Phosphorus Removal

Chemical removal with RE100 eliminates need for additional capital

INTRODUCTION

For the last twenty years, the Wisconsin Department of Natural Resources (WDNR) has limited total phosphorus (TP) in municipal wastewater treatment plant effluents to 0.6 to 1.0 mg-P/l as a means of preventing eutrophication of Wisconsin's surface waters. Wisconsin's watersheds flow into the Mississippi River Basin and Lake Michigan, and in 2010 the State accepted its share of overall nutrient reduction targets set forth under the Gulf Hypoxia Action Plan and the Great Lakes Restoration Initiative.

To meet its targets, WDNR implemented numeric nutrient-related water quality standards for all of its watersheds. As a result, four hundred Wisconsin municipal wastewater treatment plants will receive new TP discharge permits between 0.5 mg/L and 0.04 mg/L in the next few years. The majority of the affected plants cannot meet their new discharge permits with their current plant layouts and will need to install or upgrade their biological and/or chemical phosphorus removal systems. To reach a permit of 0.1 mg/L, for example, the WDNR estimated that plants would need to install enhanced biological phosphorus removal, rapid mix and flocculation chemical addition, sand filtration and enhanced biosolids handling.[1]

One of these affected plants is the City of Hartford Water Pollution Control Facility (WPCF), a 3.4 MGD municipal wastewater treatment plant which discharges directly into the Rubicon River, a "Class A" trout stream. Hartford was one of the first municipalities in Wisconsin to receive a new total phosphorus permit for a final water quality based effluent limit (WQBEL) of 0.075 mg-P/L. The permit will go into effect in 2017. The plant has no dedicated biological phosphorus removal system, and relies on ferrous chloride for chemical phosphorus removal. Attempts to reach 0.075 mg-P/L with ferrous chloride were unsuccessful. Increasing the ferrous chloride dose to 30 - 60 ppm_v only reduced TP to an average of 0.5 mg/L. Even with ferrous chloride doses of 100 – 120 ppm_v, phosphorus in the final effluent could only be reduced to 0.3 mg-P/L.

Capital costs for installation of new nutrient removal equipment were estimated at $2.8M[1], with accompanying higher maintenance and operating costs for years to come. When plant management became aware of the targeted phosphorus removal efficiency of RE100, a new rare earth chloride coagulant, they were interested to see whether chemical phosphorus removal alone could achieve the 0.075 mg/L TP permit limit.

[1] William, M.B., "Cost of Phosphorus Removal at Wisconsin Publically-Owned Treatment Works," for Wisconsin Department of Natural Resources, December 2012.

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TRIAL OVERVIEW AND RESULTS

The Hartford WPCF plant process (shown in Figure 1) includes screening, primary clarification, biological treatment in an oxidation ditch, final clarification, anthracite sand filtration and ultraviolet light disinfection. Ferrous chloride had been added in the inner channel of the oxidation ditch and the same dose location was used for RE100. The RE100 trial began in August 2014.

