Reducing Electrical Grid-Powered Aeration Use & Costs in Reactor Basins

White Paper

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Reducing Electrical-Grid Powered Aeration Use & Costs in Reactor Basins

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The Problem

Electrical-grid powered aeration in reactor basins at activated-sludge wastewater treatment plants (WWTPs) enables digestion by mixing and oxygenating the wastewater. The purchase of electricity to operate the aerators is a major part of operational expense. The use of electrical-grid power also increases the carbon footprint of WWTPs due to the associated greenhouse gas emissions, thereby contributing to global climate change (IPCC, 2007).

Goals & Objectives

The City of Eden, Mebane Bridge Wastewater Treatment Plant, investigated the ability of solar powered circulation (SPC) technology (Hudnell *et al.* 2010) to provide some of the mixing and oxygenation previously supplied solely by grid-powered aerators. The goal of the initial study was to meet National Pollution Discharge Elimination System (NPDES) standards while reducing grid-powered aeration and operating a single SPC unit in one basin. Study objectives were to compare effluent water quality parameters and grid power usage and cost during 1 year of SPC treatment with comparable data from the immediately preceding year when only aeration was used.

Methods

The investigation was conducted in the Mebane Bridge WWTP's South Basin, an earthen impoundment of length = 486 ft (with 2:1 sloping sides), width = 162 ft (with vertical sides), and operating depth = 13.5 ft (Figure 1). Surface area was 1.74 ac, and the operating volume was 7.0

MG. The twelve 20-horsepower (HP) aerators (240 HP total) shown in Figure 1 operated continuously during the pre-SPC treatment period, June 2008 through May 2009. The three aerators closest to the SPC unit remained inactive during daylight hours throughout the during-SPC treatment period, June 2009 through May 2010. Plant personnel deactivated up to six aerators during the SPC treatment period to assess the limits of the SPC unit (Figure 2) to supply mixing and oxygenation. Although the SPC unit operated continuously, day and night, personnel activated all aerators during darkness as a precaution.

The parameters measured during both study periods using standard methods (Eaton et al. 2005) were wastewater influent (IN) quantity, and effluent (EF) total suspended solids (TSS), biochemical oxygen demand (BOD), acidity or alkalinity (pH), dissolved oxygen (DO), ammonia nitrogen (AN), total nitrogen (TN), total phosphorus (TP), and fecal coliform (FC). Electrical-grid power usage and cost were monitored throughout the study. NPDES limits were: TSS mean monthly = 30 mg/l, mean weekly = 45 mg/l; BOD mean monthly = 30 mg/l, mean weekly = 45 mg/l; pH daily 6-9 su; AN mean weekly = 14.8 mg/l; and TN mean monthly =12.7 mg/l. All descriptive and inferential statistical procedures were performed using Microsoft® Excel® 2008 for Mac, Version 12.2.3.

Results

No NPDES water quality violations occurred during either study period. Water quality parameters were generally unchanged or improved during the SPC treatment period (Table 1). The closing of a Hanes textile mill in February 2008 of the pre-SPC study period was associated with an influent decrease of approximately 32%, improvement in several water quality parameters, and an increase in TN (Table 1). An apparently independent decrease in TP was observed during the SPC period. Both mean monthly electrical-grid power use and cost decreased significantly during SPC (Table 1, Figure 3). Annual electricity usage declined by 1,692,000 kWh, or 42%, whereas annual expenditure decreased by $61,101, or 31%. The cost savings on electricity resulted in a 10.7 month pay-back period.

Conclusion

These results obtained at an activated sludge WWTP supported the conclusion reached by the US Environmental Protection Agency in an evaluation of SPC use at four WWTPs (US EPA 2005). The Agency concluded that SPC reduced grid-powered aeration usage, electricity consumption and operational costs, as well as odor events, sludge buildup and greenhouse gas emissions (US EPA 2005). Similar results were obtained in a study of SPC use at three pond-based WWTPs conducted by the New Hampshire Department of Environmental Services (Hudnell *et al.* 2010).

