Cornwall
ONTARIO CANADA

CORNWALL WASTEWATER TREATMENT PLANT
ENVIRONMENTAL ASSESSMENT UPDATE

TECHNICAL MEMORANDUM NO. 6
SOLIDS TRAIN EVALUATION

December 1, 2009

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1.0 INTRODUCTION

The Cornwall Wastewater Treatment Plant (WWTP) is owned and operated by the City of Cornwall. The plant provides primary treatment with chemical addition for enhanced treatment and phosphorus removal as well as disinfection. The existing WWTP has a Certificate of Approval (C of A) average day flow (ADF) capacity of 54,432 m^3/d and a peak design capacity of 108,864 m^3/d. Biosolids are treated on site in an anaerobic digestion process and dewatered using centrifuges, prior to disposal in the City's landfill.

The Cornwall WWTP was originally constructed in 1968 and has undergone several expansions since then. The WWTP serves approximately 46,000 people, services, commercial and industrial properties and receives leachate from five waste disposal sites. Plant ownership was transferred to the MOE in 1970 and then to the City of Cornwall in 2000. Plant expansion in 1988 resulted in the current plant layout.

Figure 1 presents an aerial image of the Cornwall WWTP.

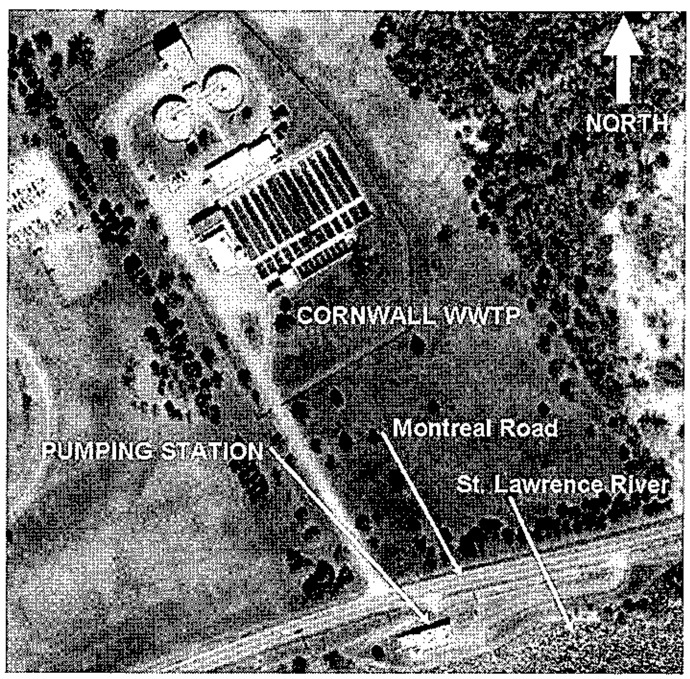

Figure 1 - Satellite Photograph of the Cornwall WWTP (courtesy of GoogleMaps)

A Pollution Control Planning (PCP) study was undertaken in 1995 to address concerns raised as part of the Remedial Action Plan (RAP), which stemmed from the designation of the St. Lawrence River (Cornwall area) as an Area of Concern (AOC) by the Water Quality Board and the International Joint Commission. The PCP is currently being updated to reflect current conditions including a hydraulic assessment of critical sewer infrastructure and to determine compliance with MOE Procedure F-5-5. In addition to other recommendations, the RAP recommended the following upgrades to the Cornwall WWTP:

- Upgrading the existing primary treatment plant to the equivalent of secondary treatment

- Achieve Total Phosphorus removal to a compliance of 1.0 mg/L, with an objective of 0.5 mg/L

- Increase removal efficiency of other toxic contaminants

- Reduce bacteria levels

Following a plant-wide evaluation for required upgrades in 2003, a Schedule C Class Environmental Assessment (Class EA) for these upgrades was completed in 2005. As a result of the Class EA, a Biological Aerated Filter (BAF) system was recommended for the secondary treatment process upgrade and Ultraviolet (UV) irradiation was recommended for the disinfection system.

