Appendix I

TM 3: Assessment Methodology

Assessment Methodology

PREPARED FOR:	The Regional Municipality of Durham The Regional Municipality of York
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Objectives

The objective of this technical memorandum (TM) is to outline the assessment methodology that will be used to assess the treatment options in the Phosphorus Reduction Action Plan (PRAP) Study (Study) for the Duffin Creek Water Pollution Control Plant (WPCP). The assessment methodology has been developed to take into account the requirements outlined in the Ministry of the Environment and Climate Change (MOECC) Order dated April 4, 2016, and also includes engagement by the Town of Ajax throughout the PRAP Study process as required by the May 12, 2016 Region of Durham Council resolution. The ultimate goal of the assessment is to provide an understanding of the performance capability of the Duffin Creek WPCP with respect to total phosphorus (TP) removal under different optimization and new treatment options, as well as the operational and cost implications of these options; thus helping to make more informed decisions regarding a PRAP for the Duffin Creek WPCP.

Introduction

The Regional Municipalities of Durham and York (Regions) are undertaking a PRAP Study for the Duffin Creek WPCP. The goals of the Study are to address the requirements as outlined by the MOECC Order for additional information dated April 4, 2016. Specifically, the MOECC Order identifies the need to consider the existing Duffin Creek WPCP's phosphorus removal efficiencies (Item 2a, MOECC Order), as well as the following treatment options to further improve phosphorus removal efficiency:

- Item 2b (MOECC Order*): "optimization of plant operations"*
- Item 2c (MOECC Order)*: "new methods that could be employed to reduce phosphorus in the WPCP effluent"*

The MOECC Order further identifies the need to consider the following while assessing different treatment options:

- Item 2d (MOECC Order): "*…an indication of how phosphorus and loadings will be impacted by each option"*

- Item 2e (MOECC Order): *"determine an option that will result in the lowest achievable level of total phosphorus levels in effluent, including an assessment of the operation implications and costs required to achieve these reductions"*
- Item 2f (MOECC Order): "*a strategy to reduce soluble reactive phosphorus (SRP) in the short, medium and long-term"*
- Item 2g (MOECC Order): "*how total phosphorus in the effluent can be further reduced during the seasonal window of nuisance Cladophora algae growth"*
- Item 2h (MOECC Order): "*feasibility of achieving a permanent (on going) annual concentration of 0.35 mg/L of total phosphorus in the WPCP effluent, as well as total phosphorus load of 190 kilograms per day based on an annual average"*

This TM provides details on the assessment methodology to meet the above MOECC Order requirements, as well as the process for engaging the Town of Ajax in the assessment. Each step in the assessment methodology is described in more detail in the following sections of this TM.

Assessment Methodology

The steps in the Regions' assessment methodology are as follows:

1. Define Existing Conditions: Use historical data from the Duffin Creek WPCP to establish the existing phosphorus removal efficiency at the plant
2. Develop Treatment Options: There are several options for optimizing the current plant operations, as well as options to upgrade the Duffin Creek WPCP with new treatment processes to achieve lower levels of phosphorus removal than currently achieved. These will be identified and assessed as part of the Study. Options will also include seasonal operation of treatment options to reduce TP during the nuisance *Cladophora* algae growth season.
3. Define Assessment Factors: Identify the factors by which to assess the different options. These factors will include the ability of the option to reduce effluent phosphorus as well as other relevant factors, such as operational and cost implications of an option.
4. Estimate Impacts: The impacts of the options on the defined assessment factors will be estimated. Where possible impacts will be quantified, such as the levels of TP and SRP in the effluent that can reasonably be achieved by each treatment option, and the costs of implementing the options. Impacts that cannot be easily quantified will be determined based on literature, operations of similar facilities, and expert judgement.
5. Compare Options: A review and comparison of each option based on their estimated impacts on all factors will be undertaken. The 'most applicable' secondary treatment optimization, and tertiary treatment options will be selected based on the comparison.
6. Develop and Document a Phosphorus Reduction Action Plan (PRAP): A comparison of the pros and cons of the 'most applicable' optimization, tertiary, and seasonal options will be made based on the defined assessment factors. A Phosphorus Reduction Action Plan for the Duffin Creek WPCP will be recommended. The study process and results will be summarized in a PRAP Study Report to the MOECC.