References

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Table 1. **Eden, NC, Mebane Bridge WWTP Mean Monthly Parametric Values**

		IN MG	**TSS** mg/l	**BOD** mg/l	**pH** su	**DO** mg/l	**AN** mg/l	**TN** mg/l	**TP** mg/l	**FC** units	**kWh** x1000	**kWh Cost** $
	Hanes Open	6.0	14.6	3.0	7.3	7.9	0.1	5.7	1.2	27.4	NA	NA
Pre-SPC	**Hanes Closed**	**4.1**	10.6*	1.4*	**6.6**	**9.7**	0.2	**12.2**	0.7	2.0	NA	NA
	Mean	5.4	13.3	2.5	7.1	8.5	0.1	7.9	1.1	19.0	254	16,254
During-SPC	**Hanes Closed**	**3.9**	**9.5**	1.8	**6.7**	8.2	0.3	8.4*	**0.3**	3.8*	**191**	**11,162**

NA = not applicable. The Hanes textile mill closed in February 2008. Inferential statistics were calculated using two-tailed Student t-tests. Statistically significant differences between Pre-SPC Hanes Open and Hanes Closed periods at $\alpha = 0.05$ are indicated in bold in the Pre-SPC, Hanes Closed row. Statistically significant differences between Mean Pre-SPC and During-SPC periods at $\alpha = 0.05$ are indicated in bold in the During-SPC row. Additional statistically significant differences at $\alpha = 0.1$ are indicated by asterisks (*).

