IMPACT OF IMPROVED PRIMARY SEDIMENTATION EFFICIENCY ON OPERATIONS AT THE ROSEDALE WWTP

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ABSTRACT

Following the recent Rosedale Wastewater Treatment Plant Stage 5 upgrade and the associated construction of two additional primary sedimentation tanks there have been some noticeable improvements in operational efficiencies and process stability. These efficiency improvements translate into increased primary suspended solids removal which now averages 74% and stable primary sludge fractions in the anaerobic digester feed stream which have increased by an average of 10% from 58% to 68%. Downstream analysis has also shown that the production of digested sludge is much more stable and predictable; however as yet there is no apparent improvement in sludge dewaterability. Internal electricity generation has increased to over 500 MWh per month resulting in energy cost savings of approximately $8,000 to $10,000 per month.

Now that these improvements have resulted in a more stable and predictable treatment process, further process analysis will be undertaken with the intention to exploit further optimisation opportunities where possible.

KEYWORDS

Anaerobic Digestion, Biogas, Primary Sedimentation, Primary Sludge, Solids Removal.

1 INTRODUCTION

The recent $17 million Stage 5 upgrade at North Shore City Council (NSCC) Rosedale Wastewater Treatment Plant (WWTP) consisted of additional inlet screening capacity, new larger grit traps, new odour biofilters and the construction of two additional primary sedimentation tanks. This upgrade was implemented as a design and build contract with Fulton Hogan awarded the contract. Fulton Hogan's design consultants were Sinclair Knight Merz Ltd, while the client's (NSCC) consultants were CH2M Beca Ltd and Evans and Peck Ltd. This upgrade was commissioned in June 2008 and this paper focuses on operational improvements that have resulted from increasing the primary sedimentation tanks capacity.

Prior to the Stage 5 upgrade the Rosedale WWTP had four rectangular primary sedimentation tanks (PST's) that had been progressively constructed over a twenty year period, with the first PST commissioned in 1962 and the fourth constructed in 1982. Following significant population growth and progressive plant upgrades over the years it was obvious that operational and process stability was being affected by a lack of PST capacity. This was noticed through fluctuating PST solids removal, changes in primary to secondary sludge ratio's, fluctuating biogas production and variable digested sludge dewatering quantities.

The respective dimensions, volumes and surface areas of the PST tanks are shown in Table 1. Of the pre-existing PST tanks two (PST's 3& 4) are 47m long, 5.8 m wide and 2.9 m deep and the other two (PST's 1&2) are 53.4 m log. 2.75 m deep and 5.8 m wide which resulted in a total PST volume of 3280 m^3. Prior to the upgrade these 4 tanks accepted a maximum combined peak flow limit of 6400 m^3/hr with flows above this bypassed around the primary sedimentation tanks direct to the activated sludge reactors. This resulted in a minimum PST retention time during peak flows of 0.5 hr for the maximum 6400 m3/hr PST inflow.

Following the upgrade two new and larger PST tanks were constructed, substantially increasing the PST peak flow capacity to 11,800 m^3/hr (3.28 m^3/s). The new system is not designed to have any bypasses as all flow will receive full primary treatment. This will result in minimum design retention time under future peak flows of 0.6 hr, although the retention time at existing peak flows is 0.75 hrs. PST's 1 to 4 have also been retrofitted with “finger” weirs to increase the weir length and decrease the weir loading, previously they just had straight flat overflow weirs at the end of the tanks. The control of flow to individual PST’s was also improved by constructing an inflow splitting chamber and individual PST inlet channels.

Table 1: Size and flow specifications for each primary sedimentation tank.

