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**WASTEWATER TREATMENT EVALUATION**  
**BOROUGH OF BRYN ATHYN STP**  
MONTGOMERY COUNTY, PA  
NPDES #PA0030023

JULY through AUGUST 2015



Bureau of Point and Non-Point Source Management

September 2015

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## **Executive Summary**

The Borough of Bryn Athyn (BBA) operates a small conventional activated sludge treatment facility that was formerly independently owned and operated by the Academy of the New Church (Bryn Athyn.) It is presently permitted an annual average design flow of 0.065 MGD, with a peak of 0.080 MGD. The facility serves approximately 330 residential connections, most of which are merely septic tank effluents, in addition to the adjacent college and church property. This results in a rather unique quality of wastewater entering the plant: ammonia-nitrogen in the 50 ppm range, very low carbon loading, and variable loading based on the occupancy schedule of the college.

A new permit issued in April 2013 required imposition of a 10 mg/L concentration limit for Total Nitrogen (TN) in the effluent, to become effective in January 2016. Various options are available for complying with this limit, including modification of the existing facility to treat for nitrogen, replacement of the facility with different technology, or closure of the treatment plant and connection to the collection system of Lower Moreland Township, which discharges to the City of Philadelphia for treatment.

For the time being, Reid Heinrichs, the plant operator, decided to experiment with a modified Ludzak-Ettinger process, erecting a temporary baffle wall in one of the plant's two aeration tanks to form an anoxic pre-treatment zone, ahead of aeration, to convert soluble nitrate to nitrogen gas. Staff from US EPA Region III's outreach program, in association with DEP's south east regional office (SERO) staff, were asked for assistance with improving and optimizing the treatment process. In May of 2015, Walter Higgins of EPA and David Burke of SERO requested DEP's wastewater technical assistance program (WWTAP) to provide instrumentation and laboratory equipment to aid them in their efforts. Marc Neville brought and installed nine continuously monitored ion-selective probes throughout the treatment process to record eight different chemical quality parameters during a three-month study. He also installed supplemental laboratory equipment, including a spectrophotometer and phase-contrast microscope.

The continuous-monitoring probes were deployed at the plant on May 27, 2015. At the same time (late May and early June) the plant was making necessary adjustments to the process, including establishing an internal mixed liquor recycle flow (IMLR), and implementing aeration improvements by replacing diffusers and air piping. In the beginning phase of the instrument-based study, it was determined that the main limiting factor in denitrification was the lack of available carbon source to complete the process. DEP staff recommended various industrial waste products to be used as supplements in the raw wastewater, and Mr. Heinrichs found and sourced a dry waste molasses sugar that could be diluted into make-up water and metered into the waste stream. After testing an adjustment, they settled on a 40%-by-volume mixture of sugar water. The material was added at the plant headworks beginning on June 24, 2015. The results were dramatic and very rapid, with effluent nitrate-nitrogen concentration dropping from 45 mg/L to approximately 7 mg/L within a week.

Mr. Heinrichs proceeded with modifying the second aeration tank to add an anoxic pretreatment zone, work that is underway, as well as permanent handling facilities for managing supplemental carbon. It is expected that the facility will now have the capability of meeting the total nitrogen limits.

While it is possible for the MLE modifications to reduce effluent nitrate concentrations from the present flow and loading conditions, BBA is operating a facility that is at or near the end of its design life, and steps should be taken to plan for a future where the existing facility is expanded and modified or if it is replaced in its entirety by a successor facility or by contracting with a regional facility to process BBA's collection system sewage.