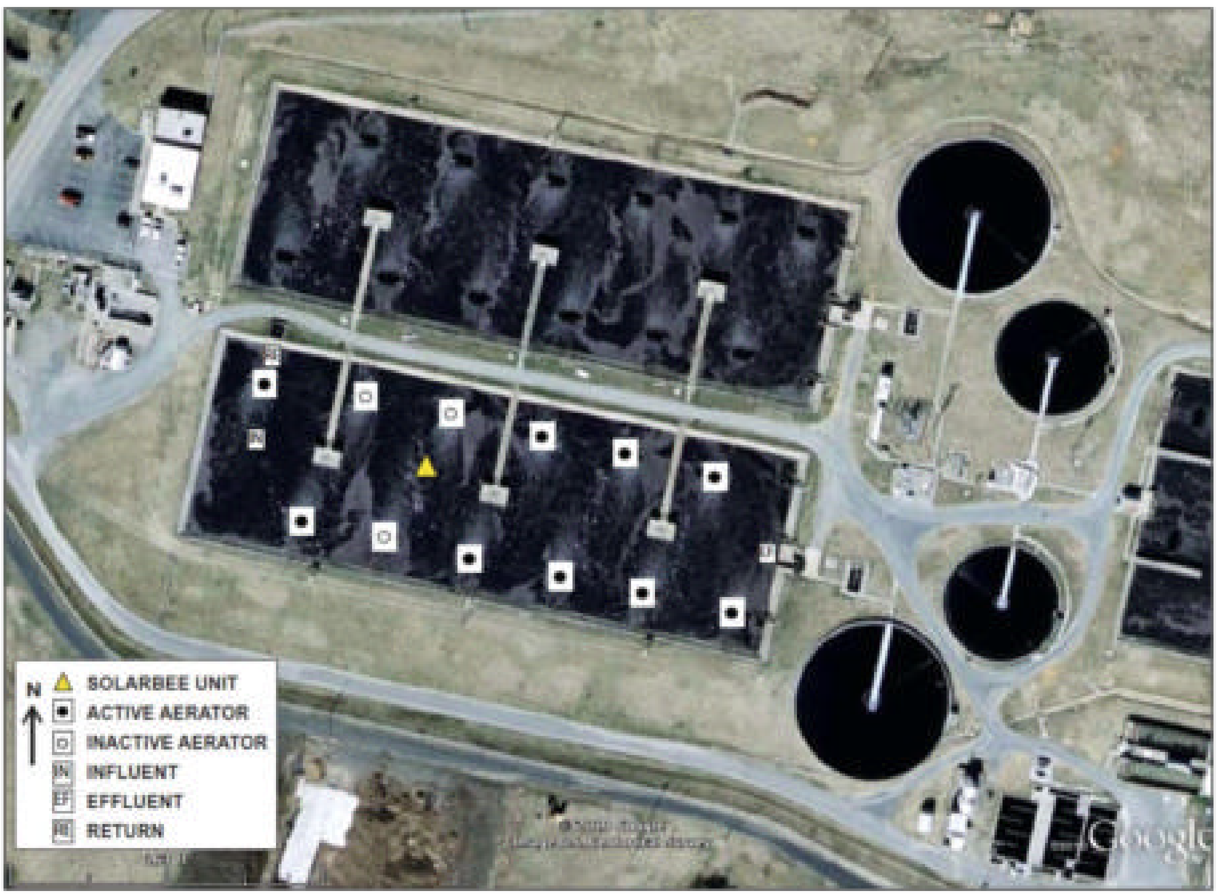

Figure 1. An aerial photograph of the Eden, NC, Mebane Bridge WWTP, and symbols in the South Basin as indicated in the key. The return (RE) indicates the return of activated sludge from the clarifier basins shown on the right.

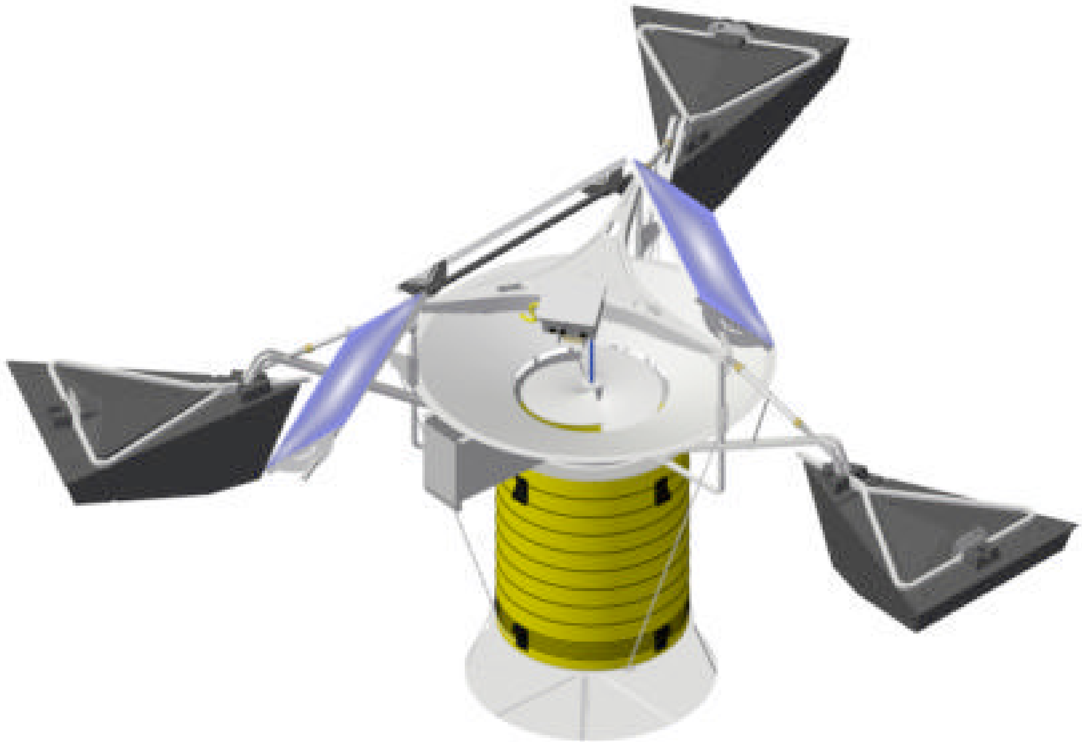

Figure 2. An illustration of a SolarBee®, Inc., SPC unit (SB10000v18). The unit consists of three pontoons that provided buoyancy for above water, near surface and underwater components. Solar panels, an 18 volt, high-efficiency brushless (gearless) motor, a digital-electronic control box, and accessories were mounted on an above-water frame. A distribution dish, impeller and battery are suspended from the frame just below the surface. A 3 ft diameter, flexible, intake hose is attached to the frame at the base of the impeller. A steel plate suspended 1 ft beneath the hose intake causes water to be drawn in radially with near-laminar flow. Adjustments of chains attached to the plate and frame control the intake depth. Additional chains attached to the frame and two moorings maintain the spatial position of the unit. The battery powers the motor to rotate the impeller at 80 RPM 24 hours/day, 7 days/week. If prolonged periods of low light incidence caused the battery charge to fall below 60%, the electronic controller switched on grid-power to charge the battery. The unit transports approximately 10,000 gal/min of water to the surface (Ohio EPA 2004). Approximately 3,000 gal/min of direct flow ascends through the hose, and another 7,000 gal/min of induced flow ascends external to the hose. Water departs from the unit radially without turbulence, both above and below the distribution dish. The outflow mixes with other surface currents to redistribute water across the treatment area. The units are designed for low maintenance and a 25-year lifetime.