The Regions will be working with the Town of Ajax throughout the development of the PRAP, as well as meet with the MOECC at key milestones in the assessment to receive input.

Step 1: Define Existing Conditions

To set the basis for the assessment of treatment options, phosphorus removal efficiencies of the existing processes at the Duffin Creek WPCP will be established. As per the MOECC Order, the best available data from the "*past five years on phosphorus concentrations and loadings"* will be reviewed and evaluated to determine existing conditions. The data will also be used to develop and calibrate the hydraulic model used to assess the optimization options (as described in TMs 1 and 2).

Step 2: Develop Treatment Options

Options for improving performance capability of the Duffin Creek WPCP with respect to TP removal include optimization of secondary treatment, new treatment methods, and seasonal treatment. The options are described below.

Optimization of Plant Operations

The Duffin Creek WPCP is a secondary treatment facility with a rated capacity of 630 ML/d average day flow. The WPCP uses nitrifying step feed activated sludge processes to provide nitrification, as well as a multi-point chemical addition system for enhanced phosphorus removal. There are several options for optimizing the Plant to reduce total phosphorus in the effluent, as described in TM#2, and include:

- Dual point ferrous chloride dosing upstream of primary and secondary clarifiers (current operation)
- Dual point ferrous chloride dosing upstream of primary and secondary clarifiers, polymer dosing to secondary clarifiers
- Dual point ferric chloride dosing upstream of primary and secondary clarifiers
- Dual point ferric chloride dosing upstream of primary and secondary clarifiers, polymer dosing to secondary clarifiers
- Dual point ferric chloride dosing upstream of primary and secondary clarifiers, polymer dosing to both primary clarifiers and secondary clarifiers (ferric chloride and polymer dosing upstream of primary clarifiers is referred to as chemically enhanced primary treatment or CEPT)

New Treatment Options

The new methods that could be employed to reduce phosphorus in the WPCP effluent essentially refer to upgrading and modifying the plant to provide more enhanced levels of treatment (i.e. tertiary treatment). Tertiary treatment technologies that are deemed appropriate at the Duffin Creek WPCP include:

- Ballasted flocculation
- Cloth media filtration
- Deep bed media filtration
- Membrane filtration

These options were selected on the basis that they are industry-accepted and proven at plants of similar scale to the Duffin WPCP, and will be further developed in TM 4. Specifically, a conceptual design will be completed for each option including process configurations, integration with existing infrastructure, equipment and tank sizing, and site layouts.

It should be noted that one of the requirements of the MOECC Order is to "*determine an option that will result in the lowest achievable level of total phosphorus levels in effluent".* Based on the current limits of treatment technology, the lowest level of total phosphorus that can be achieved in a wastewater treatment plant effluent is to use microfiltration with membranes followed by reverse osmosis (RO). This is currently the most advanced treatment, and can produce effluent TP below the normal detection limit of 0.005 mg/L. To address the MOECC Order, the Regions will provide a brief description of this treatment technology, referred to as a quaternary treatment technologies (i.e. beyond tertiary) for information purposes only in TM 4. It will not be assessed to the level of the tertiary treatment options, as it is deemed not an appropriate technology at the Duffin Creek WPCP at the current time based on implementation, regulatory, and costs considerations.

Seasonal Treatment Options

The assessment process is an iterative process. As secondary treatment optimization and tertiary treatment options are developed and assessed, seasonal treatment options to potentially reduce total phosphorus in the effluent further during the *Cladophora* growing season will become apparent. For instance, it may be appropriate to implement secondary treatment optimization throughout the year, and utilize a tertiary treatment option only during the *Cladophora* growing season. Dr. Auer, who is engaged in the process as a scientific expert on behalf of the Town of Ajax, will provided input to help establish the nuisance *Cladophora* algae growth season (TM 5).

