Application:

Williamsburg Aeration Tank Modifications

Page: NEAA Nomination Form

APPLICATION DEADLINE: **Wednesday, September 26, 2018, 11:59 pm EST**

All fields indicated by a red asterisk (*) Must be completed

Category

Research & Technology (Agency)

NOMINATING AGENCY'S INFORMATION

Name & Title of Individual Submitting this Application

Ted Henifin

Submitting Agency's Name

HRSD

Service Area Population of Submitting Agency

1.7 million

PROJECT / INDIVIDUAL NOMINEE'S INFORMATION

Name of Nominated Project / Program or Nominee (as it will appear on the NEAA award)

Williamsburg Aeration Tank Modifications

Has this project / program ever been submitted for NEAA recognition in the past?

No

SUPPORTING DOCUMENTATION

Narrative Description: Project / Program or Individual (attach pdf, limited to 4 pages, double-spaced, 12pt)

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Supplemental Information Included - i.e. images, video, add'l document (Optional)

No

Please attach a third-person article (350-400 words MS doc) - something that a layperson would understand, describing your project / program to be posted on the front page of NACWA's website as part of our "Member Spotlight" section.

Member Spotlight Document (MS Word)

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APPLICATION AUTHORIZATION

Signature of Individual Submitting Application (pdf/jpg)

Name of Submitting Agency's NACWA Representative

Edward Henifin

Title of Submitting Agency's NACWA Representative

General Manager

Email of Agency's NACWA Representative

Signature of Agency's NACWA Representative (pdf/jpg)

Does this Project/Program involve another NACWA Agency?

No

Please review your application prior to finalizing. All fields with a red asterisk (*) must be completed. If you have any questions in regardings to sumbitting your appliation, please contact Bredy Trombino at 202.533.1820.

HRSD Nutrient Removal Program: Williamsburg Aeration Tank Modifications

Introduction: The Williamsburg Treatment Plant (WBTP), owned and operated by HRSD, treats approximately 9 million gallons a day (MGD). Liquid treatment at the WBTP consists of mechanical screening, grit removal, primary clarification, oxidation towers, biological nutrient removal (BNR), secondary clarification, chlorination, and dechlorination prior to discharging into the James River. The plant was originally designed to fully nitrify with no nutrient removal, however modifications were implemented in 2011 to operate as a Modified Ludzak Ettinger (MLE) process. Prior to upgrades discussed in this paper, the BNR process was operated in a MLE configuration, with four tanks in parallel. Each tank had five cells of equal size with the first two operated anoxically. Solids treatment at WBTP consists of in-tank gravity thickening of primary solids (PS) and gravity belt thickening of combined oxidation tower solids and waste activated sludge (WAS). The thickened sludges are dewatered by solid bowl centrifuges and the dewatered cake is incinerated. The current WBTP concentration based limits are total nitrogen (TN) of 14 mg/L and total phosphorus (TP) of 2 mg/L on an annual average basis. As part of an aggregate annual mass allocation (bubble permit) with six other HRSD treatment plants discharging into the James River, the treatment objectives for WBTP are more stringent than the concentration-based limits with targets of less than 5 mg/L TN and 0.7 mg/L TP. Achieving this level of treatment at WBTP represents a significant cost savings for HRSD, because other plants can be operated more cost-effectively while still complying with the bubble permit. In addition, the HRSD SWIFT program will require more stringent nutrient goals, including total inorganic nitrogen (TIN) < 6 mg/L (instantaneous), TN < 4 mg/L (monthly average), and TP < 1 mg/L (monthly average). A unique treatment technology at the WBTP is the oxidation towers. The plant receives a significant fraction of readily biodegradable chemical oxygen demand (rbCOD) from the Anheuser-Busch Brewery located in the service area. This greatly enhances the potential of the facility to remove nutrients, however, the loading from the brewery is variable. Primary effluent (PE) flow can be bypassed around the oxidation towers. The more PE bypassed, the more rbCOD is available for denitrification and biological phosphorus removal. However, the available carbon source also utilizes aeration tank capacity that is needed for nitrification. HRSD plant staff balances these competing interests by controlling the amount of flow sent to the oxidation towers. In addition to variable COD loading, additional nitrification issues have been linked to incinerator scrubber water. There is no formal side-stream treatment process to treat this recycle flow, however, it is directed to the oxidation towers prior to entering the aeration tanks.