	PST’s 1 & 2 (each)	PST’s 3 & 4 (each)	PST’s 5 & 6 (each)	Total
Length (m)	53.4	46.95	50	-
Depth (m)	2.75	2.9	4.45	-
Width (m)	5.8	5.8	8.7	-
Surface Area (m^2)	309	272	435	2032
Volume (m^3)	850	790	1936	7,152
Flow Split (%)	16.5	14.5	19.0	100
ADWF	518	486	594	3,196
PWWF	1,900	1,800	2,200	11,800

2 PROCESS PERFORMANCE IMPROVEMENTS AND CHANGES

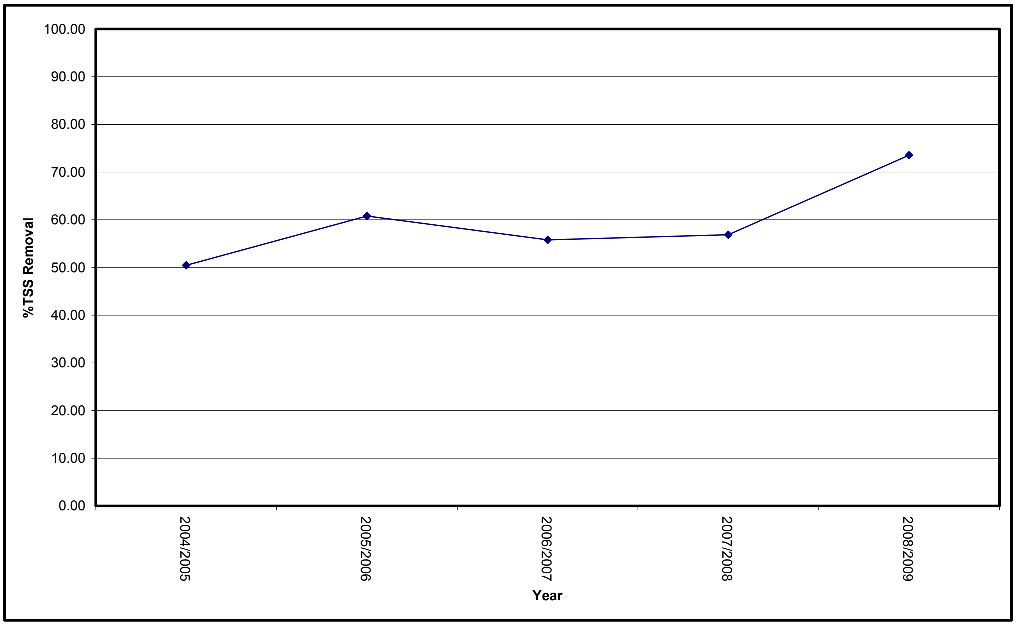
2.1 TYPICAL PST DESIGN PARAMTERS AND EFFICIENCIES

Rectangular PST tanks generally range from 15 to 90 m in length and 3 to 24 m in width and acceptable depths are generally greater than 3 m. The depth of the older PST tanks (1 to 4) are on the lower range of acceptable standards while the new PST’s (5 & 6) are between 53% and 62% deeper than PST 1&2 and PST 3&4 respectively. The typically accepted performance specification for primary sedimentation performance is 50 to 70 percent removal of suspended solids with an average liquid retention time of about 2 hours (Metcalf and Eddy, 2003; Vesilind, 2003) . Currently under average daily flow conditions the average PST retention time is 2.25 hours. Prior to the upgrade the average daily PST retention time was only about 1.4 hours.