In May 2009, the City retained J.L. Richards & Associates Limited, in association with XCG Consultants Ltd. and CH2M HILL Canada Limited, to update the 2005 Class EA and to update the budget for capital-required upgrades as well as life-cycle costing over the 20 year EA planning period. The update will revisit the preferred treatment technologies identified in the EA based on existing conditions and constraints and provide updated construction and life-cycle cost estimates.

The purpose of Technical Memorandum No. 6 (TM6) is to conduct a full review of the existing plant's solids stream (primary sludge handling) and will confirm the existing anaerobic digester and centrifuge capacity. Future sludge production rates with the recommended alternative from TM5 will be developed and compared to current digester and centrifuge capacities to determine the required solids train improvements. City Staff have affirmed previous indications that maintaining the current dewatering and disposal of biosolids at local landfill is the preferred biosolids disposal methodology. This technical memorandum will form part of the Environmental Study Report Addenda (ESR Addenda), which is anticipated to be the main deliverable for this project.

2.0 EXISTING SOLIDS HANDLING

Solids handling at the existing Cornwall WWTP consists of a single stage primary anaerobic digestion system. Primary sludge is pumped to two primary anaerobic digesters and then dewatered in two centrifuges prior to disposal in the City's landfill. Currently there is no additional on-site digested sludge/biosolids storage. With no additional liquid biosolids storage, primary sludge feed to the digesters and digested sludge feed to the centrifuges must be closely controlled to maintain preferred digester loadings and operating levels and to balance the sequential digestion and dewatering process operations. On a daily basis, the volume of digested sludge feed to the centrifuges should approximately equal the volume of primary sludge pumped to the digesters.

Table 1 presents the design parameters for the existing sludge handling system at the Cornwall WWTP.

Table 1 – Existing Cornwall WWTP Sludge Handling System Design Parameters

Parameter	Process Design
Primary Anaerobic Digesters	
Type	Anaerobic - mesophilic
Number	2
Volume, Each	2,237 m3
Total Volume	4,474 m3
Sludge Dewatering	
Type	Centrifuge
Number	2
Capacity, Each	9 L/s
Total Capacity	18 L/s

2.1 Historic Sludge Generation Rates and Characteristics

Historic average daily primary sludge generation rates and plant average daily flows, from 2006 to 2008, are presented in **Table 2**.

Table 2 – Historic Average Primary Sludge Generation Rates

Parameter	2006	2007	2008	Average
Plant Average Day Flow	50,449 m^3/d	45,437 m^3/d	48,333 m^3/d	48,071 m^3/d
Primary Sludge Generation	92 m^3/d	110 m^3/d	116 m^3/d	106 m^3/d
Total Solids (TS)	4.9 %	4.4 %	3.6 %	4.3 %
Volatile Solids (VS)	63 %	66 %	68 %	66 %

Based on the above information, the resulting historic average primary sludge mass (total solids) generation rate is 4,558 kg/d.

2.2 Historic Dewatering System Performance

There are two centrifuges currently in use at the Cornwall WWTP and typically one or sometimes two centrifuges are operated approximately 6 hours per day, five days per week. Each centrifuge has a rated capacity of 9 L/s for a total capacity of 18 L/s or 389 m^3/d (6 operating hours per day with two centrifuges). If a duty/standby centrifuge configuration is considered at a similar 6 hour operating shift 5 days per week, the effective per day digested sludge generation rate processing capability is 140 m^3/d (9 L/s * 6 hr * 5/7 days). Historic centrifuge performance is shown in **Table 3**.

Solids mass balances around the dewatering centrifuges were used to estimate the centrate and dewatered biosolids flow from the centrifuges. It was assumed that supernating was not practiced in the digesters prior to dewatering.