Project Objectives: HRSD initiated a process optimization study with the objective of consistently treating to lower effluent TN and TP with a more reliance on biological phosphorus removal. Historical plant data was reviewed, a calibrated process model was developed, and the process model was used to determine simple basin configuration upgrades that could be used to treat to lower effluent limits. A calibrated Biowin® (EnviroSim, Ltd) model of the WBTP was developed to evaluate alternative nitrogen and biological phosphorus removal strategies to meet current and future permit limits at current flows and loads. Once the calibrated process model was developed, various scenarios were modeled to determine the optimum process scheme to upgrade the BNR tanks to reliably meet current treatment targets and proposed future effluent requirements associated with SWIFT. Evaluation of the modeled scenarios indicated that converting the existing tanks into an unusual step feed 5-stage process would provide for the largest reduction in nitrogen and phosphorus. HRSD staff made these modifications in-house and had maintenance and operation staff design, internally manufacture, and install all the required equipment and upgrades for the configuration changes. HRSD was able to make all required equipment upgrades and operational changes for under $200,000.

Project Results: The selected upgrade was to convert the existing MLE process to a 5-stage process. The upgrades were divided into two phases, which are described below. The original MLE configuration is shown in Figure 1. The modifications were installed in two phases. Phase I upgrades are shown in Figure 2 and included the installation of three baffles walls, which are shown by yellow dashed lines, in each of the four trains and piping improvements to incorporate the step feed. The existing top-entry mixer located in cell 2 was moved to cell 4. Phase 2 upgrades are shown in Figure 3 and included additional baffle walls to incorporate a swing zone into each of the four trains after the second anoxic zone, addition of large bubble mixing in the swing zone, aeration grid modifications, and modification to the internal nitrate recycle (NRCY) piping. The swing zone was added to be able to further enhance denitrification under conditions of good nitrification performance or offer additional nitrification when needed. Nitrate and ammonia sensors were deployed in the aeration effluent and a custom control system was designed and implemented to determine if the swing zone should be operated as anoxic, low DO, or in ammonia-based aeration control (ABAC) for additional nitrogen removal.

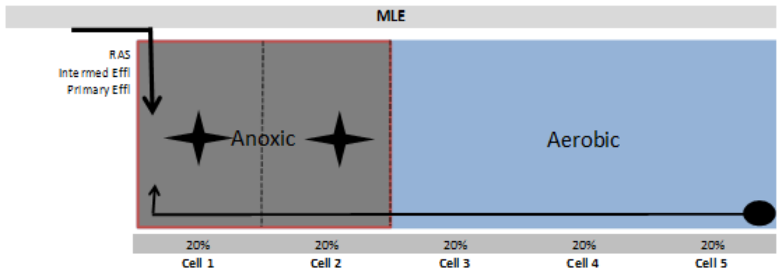

Figure 1: Original MLE Configuration

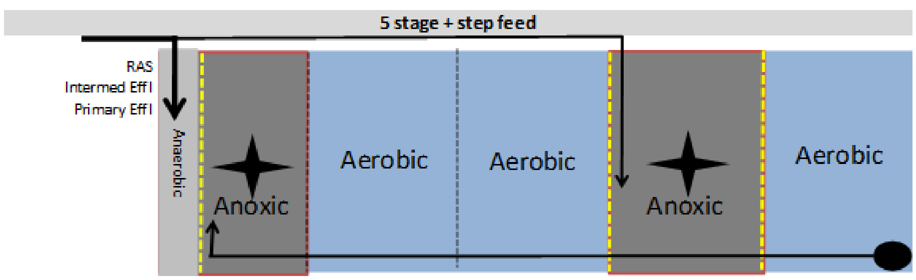

Figure 2: 5-Stage Upgrades (Phase 1)