2.2 PST SOLIDS REMOVAL

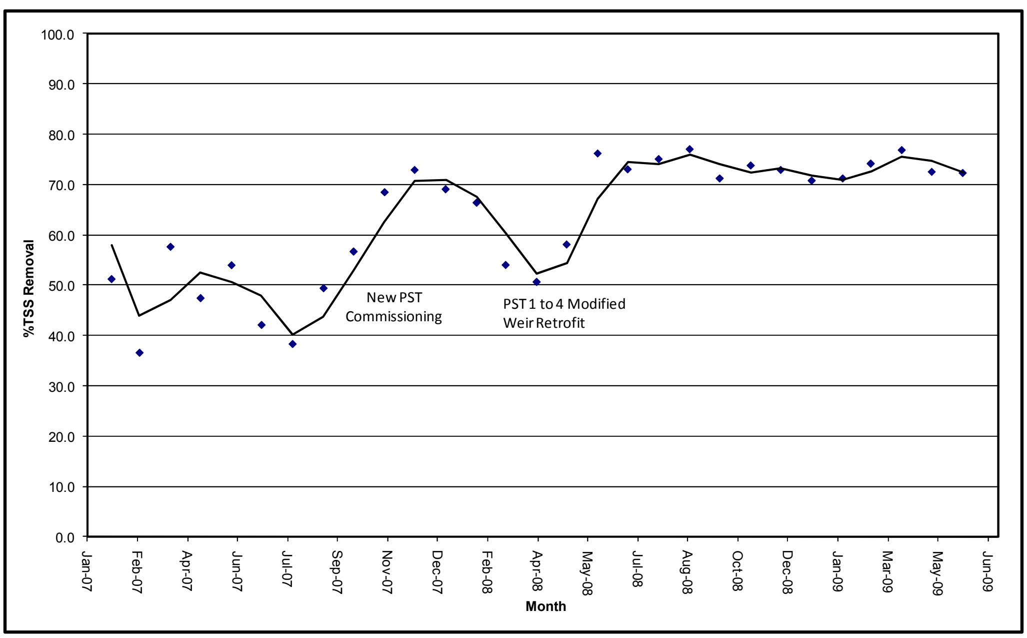
Since the completion of the Stage 5 upgrade the TSS solids removal performance in the primary sedimentation system has increased to 74% from approximately 55% in previous years (Figure 1). It must be noted that the calculation of the PST suspended solids removal performance prior to Stage 5 is overestimated as the effect of the PST bypass during peak flow events was not included in the calculation and it likely that the actual TSS removal values are closer to 50% or less which is the absolute typical design minimum. From Figure 1 it can be seen that the average annual TSS removal performance increased after the 2004/2005 year. This improvement in PST performance is most likely due to the fact that there has been construction of storage facilities in the wastewater collection network at various locations over the years which has reduced peak flow frequencies. Some of the benefit of the network storage on PST performance will have been offset by progressive population growth and increased daily inflows.

Figure 1: Average annual TSS removal in PST’s since 2004
(years shown are from 1 July to 30 June).



Following the commissioning in June 2008 of the six PST system after the PST 1 to 4 weir modifications the performance of the PST system became very stable with TSS removal consistently above 70%. This improvement in process efficiency is shown in Figure 2 below and it is evident is that there is no noticeable seasonal or peak flow effect on the PST system performance.

Figure 2: Average monthly solids removal in PST's since 2007.