Table 3 – Historic Dewatering Centrifuge Performance

Parameter	2006	2007	2008	Average
Sludge Feed[1]	2,558 kg/d ($91.5\ m^3/d$)	2,558 kg/d ($110.2\ m^3/d$)	2,630 kg/d ($116.0\ m^3/d$)	2,582 kg/d ($105.9\ m^3/d$)
Sludge Feed Solids Concentration	2.8 %	2.3 %	2.3 %	2.5 %
Estimated Centrate Solids[2]	36 kg/d ($83.7\ m^3/d$)	35 kg/d ($101.7\ m^3/d$)	39 kg/d ($106.5\ m^3/d$)	37 kg/d ($97.3\ m^3/d$)
Centrate Solids Concentration	431 mg/L	342 mg/L	367 mg/L	379 mg/L
Estimated Dewatered Sludge Cake[3]	2,522 kg/d ($7.8\ m^3/d$)	2,523 kg/d ($8.5\ m^3/d$)	2,590 kg/d ($9.4\ m^3/d$)	2,545 kg/d ($8.6\ m^3/d$)
Dewatered Sludge Cake Concentration	32.2 %	29.5 %	27.5 %	29.7 %
Solids Capture	98.6 %	98.6 %	98.5 %	98.6 %

Notes:

1. Calculated based on volume of sludge pumped to dewatering unit and sludge solids content.
2. Centrate solids loading estimated based on mass balances around the dewatering unit.
3. Dewatered sludge cake estimated based on mass balance around the dewatering unit.

3.0 SLUDGE DIGESTION AND BIOSOLIDS HANDLING

3.1 Plant Design Flows and Raw Wastewater Characteristics

A summary of the historical influent loading and the conceptual level design basis for the Cornwall WWTP raw wastewater is presented in **Table 4**.

Table 4 – Cornwall WWTP Raw Wastewater Design Basis

Parameter	Historical Influent Loading	Updated Design Basis
Average Day Flow	48,071 m^3/d	65,318 m^3/d
Peak Flow	116,000 m^3/d	130,000 to 160,000 m^3/d[1]
Peak Flow Factor	2.41	2.0 to 2.45[1]
BOD_5 Concentration	64 mg/L	110 mg/L
TSS Concentration	110 mg/L	165 mg/L
TP Concentration	2.4 mg/L	4 mg/L
TKN Concentration	16.4 mg/L	26 mg/L

Notes:
1. Peak Day and Peak Instantaneous shall be 130,000 m^3/d, as a minimum, consistent with 2005 ESR. This will be reviewed further during the design phase based on value engineering and a comprehensive cost-benefit analysis.

3.2 Design Sludge and Biosolids Generation Rates and Composition

Design sludge and biosolids generation rates and composition were estimated based on: typical TSS removal in the primary clarifiers and WAS generation rates for secondary treatment processes with chemical addition for phosphorus removal; co-thickening of primary and waste-activated sludge within the primary clarifiers; and primary anaerobic digestion. The design sludge and biosolids generation rates were estimated at the historic ADF and loading, and at the design ADF of 65,318 m^3/d.

The design total sludge and biosolids generation rates are presented in **Table 5**. Included in the table are the estimated sludge generation rates upon completion of the proposed secondary treatment upgrade works.

Table 5 – Design Total Sludge and Biosolids Generation Rates

Parameter	Estimated Sludge Generation at Historic Conditions[1]	Estimated Sludge Generation at Updated Design Basis[2]
Primary Sludge Generation	2,992 kg/d	6,205 kg/d
WAS Generation	2,013 kg/d	4,703 kg/d
Total Co-thickened Sludge	5,005 kg/d	10,908 kg/d
Co-thickened Sludge VS[3]	3,253 kg/d	7,156 kg/d
Co-thickened Sludge FS	1,752 kg/d	3,752 kg/d
Digested Sludge TS[4]	2,891 kg/d	6,257 kg/d

Notes:
1. 48,071 m^3/d at raw wastewater historic concentrations.
2. 65,318 m^3/d at raw wastewater design basis concentrations.
3. Estimated based on co-thickened sludge VS:TS ratio of approximately 65 %.
4. Estimated based on volatile solids destruction of approximately 65 %

4.0 PREFERRED DESIGN OPTION

Currently, primary sludge at the Cornwall WWTP is digested in a single stage anaerobic digestion process prior to dewatering in dewatering centrifuges and subsequent disposal at the City's landfill. City Staff have affirmed the preferred solids train and biosolids management option is to retain and expand the existing biosolids treatment train to meet the proposed upgrade future design conditions.