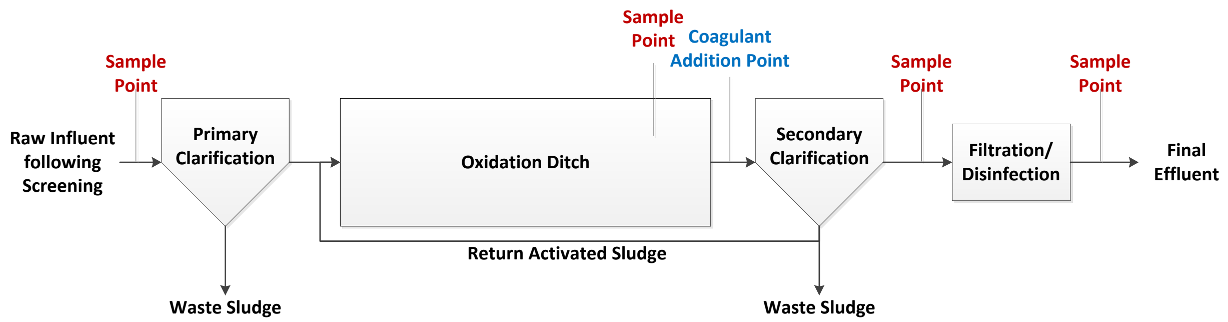

Figure 1. Hartford WPCF process

Figure 2 shows RE100 dosing and TP in the final effluent during the trial to achieve 0.075 mg-P/L. The plant turned off the ferrous chloride for nine days prior to dosing RE100. This approach minimized the chance that RE100 would remove phosphorus from iron flocs already present in the activated sludge. Right before the trial, after nine days of no chemical phosphorus removal, TP in the final effluent was 2.2 mg-P/L. After 16-18 hours at a dose of 44 ppm_v, orthophosphorus in the final effluent went down from 2.1 mg/L to 0.6 mg/L. After an equilibration time of approximately three weeks, the total phosphorus in the effluent could be maintained to an average of less than 0.075 mg/L with 100 ppm_v of RE100.

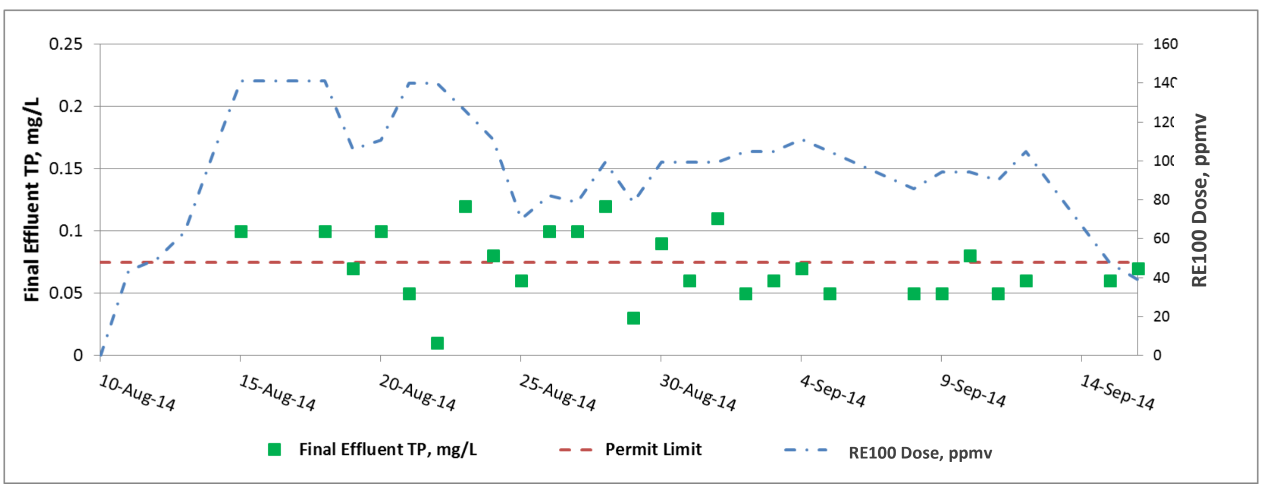

Figure 2. During the first trial, the influent total phosphorus averaged 7.3 mg-TP/L, while the final effluent averaged 0.072 mg-TP/L.

The goal of the next phase of the trial was to generate a dosage curve. From September 17 to October 17 (Figure 3), the average TP in the effluent was 0.19 mg-P/L, which required an average of 44 ppm_v. From October 21 to November 6 (left side of Figure 4), the average TP in the effluent was 0.64 mg-P/L, which required an average of 40 ppm$_v$. From November 7 to November 30 (right side of Figure 4), the average TP in the effluent was 0.26 mg-P/L, which required an average of 50 ppm$_v$.