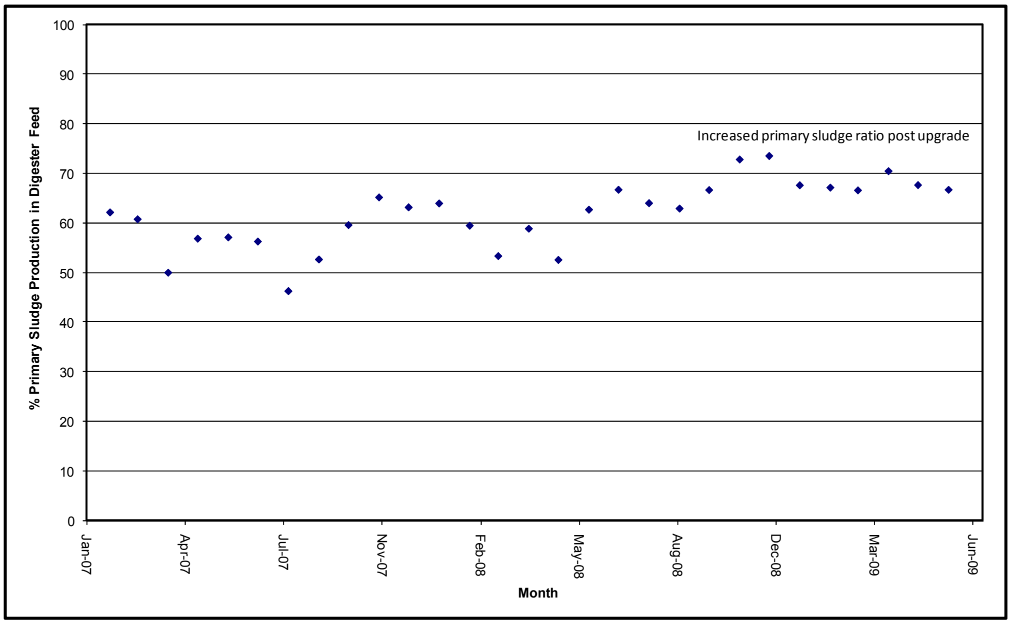


2.3 SLUDGE GENERATION RATIO'S AND DIGESTED SLUDGE PRODUCTION

At the Rosedale WWTTP both primary and secondary sludge are combined and fed to anaerobic digesters and then the digested sludge is dewatered in centrifuges. A significant influence on digester stability and biosolids production is the ratio of secondary and primary sludge's. It is generally accepted that primary sludge is more readily digested and that dewatering digested sludge is easier the higher the ratio of primary sludge in combined sludges.

Prior to the Stage 5 upgrade the ratio of primary sludge to total sludge production averaged 58% from January 2007 to June 2008. Subsequent to the operation of six PST's from mid 2008 the ratio of primary sludge has increased to an average of 68% and has become less variable. Since October 2008 after 3 months of operating with the new PST's the primary sludge ratio has only varied from 67% to 73% (Figure 3).

Figure 3: Average ratio of primary sludge to total sludge feed to digesters.



Potentially one of the most significant benefits to the solids treatment operational costs is through reductions in the digested sludge production and subsequent improvements in dewatering. Figure 4 shows the monthly dry tonnes of digested sludge produced at the Rosedale WWTP since January 2007. In the past this has been variable due to variations in the ratio of primary and secondary sludge production. Since October 2008 (after about 3 digester retention times post upgrade) the dry tones of digested sludge produced has become more stable and less influenced by seasonal changes. The final two data points in Figure 4 are affected by slit ingress into the sewer network from the dewatering of the new Rosedale WWTP marine discharge tunnel and outfall project which is currently under construction. The overall benefit and savings from more stable and consistent sludge production will largely be gained from reduced biosolids water content through improved dewatering performance. The average monthly solids content of the biosolids since 2007 is shown in Figure 5. There has been no obvious improvement in the dewatering performance since the operation of the six PST system. The high total solids data point in June 2009 is due to the presence of silt in the sludge mentioned previously. This suggests that there are other contributing influences on dewatering performance besides the ratios of primary and secondary sludge's, such as specific sludge characteristics. These characteristics include amongst others the volatile fraction of the primary sludge and the bacterial composition (e.g. various filaments organisms) of the secondary sludge.

Figure 4: Monthly digested sludge production in tones dry solids.