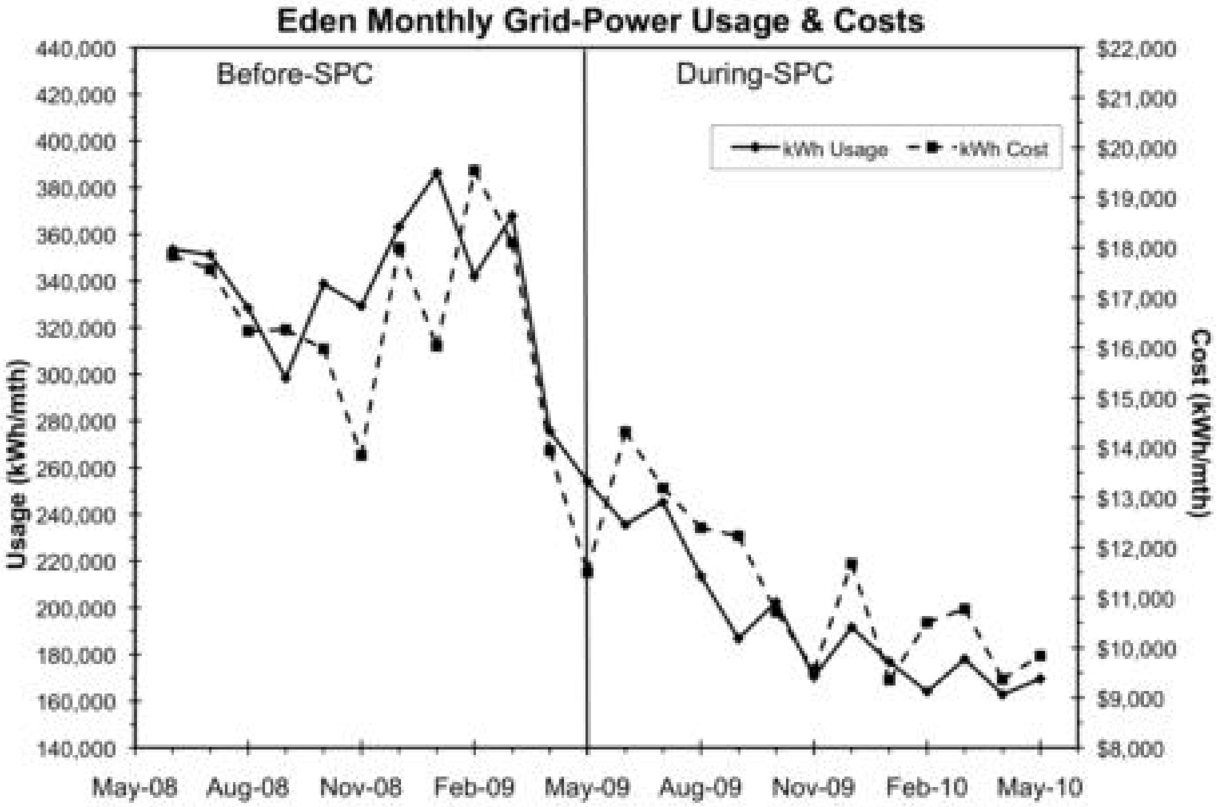

Figure 3. The use of 12 20-HP aerators at the WWTP was cut to nine at the start of the during-SPC study period, and was further reduced to six over the course of the study. The decrease in aerator usage resulted in reduced grid power consumption and expenditures. The utility is currently investigating the use of three SPC units in one reactor basin, and an additional unit in the activated sludge basin shown on the far right of Figure 1.