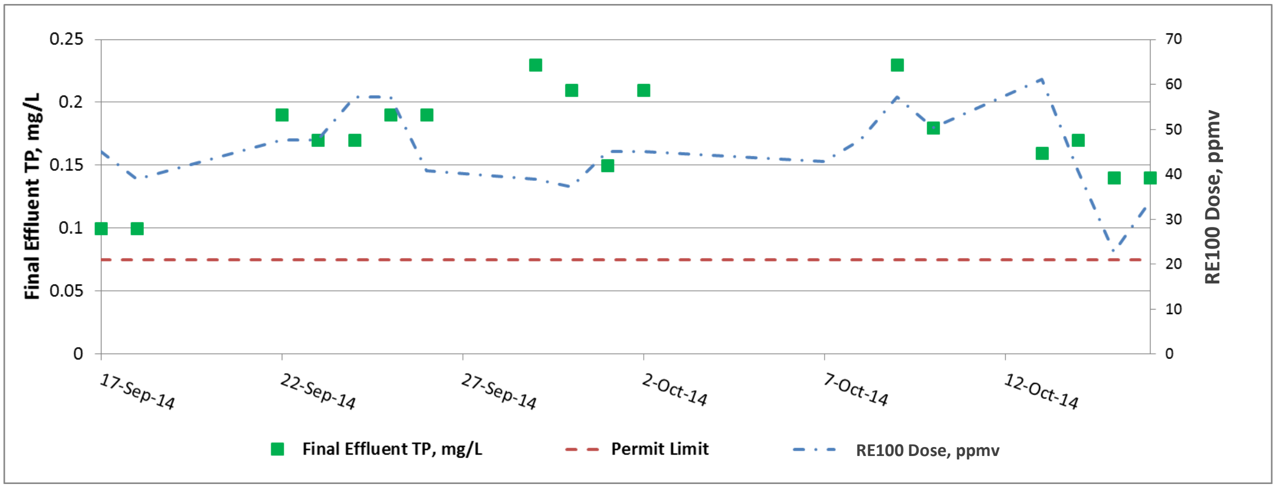

Figure 3. Dose curve generation for average TP of 0.19 mg/L.

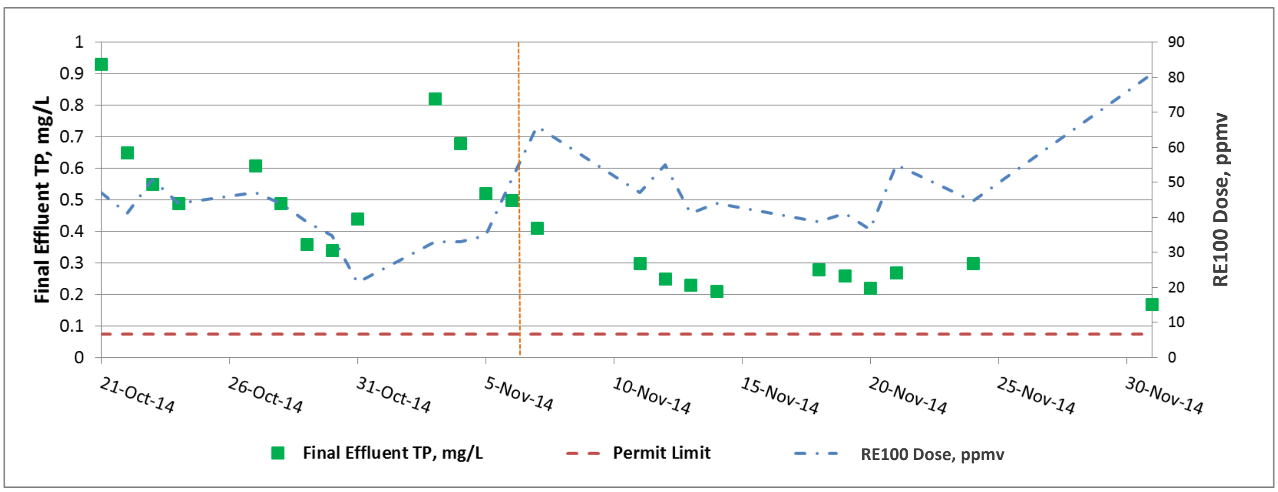

Figure 4. Dose curve generation for average TP of 0.56 mg/L (left side of the chart) and 0.26 mg/L (right side of the chart).

Hartford WPCF wanted to evaluate the performance of RE100 during cold weather months to verify the plant could meet the 0.075 mg/L target. Figure 5 charts a second study from December 1, 2014 to March 5, 2015 to achieve 0.075 mg/L. After six weeks of equilibration, RE100 maintained an average effluent TP of 0.036 mg/L with a dose rate of 77 ppm$_v$ (equivalent to molar ratio 1.4:1 Ce/P).