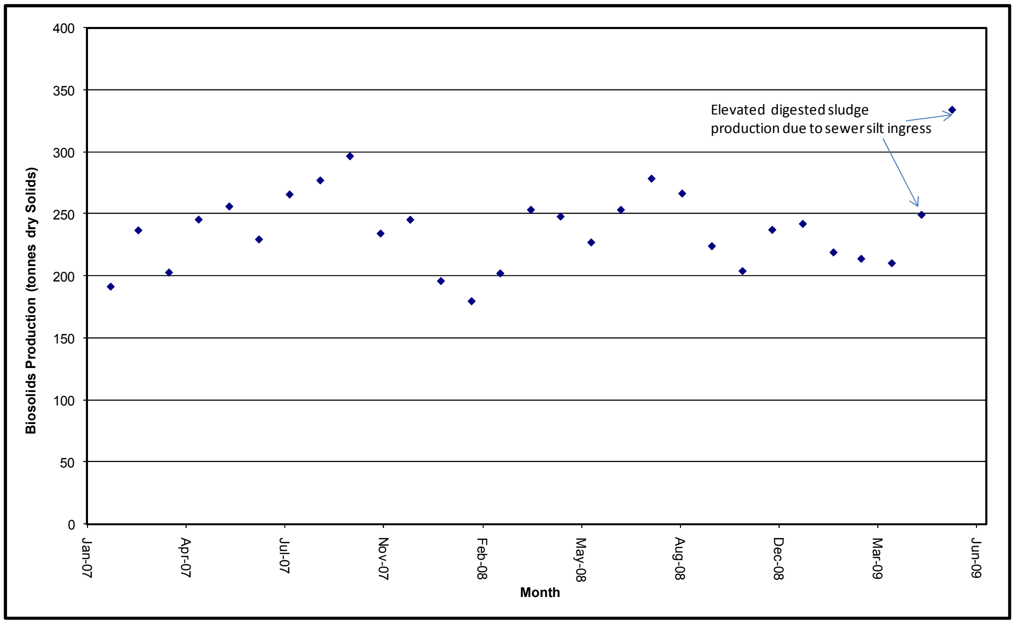
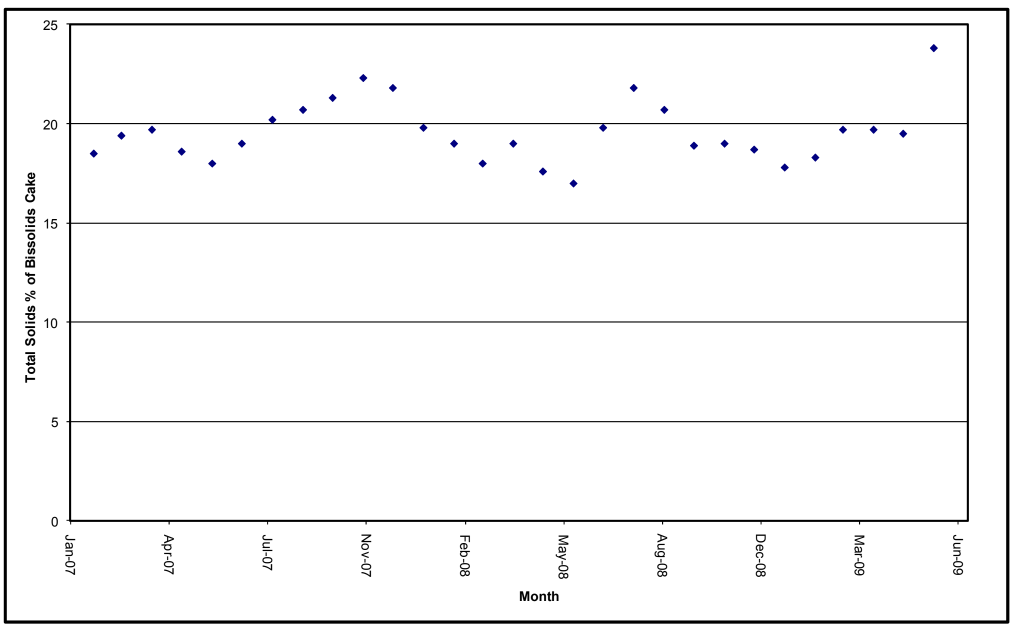