Step 3: Define Assessment Factors

Secondary treatment optimization, tertiary treatment, and seasonal treatment will be assessed using similar factors. The effectiveness of the option in reducing phosphorus in the effluent is a key factor that is driving the assessment, and may also serve as an indicator of the implications for Lake Ontario water quality. However, in selecting among options it is also important to consider other factors that may differ among options, including, as a minimum, the factors identified in the MOECC Order (i.e. operating implications, modifications required to the existing Duffin Creek WPCP, and costs). The assessment factors are presented in Table 1.

Table 1

Assessment Factors

Factor	Description	Method of Estimating Impacts
Phosphorus Removal Effectiveness	• Achievable effluent TP concentration • Achievable effluent SRP concentration	• To determine the performance capabilities with respect to TP and SRP removal of each optimization option, the dynamic model of the Duffin Creek WPCP as well as the results of the field study will be applied • The effectiveness of tertiary treatment options will be determined by the Project Team treatment process experts using benchmarking information on standard industry accepted standards (e.g. Water Environmental Research Foundation [WERF] guidelines, vendor specifications, and experience at other similar sized plants)
Technical Reliability and Robustness	• Robustness to manage flow and loading variations • Risk and impacts of failure	• A description of the impacts will be provided based on historical Duffin Creek WPCP data, operations of similar facilities, and expert judgement

Table 1

Assessment Factors

Factor	Description	Method of Estimating Impacts
Operation and Maintenance (O&M) Requirements	• Impact on downstream solids and liquids treatment processes • Ability to be operated seasonally or intermittently • Operational complexity/risk and required operator attention • Maintenance requirements • Hydraulic requirements	• A description of the impacts will be provided based on historical Duffin Creek WPCP data, current plant operations, operations of similar facilities, and expert judgement
Constructability	• Compatibility with existing system • Ease of implementation (e.g. permits and approvals, construction timing) • Operational risk during construction	• A description of the impacts will be provided based on historical Duffin Creek WPCP data, facility layout and site conditions, permit and approval requirements, and expert judgement
Future Proofing	• Ability to be optimized to meet more stringent effluent limits in the future • Ability to be expanded to increase treatment capacity • Site utilization i.e. footprint	• A description of the impacts will be provided based on knowledge of potential future regulations, existing plant layout, and site conditions
Carbon Footprint	• Greenhouse gas emissions	• Use model techniques to estimate greenhouse gas emissions (GHG) emissions associated with construction and operations
Capital Cost	• Capital costs	• Professional cost estimators utilize Parametric Cost Estimating Tools to estimate capital costs of options
Operating costs	• Operating Costs	• Professional cost estimators utilize Parametric Cost Estimating Tools to estimate operational costs of options
Life-Cycle Costs	• 20-Year life cycle costs	• Estimate of overall life-cycle costs of designing, construction, operating, and maintaining the option over a 20-year timeframe; includes estimates of: o Initial capital cost o Yearly operating and maintenance costs

Step 4: Estimate Impacts

Where feasible, impacts will be quantified based on the specific criterion. For factors that are not subject to quantification, a description of the impacts will be provided based on historical data, operations of similar facilities, and expert judgement. An overview of the methods to estimate impacts on each assessment factor is provide in Table 1.

Step 5: Compare Options

The options will be compared taking the following approach:

- **Secondary Optimization Options**: Optimization options will be compared based on the estimated impacts using the factors described in Table 1. The most applicable optimization option will be selected based on the comparison; specifically the option that best meets the MOECC Order requirement "*of achieving a permanent (on going) annual concentration of 0.35 mg/L of total phosphorus in the WPCP effluent, as well as total phosphorus load of 190 kilograms per day based on an annual average".*
- **Tertiary Treatment Options:** Tertiary treatment options will be compared using the same factors as defined in Table 1; specifically, their TP and SRP removal efficiencies, construction and operating implications, and costs will be described. The most applicable tertiary treatment option(s) will be selected based on the comparison. The goal will be to select the best option for achieving low TP and SRP removal efficiencies, while also having the most benefits in terms of the other assessment factors.
- **Seasonal Treatment Options:** Based on the above assessment, seasonal treatment options to potentially reduce total phosphorus in the effluent further during the *Cladophora* growing season will also be developed and compared**.** The most appropriate will be selected based on the comparison of the impacts using the factors in Table 1.