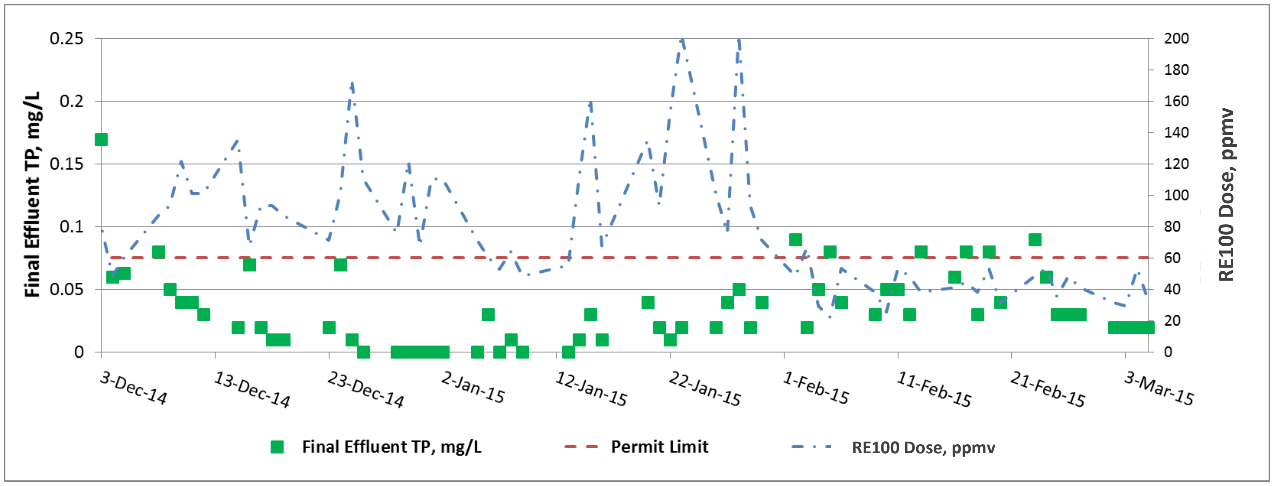

Figure 5. During the second trial to reach 0.075 mg/L, the influent total phosphorus averaged 5.2 mg-TP/L, while the final effluent averaged 0.036 mg-TP/L.

The plant does not need to meet its new 0.075 mg/L TP permit until 2017, but decided to switch over to RE100 to meet its interim 0.60 mg/L –P limit. As shown in Figure 5, the RE100 dosage was reduced to allow the effluent phosphorus levels to rise. Since March 1, 2015, the RE100 dose was reduced to an average of 55 ppmv, which is approximately 105 gallons per day to treat 1.9 MGD of influent. The final effluent TP subsequently rose to an average of 0.11 mg/L total phosphorus, which is still far below the current permit limit. When Hartford was using ferrous chloride, they would add approximately 160 gallons per day to reach an effluent TP concentration of 0.45 mg/L.