4.1 Anaerobic Digestion

In the conventional mesophilic anaerobic digestion process, anaerobic and facultative micro-organisms decompose organic matter in the absence of oxygen. The organic matter is converted into methane, carbon dioxide, water and partly degraded intermediate organics. Operating temperatures typically are maintained at 30 to 38°C through use or partial use of the methane gas produced by the process as a boiler fuel, as is practiced at the Cornwall WWTP. A minimum digestion (hydraulic retention) time of 15 days in combination with heated and well-mixed contents is usually necessary.

Anaerobic digestion is the dominant process for sludge stabilization (Metcalf & Eddy, 2003), and is commonly used in activated sludge processes that generate both primary sludge and WAS.

The anaerobic digestion process provides the potential for energy savings at a WWTP, as the digester gas can be used for heat and/or energy production.

While the anaerobic digestion process is a proven technology for sludge stabilization, operator attention is required to ensure the process is functioning properly and for digester maintenance procedures. Associated capital and operating costs of sludge digestion and biosolids handling systems constitute a significant portion of wastewater treatment plant expenditures.

4.1.1 Preliminary Anaerobic Digester Design

The design basis for an anaerobic digestion process is shown in **Table 6**.

Table 6 – Anaerobic Digestion Design Basis

Parameter	Design Basis[1]
Primary Digester HRT	>15 d
Primary Digester VS Loading	650 – 1,600 $g/m^3 \cdot d$
Notes: HRT – hydraulic retention time 1. MOE (2008). Design Guidelines for Sewage Works.	

For the purposes of this assessment, and to be consistent with TM5, it was assumed that WAS co-thickening would be performed at the Cornwall WWTP. The co-thickened sludge concentration was assumed to be 3.0 percent, which is within the range of typical values of 2 – 6.5 percent (MOE, 2008), and at the lower end of the typical range of 3 – 8 percent (Metcalf & Eddy, 2003). The average co-thickened sludge flow rate is estimated to be 167 m^3/d at the historic conditions and 364 m^3/d at the design conditions.

Based on the design sludge generation rates presented in **Table 5**, and on the design basis presented in **Table 6**, the total required digester capacity was estimated.

Table 7 presents the estimated equivalent ADF capacity of the Cornwall WWTP based on the theoretical capacity of the anaerobic digesters. Based on a TS concentration of 3.0 percent, and assumed linear growth from the historic conditions to the design conditions, the capacity of the existing primary anaerobic digesters results in an equivalent plant capacity of approximately 59,500 m^3/d.

Table 7 – Existing Anaerobic Digester Capacity

Parameter	Design Basis[1]	ADF Capacity[2]
Primary Digester HRT	15 d	59,568 m^3/d
Primary Digester VS Loading	650 – 1,600 g/m^3·d	65,622 m^3/d
Equivalent ADF Capacity (approximate)		59,500 m^3/d

Notes:
n/a – not applicable
HRT – hydraulic retention time
1. MOE (2008). Design Guidelines for Sewage Works.
2. Based on assumed linear growth from historic conditions to design conditions.

Based on the estimated sludge flow rates and the minimum hydraulic retention time, the minimum digester volume required is 2,505 m^3 under historic conditions and 5,460 m^3 under the design conditions. The existing anaerobic digesters each have a volume of 2,237 m^3 and a total volume of 4,474 m^3. Therefore, immediately after the construction of the secondary treatment upgrade, the existing primary anaerobic digesters will have sufficient capacity to treat the sludge generated. At the design conditions, one additional digester with equivalent dimensions to the existing anaerobic digesters would be required, providing a total digestion volume of 6,711 m^3.