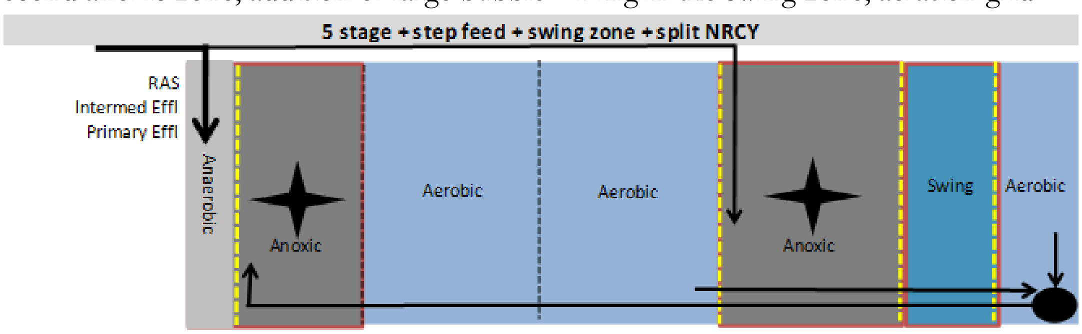

Figure 3: 5-Stage Upgrades (Phase 2)

Baffle Walls: Four baffle walls were installed in each of the four trains to modify the original tank and create the discrete zones needed for a 5-stage process. The location of each baffle wall is indicated in yellow in Figures 2 and 3. Material to construct each baffle wall was approximately $4,000 each using fiberglass and 1/8" PVC roofing panels and stainless-steel accessories shown in photos. Fabrication and installation was performed by HRSD maintenance staff.

Flow Splitting: Each of the phased upgrades required modifications to the existing process flow. Phase 1 implemented step feed which was achieved through extending the existing influent feed piping to Cell 4 in each tank. The purpose of the step feed is to provide internal carbon to improve denitrification in this second anoxic zone, but it is a bit unusual since a portion of the return activated sludge is also step fed to this location. The upgrades also included an unusual modification to the NRCY system to allow the suction location to be selected based on process conditions to either cells 3 or 5 or a combination of the two. The purpose of this is to be able balance the nitrate loading between the first or second anoxic zone depending carbon availability and nitrification performance. Piping modifications were completed by HRSD maintenance staff.

Swing Zone: To mix the new swing zones when unaerated, plant staff designed, tested, optimized, and then built and deployed large bubble mixers. The main plant air header was tapped to provide a small amount of air into the PVC chamber, releasing big air bubbles when the chamber fills with air. The handcrafted big bubble mixers are shown in the photo. Half of the diffuser grid in Cell 5 was joined to the grid from Cell 4 and an actuated air flow control valve was added to be able to automatically turn air on and off as needed to achieve the desired effluent nitrogen.

Automation: An innovative and unique control system was developed and implemented to control air flow to the swing zone based on the feedback from the aeration effluent nutrient sensors, swing zone dissolved oxygen (DO) probes, and the plant influent flow meter. Under normal conditions, the swing zone operates at a DO setpoint of 0.25 mg/L. If effluent nitrate increases, the air is turned off to provide additional anoxic capacity. If effluent ammonia increases, the DO is controlled based on an ammonia setpoint (ABAC). During high influent plant flow (wet weather mode), the swing zone operates at a DO setpoint of 2 mg/L. The control logic has three control modes. They operate in the following order of priority: (1) wet weather mode, (2) nutrient control (ammonia and nitrate) and ABAC and (3) nitrate control.

Results and Discussion: Total nitrogen from the plant has decreased as a result of the improvements. Historical effluent TN has decreased from an annual average of 7.4 to 3.2 mg/L with no external supplemental carbon addition. Effluent total phosphorus has also decreased with the addition of the anaerobic zone which has stabilized biological phosphorus removal (bio-P). There are still bio-P upset periods when ferric addition is needed, but we believe these issues are related to the oxidation towers nitrifying in the warmer months of the year and the nitrate load that it brings into the anaerobic zone. Future upgrades to improve bio-P may involve step feeding this intermediate effluent into the first anoxic zone or the aerobic zone depending on whether the oxidation towers are nitrifying or not.

Conclusion: Significant improvements in nitrogen removal were proven to be achievable and affordable at this facility, though admittedly this opportunity was a result of the excess capacity available with WBTP operating well below the rated design flow. Integration of historical data analysis, process modeling, in-house engineering, and mechanical ingenuity all played a role in the development of a cost-effective nutrient removal upgrade at the WBTP. All upgrades were completed in mid-2018. Over the last five months of operation with Phase II tanks in service, the effluent total nitrogen has averaged 2.8 mg/L with the lowest two-week average at 1.7 mg/L. It is also clear that bioP is now not as sensitive to changes in brewery loading, and while the plant ferric demand has not significantly changed, slightly improved TP removal is evident.