWTP required attention to three equally important components: the assimilative capacity of the receiver, capacity demonstration over a minimum of four seasons, and ongoing communication with MOECC.
- Discussions with the MOECC focused on the impact of the increased flows on water quality in the receiver, determination of the Municipal Environmental Assessment and notification requirements, and documenting the ability of the facility of treat to the proposed limits at the re-rated flow.
- The capacity study required the support and engagement of operational staff. Comprehensive Technical Assistance, the second step of the CCP, was effective for achieving operator buy-in, improving skills and procedures and ensuring sustainability after completion of the demonstration.

Acknowledgements

The Grand River Watershed-wide Optimization program wishes to thank Haldimand County for sharing this information on the Cayuga WWTP re-rating.

References

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