As shown in **Table 7** , the existing digesters would reach theoretical capacity at an equivalent plant ADF of approximately 59,500 m^3/d; therefore, subject to digester operating conditions and performance, the construction of the additional digester is not required until average day flows approach 59,500 m^3/d. As such, staged construction of a new primary digester can be considered as a measure to reduce near-term capital costs of the WWTP upgrade. Planning projections and historic condition monitoring can be reviewed in order to estimate a potential timeframe for potential staging of the primary anaerobic digestion upgrades.

The anaerobic digester design parameters at the historic conditions and at design flows and loadings, upon completion of the proposed secondary treatment upgrade works, are summarized in **Table 8**. No additional primary digester volume is required in the immediate term based on the projected sludge generation at historic conditions. One (1) new similar sized primary digester is recommended prior to plant average day flows approaching 59,500 m^3/d.

Table 8 – Anaerobic Digestion Design Parameters

Parameter	Projected Sludge Generation		Design Basis[1]
	Historic Conditions	Updated Design Basis	
Number of Existing Digesters	2		n/a
Existing Digester Volume (each)	2,237 m^3		
Existing Digester Volume (total)	4,474 m^3		n/a
Average Co-Thickened Sludge Flow	167 m^3/d	364 m^3/d	n/a
Required Primary Digester Volume[2]	2,505 m^3	5,460 m^3	n/a
Required Additional Digester Volume	0 m^3	986 m^3	n/a
Additional Digesters[3]	0	1	n/a
Digester Volume (total)	4,474 m^3	6,711 m^3	n/a
Primary Digester HRT	26.8 d	18.4 d	>15d
Primary Digester VS Loading	727 $g/m^3 \cdot d$	1,066 $g/m^3 \cdot d$	650 – 1,600 $g/m^3 \cdot d$

Notes:
n/a – not applicable
HRT – hydraulic retention time
1. MOE (2008). Design Guidelines for Sewage Works.
2. Based on minimum HRT = 15d.
3. Additional digester(s) assumed equivalently sized to the existing digesters.

Additional options to be considered during the preliminary design stage could include: separate WAS thickening; digested sludge storage options and alternative sizing options for the additional digester(s). Separate WAS thickening may improve primary clarifier performance and capacity, and result in increased solids concentration in the sludge feed to the digesters, effectively reducing the volume of sludge to the digesters and the digester sizing requirements. Construction of secondary digesters or biosolids storage with provisions for supernating can reduce the volume of digested sludge feed for dewatering and disposal. A digester constructed in the near term could serve as a biosolids storage tank or a secondary digester, and then be converted to operate as a third primary digester in the future. Sizing of the primary anaerobic digester(s) should be revisited during the preliminary design stage, and/or during review of potential implementation staging.

4.2 Dewatering Centrifuge

Dewatering centrifuges separate the digested sludge/biosolids feed stream into a solid cake and a waste centrate stream by means of high-speed rotation. Two dewatering centrifuges are currently utilized for dewatering the biosolids at the Cornwall WWTP prior to disposal at the City's landfill. Historically, polymer has been used to enhance solids capture of the dewatering centrifuges.

Based on the sludge generation rates, an estimated VS destruction of 65% in the anaerobic digesters, and no digester supernatant return stream, the projected design digested sludge generation rates upon completion of the proposed secondary treatment upgrade works are presented in **Table 9.**

Table 9 – Digested Sludge Generation Rates

Parameter	Projected Digested Sludge Generation at Historic Conditions[1]	Projected Digested Sludge Generation Updated Design Basis[1]
Digested Sludge Feed to Dewatering	167 m^3/d	364 m^3/d
Digested Sludge Feed TS	2,891 kg/d	6,257 kg/d

Notes:
1. Based on the design total sludge generation rates and the historic VS destruction of approximately 65 %. Assumes primary anaerobic digestion with no supernatant return.