Step 6: Develop a Phosphorus Reduction Action Plan (PRAP)

A comparison of the pros and cons of the 'most applicable' secondary treatment optimization, tertiary treatment, and seasonal treatment options will be made based on the defined assessment factors in Table 1. The pros and cons of each applicable option will be described and documented. Implementation plans for each will also be established, including schedules for implementation, a phasing plan (if applicable), and a description of costs, financing requirements, and measures to mitigate impacts. Any need for pilot testing of an option will also be identified. The information will be used by the Regions to recommend a phosphorus reduction strategy for the Duffin Creek WPCP. The strategy will be presented to the MOECC.

Town of Ajax Engagement

The Regions are committed to working in an open and collaborative scientific manner with the Town of Ajax. Expert representatives from the Town are engaged throughout the Study process, through regular progress meetings and input into the development and content of study technical memorandum and reports. The goal is to achieve expert points of consensus wherever possible through the Study. If consensus cannot be reach differences of opinion will be noted and documented in the final PRAP Study Report to the MOECC.

Specifically through a Motion to the Municipality of Durham Council by the Town of Ajax (May 12, 2016), the Regions have agreed to involve the Town of Ajax in the development of the PRAP in the following ways:

A. Meet "*with the Town staff regularly throughout the PRAP study process"*;

B. Have "*Dr. Martin T. Auer of Michigan Technology University fully participate in the PRAP study in a collaborative scientific manner"*;

C. Include "*Actiflo (or ballasted flocculation) among the tertiary treatment technologies studies, and apply standard evaluation criteria to each"*; and

D. Document the "*expert points of consensus and scientific differences of opinion in the final PRAP Study Report".*

Ministry of Environment and Climate Change Involvement

As per the MOECC Order, the Regions will "*meet with the Ministry at a minimum of once while undertaking the study and once when the study is complete".* It is the Regions' plan to meet with the MOECC to present results and receive input at key study milestones, including:

- Existing Conditions Development
- Optimization Options Assessment
- Tertiary Treatment Options Assessment
- Development of the PRAP

The completed PRAP will be finalized and "*submitted to the Director of the Approval Branch".*

Public Posting

At the same time the final PRAP is submitted to the MOECC, the Regions will "*post the completed PRAP on the Project website"* for public review and input. As per the MOECC Order, the public has 45 days from posting to submit comments regarding the PRAP to the Director of the Approval Branch (as well as the Regions).