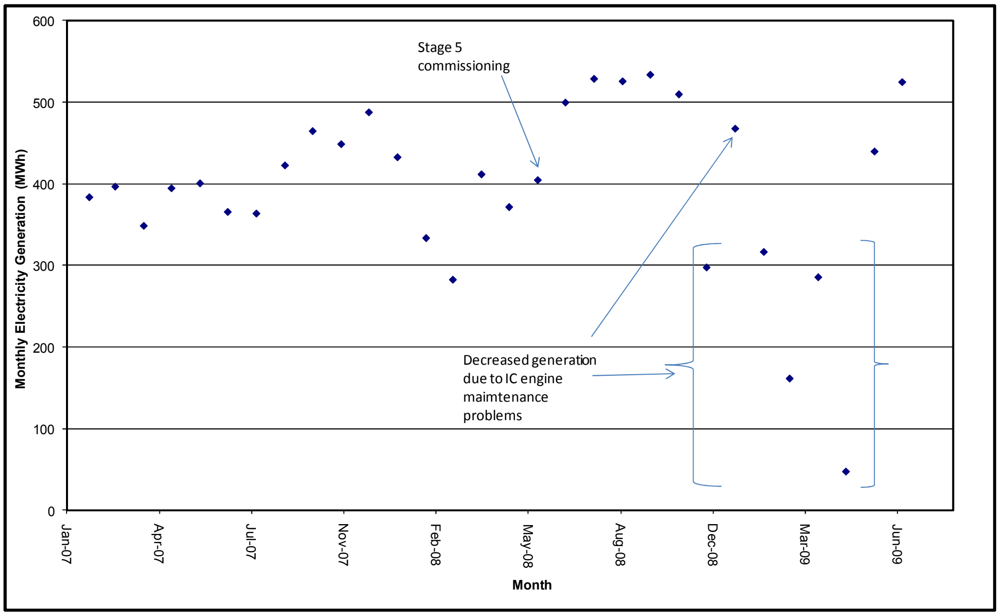
Figure 5: Totals solids content of biosolids cake at the Rosedale WWTP.



2.4 INCREASED POWER GENERATION FROM BIOGAS

The most obvious change at the Rosedale WWTP since the Stage 5 upgrade has been increased internal power generation from additional biogas production through improved primary solids capture. The additional biogas is most accurately quantified by analysing the monthly gas engine electricity generation in MWh. After Stage 5 commissioning monthly electricity generation increased to over 500 MWh for the first at the Rosedale WWTP (Figure 6). From December 2008 to June 2009 operational problems were experienced with the gas engine, and the exhaust heat exchanger was replaced. After being taken off line for various maintenance inspections eventually a major engine overall was done in May 2009 which also impacted slightly on the June 2009 generation figure. A full month of operation was again achieved in July2009 after the major overall with a monthly electricity output of 525 MWh. It is expected that monthly generation figures will consistently be above 480 MWh when no engine maintenance downtime is required. This compares to previous monthly generation figures ranging from 360 to a maximum of 485 MWh. Assuming no unplanned engine downtime electricity savings will be in the order of $8,000 to $10,000 per month.

Figure 6: Monthly Electricity Generation (MWh).



3 CONCLUSIONS

By upgrading the primary sedimentation capacity at the Rosedale WWTP improved operational stability has been achieved. This is evidenced by stable PST solids removal, which during the twelve months since commissioning has averaged 74% compared to about 55% previously. The PST performance is no longer influenced by seasonal peak flows or storm events and all flow is primary treated with PST bypasses no longer operational.

The average ratio of primary sludge in the combined primary and secondary sludge fed to the digesters has increased by 10% from 58% to 68%. This has resulted in improved digester operational stability and much less variable digested sludge quantities after three digester retention times of post Stage 5 operation, with the digested sludge quantities ranging from 204 to 242 dry tones per month. No improvements however have yet been noticed in the sludge dewatering performance.

The most significant impact of the increased PST capacity has been increased biogas production and the resultant increase in electricity generation from the CHP plant. It is estimated that monthly power savings are in the order of $8000 to $10,000 per month. The full long term benefits of the Stage 5 upgrade have yet to be assessed and quantified but these initial observations show that the operation of the Rosedale WWTP is now much more stable and predictable. It is planned that through detailed process analysis further plant and process optimisation will be undertaken and potential cost savings realised.

ACKNOWLEDGEMENTS

The work undertaken by the Stage 5 contractor Fulton Hogan Ltd and their design consultants Sinclair Knight Merz (SKM) in delivering a successful product is acknowledged.

The input of both CH2MBeca Ltd and Evans and Peck Ltd, the client's consultants, into scoping and ensuring a successful contract outcome is also gratefully acknowledged.

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