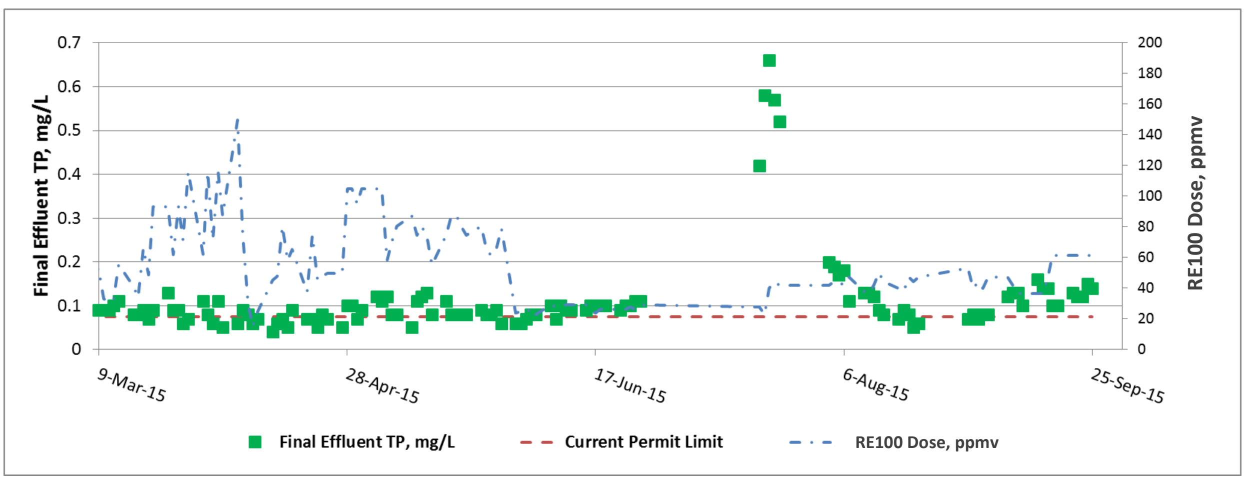

Figure 5. Decreasing the dosage to meet current permit of 1.0 mg/L. Influent TP during this time averaged 6.1 mg/L.

Figure 6 summarizes the trial in the form of a dosage curve. After one year of use, the dosage required to achieve less than 0.075 mg/L had dropped by 20% due to the accumulation of rare earth solids in the system which provided secondary adsorption of phosphorus.

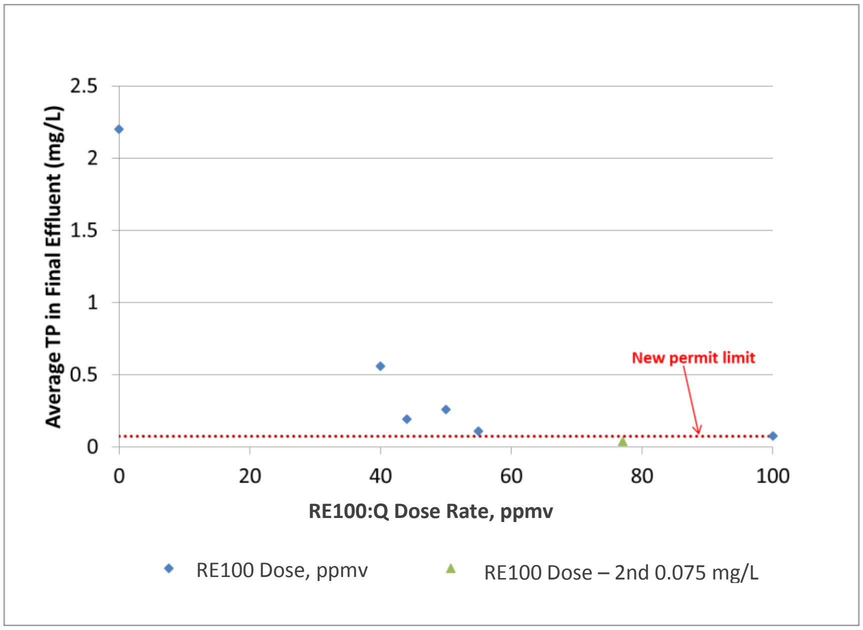

Figure 6. RE100 dose in ppm$_v$ and average TP in final effluent.

ADDITIONAL BENEFITS OBSERVED

With RE100, the product allows the facility to maintain a thicker mixed liquor concentration of up to 2,800 mg/L in the winter. In the past with ferrous chloride, severe foaming would occur at that concentration. Hartford WPCF has also experienced a 35% reduction in solids production through reduced sludge wasting. This decrease in solids production occurred while the plant was achieving an even lower effluent TP than before. Other advantages include better sludge settling (a lower Solids Volume Index) and a lack of odor in the WPCF non-potable water system.

NEXT STEPS

Based on the promising results of trial, Hartford included use of the existing treatment process using RE100 in their Preliminary Facilities Plan to the Wisconsin DNR. This option has the lowest net present value cost among all alternatives considered, which included ultrafiltration, disc filtration and ballasted sedimentation. Hartford's next step in its permit phosphorus compliance schedule is the Final Facilities Plan. If the plant reports that they can meet the WQBEL with optimization measures, the WDNR will likely implement the final WQBEL in Hartford's next permit to be issued in 2017.

For **RE100** Inquiries, please contact:

8101 East Prentice Avenue, Suite 525
Greenwood Village, CO 80111
P: 303.843.8065 F: 303.843.8082
phosphorusremoval@neomaterials.com neowatertreatment.com