Attachment A

Comment Review Log

DELIVERABLE REVIEW LOG													
Project:	**Duffin Creek WPCP Phosphorus Reduction Action Plan Study**							Agree - will make suggested changes		**1**			
Deliverable:	**TM3 – Assessment Methodology**					Requires response and/or action before acceptance	**1 (H)**	Agree - will provide alternate solution		**2**			
Deliverable(s) Date:	**30/11/16 (Workshop 1 Presentation), 21/12/16 (Draft TM 3)**					Requires response during next phase	**2 (M)**	Disagree OR no action required		**3**			
Log Date:	**8-Sep-17**					Editorial comment or question - does not require change	**3 (L)**	Additional information required		**4**			
Reviewer to fill in these columns								**Consultant Response**			**Reviewer's Acceptance/Rejection**		
Comment No.	Deliverable	Page No.	Section	Drg/Fig/ Table No.	Reviewer Name	Review Comment	Comment Type Code (1 to 3)	Responder Name	Response Comment	Response Type Code (1 to 4)	Reviewer originating the comment enters either: **Accept** or **Reject** (provide reason for rejection).	Open/Closed	
Comments													
1	Workshop 1 Presentation	General			M.T. Auer	The Town notes the need for a clear and consistent definition of “lowest achievable level” of effluent TP.	3	CH2M	The lowest acheivable level of effluent TP for secondary treatment optimization will be determined by process modelling and field testing. The lowest acheivable level of effluent TP will be determined for each tertiary technology option. The project team will consider operations data from similarly sized facilities, WERF studies on limit-of-technology, and vendor information to make an engineering judgement on the lowest-acheivable effluent TP/SRP concentration for the different tertiary treatment options. Other advanced treatment technologies such as RO are available but will not be considered as options in this study as they are not feasible from a cost/future site use standpoint.	3	We accept the explanation, but note the Town's subsequent request to extend the literature review beyond the WERF studies; a request that, to our understanding was denied by the Regions.	Closed	
2	Workshop 1 Presentation	General			M.T. Auer	The Town has no current comment or concerns with the Draft list of Assessment Factors and looks forward to additional details of how these will be applied.	3	CH2M	Noted.	3	Accept	Closed	
3	Draft TM 3	4	Step 3: Define Assessment Factors	Table 1	Al Saikkonen (Transcribed by M.T. Auer)	Add FACTORS for space requirements and hydraulic constraints.	1	CH2M	Space requirements and hydraulic requirements have been added to descriptions of assessment factors.	1	Accept	Closed	
4	Draft TM 3	4	Step 3: Define Assessment Factors	Table 1	Al Saikkonen (Transcribed by M.T. Auer)	Note “as per benchmarking” to achievability bullets	1	CH2M	Text has been modified to include reference to benchmarking acheivable tertiary effluent quality.	1	Accept	Closed	
5	Draft TM 3	5	Step 3: Define Assessment Factors	Table 2	M.T. Auer	The Town requests that a ‘spare parts’ approach, as opposed to ‘complete redundancy’ be included in the main report / cost comparison). The Town requests that the availability of in-place equipment (e.g. the chemical storage and dosing building) and the attendant cost savings be recognized in the comparison of capital costs.	1	CH2M	The tertiary treatment systems will be designed such that the design peak flow can be treated with one unit out of service, i.e., with one redundant unit. Provision of redundant treatment capacity is part of the Regions' overarching design philosophy for all treatment processes and is consistent with the MOECC design guidelines for sewage treatment processes. This strategy does not provide a "complete" redundancy of the design treatment capacity, rather, redundancy is provided via one additional treatment unit, the capacity of which depends on the tertiary treatment technology. Redundant treatment capacity provides a greater amount of risk mitigation for maintenance events (emergency or planned) compared to a "spare parts" approach only.	3	Accept, however this issue is to be noted as a difference of opinion in Table 2-1 of the PRAP report	Closed, assuming the difference of opinion is noted in Table 2-1 of the final report	
6	Draft TM 3	5	Step 4: Estimate Impacts	Table 1	Al Saikkonen	For evaluation non-economic factors, pros and cons and some sort of ranking procedure should be considered.	3	CH2M	Non-economic factors will be documented on a comparative basis for each tertiary treatment option. A quantitative ranking procedure for non-econimc factors is not included in the assessment as this is not a requirement of the MOECC Order.	3	Accept, however this issue is to benoted as a difference of opinion in Table 2-1 of the PRAP report	Closed, assuming the difference of opinion is noted in Table 2-1 of the final report	
7	Draft TM 3	5	Step 5: Compare Options		M.T. Auer	The Town requests that the comparison of options be made and presented in two stages, Stage 1 – a comparison and ranking of the ability of options to reach “the lowest achievable level” of total phosphorus in the effluent (Minister’s Order, Item 2e). Stage 2 – an assessment of the operating implications of, and the modifications and costs required to achieve such reductions (Minister’s Order, Item 2e). The Town notes that TM4 indicates that both ‘soluble P’ and total phosphorus will be included in its assessment. Please clarify whether ‘soluble P’ refers to SRP or to the sum of SRP and DOP. The Town requests that, where ‘expert judgement’ is used as a criterion in estimating impacts, that this be so noted and that the foundation of that ‘expert judgement be clearly described.	3	CH2M	The assessment of secondary and tertiary treatment options will include a comparison of the acheivable effluent SRP and TP concentrations as well as a description of the economical and non-economical impacts of implementation. SRP concentrations will be evaluated as this is the most commonly measured soluble phosphorus constituent and therefore is most applicable for this assessment when comparing acheivable effluent limits at the Duffin Creek WPCP to historical plant data and other literature. The TMs will make note of where the expert judgement or opinion of the project team members is used in decision-making or benchmarking treatment performance.	1	Accept	Closed	