The projected secondary treatment average digested sludge feed rate at historical conditions is approximately 1.6 times that of the existing treatment process historical feed rate. The design basis average digested sludge feed rate is approximately 3.4 times that of the existing treatment process historical digested sludge feed stream to the dewatering centrifuges. These projected design basis values reflect a higher average day flow (40% increase to historic average); a higher influent total suspended solids loading (50% increase to historic average); the generation of secondary treatment process activated sludge solids; and no digester supernatant return. The projected 7-day weekly volume of generated digested sludge is 1,169 m^3 at historic conditions and 2,548 m^3 at the design basis conditions.

The existing dewatering centrifuges each have a hydraulic rated capacity of 9 L/s, and a total capacity of 18 L/s. **Table 10** presents the estimated runtimes of the existing dewatering centrifuges at the digested sludge generation rates at historic and design basis conditions.

Table 10 – Existing Dewatering Centrifuge Estimated Runtime Requirements

Parameter	Estimated Sludge Generation at Historic Conditions	Updated Design Basis
Weekly Digested Sludge Feed to Dewatering	1,169 m^3	2,548 m^3
Required Weekly Centrifuge Runtime[1]	18 hr	39 hr

Notes:
1. Based on existing dewatering centrifuge total capacity of 18 L/s.

Assuming an operating time of 6 hours per day, 5 days per week; the existing dewatering centrifuges have a theoretical total (combined) capacity to dewater 1,944 m^3 of digested sludge per week. Under historic conditions, the existing dewatering centrifuges have sufficient capacity to dewater all of the digested sludge generated on a weekly basis. The total capacity of the dewatering centrifuges is less than 7-day volume of generated digested sludge at design conditions and provides for no redundancy or operating capacity contingency. Therefore, upgrades to the existing dewatering system capabilities are required.

Based on the projected digested sludge generation at the historic and at the design conditions, the digested sludge generation would meet the total capacity of the existing dewatering centrifuges at an equivalent ADF of approximately 57,750 m^3/d. However, the existing dewatering centrifuges have a firm capacity that is only slightly greater than the projected digested sludge generation immediately after construction of the secondary treatment upgrade works. Sizing and selection of dewatering equipment upgrades should be revisited during the preliminary design stage, and/or during review of potential implementation staging.

To more effectively support the dewatered biosolids management and disposal program, as a minimum it is recommended that two new centrifuges and associated conveyance provisions be incorporated to provide sufficient capacity to dewater digested sludge produced. It is also recommended that consideration during preliminary design be given to related findings of the facility condition assessment (TM4), and to potential options such as: alternate dewatering technologies; sufficient provisional liquid digested sludge storage capability/facilities to relax the firm capacity sizing requirement for dewatering equipment (e.g. – quantity two (2) 60 percent capacity units); and/or provisional liquid sludge loading/transfer facilities.

4.3 Biosolids Disposal

Dewatered sludge from the Cornwall WWTP is currently disposed of at the City's landfill. Continuing this practice was previously identified as the preferred option for the upgraded solids treatment train disposal method, and the City affirms this remains the preferred alternative. Based on the future design condition digested sludge production rate, and an assumed centrifuge performance of 95% solids capture and a dewatered cake solids concentration of 28%, the resulting average per day volume of dewatered cake is approximately 21 m^3/d.

5.0 SUMMARY

Based on the results of the preliminary solids treatment train evaluation, the existing anaerobic digestion system requires as a minimum the major additions of one additional digester and additional dewatering capacity in order to meet the estimated sludge generation at the updated design basis flows and loadings. These upgrades may potentially be implemented in phases to reduce near term capital costs of the WWTP upgrade. It is recommended that related findings of the facility condition assessment (TM4), and that options relating to a new digester, additional centrifuge(s), and other associated solids train systems and potential staging be given consideration during preliminary design.

REFERENCES

Hydromantis, 2005. Environmental Study Report: Cornwall Waste Water Treatment Plant.

Metcalf & Eddy, 2003. Wastewater Engineering – Treatment and Reuse.

MOE, 2008. Design Guidelines for Sewage Works.