Based on the discoveries and findings during this evaluation DEP's WWTAP staff recommends the following:

- Continue efforts to operate the facility based on the results of regular process monitoring and control testing, with an eye toward employing accepted methods of sludge age, mean cell-residence time, or food-to-mass ratio.
- Obtain regulatory clearances including NPDES Part II permit amendment to allow facility to operate as a modified Ludzack-Ettinger process and finalize conversion of the facility begun during the optimization study;
- Have consulting engineer evaluate and re-rate modified facility for increased organic load, taking into consideration also the facility's intent to install flow equalization;
- Replace the temporary baffle wall in aeration tank #1 in summer of 2016;
- Secure and maintain one or two regular sources of supplemental carbon;
- Install monitoring probes and systems to permit better control of dissolved oxygen levels in the aeration tanks, including installation of in-line Dissolved Oxygen and Oxidation / Reduction Potential probes that will permit optimization of aeration, BNR, and energy consumption;
- Replace existing centrifugal blower units with positive-displacement blowers that are controlled with variable-speed drive and DO feedback technology;
- Establish standard operational procedures for maintaining regular process monitoring and control as described during on-site evaluation;
- Write a laboratory testing manual specific to the facility, instructing operators in standard methods for determining treatment parameters;
- Reorganize laboratory functional space to permit increased process monitoring<sup>1</sup>;
- Develop a sludge management plan having at least one backup facility available to receive and process waste sludge or reed bed wastes;
- Develop Spill Prevention Control & Counter-measures for chemicals and supplements used and stored on site;
- Examine and/or incorporate the use of asset management planning into the overall strategy for monitoring and replacing equipment on a cost-effective basis.
- Improve upon Municipal Wasteload Management Reporting with more accurate accounting of population trend's impact on organic loading, with clearer understanding of wastewater sources and types and their impact on the collection system hydraulics, and account for precipitation, inflow, and infiltration effects on hydraulic surges that necessitated approval of an equalization tank.

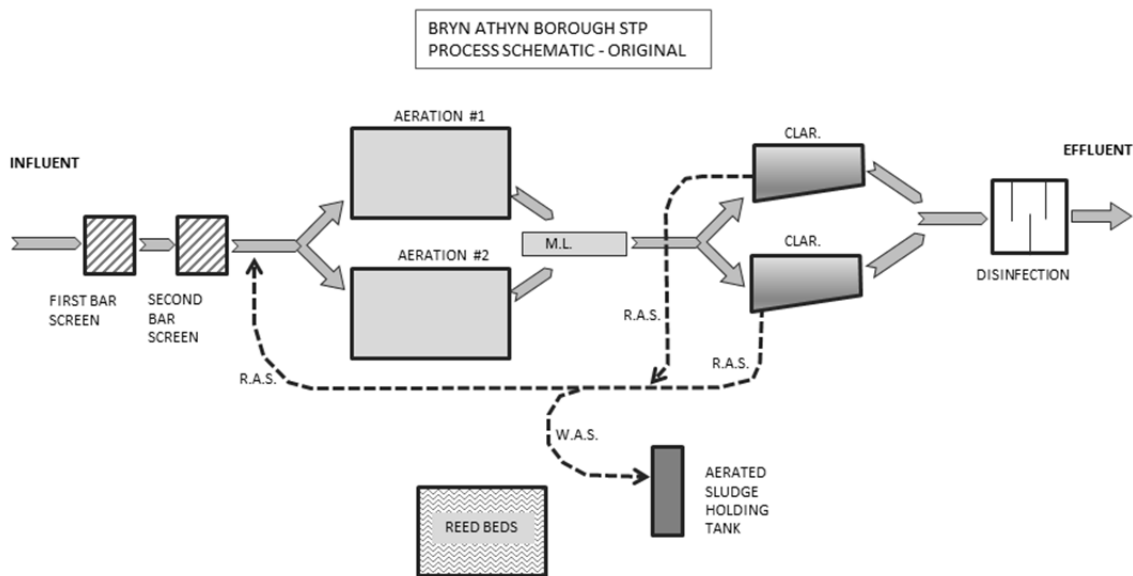
The owners and operators of the Borough of Bryn Athyn STP are commended for their pro-active efforts to improve effluent water quality through the use of innovative thinking and problem-solving as applied to wastewater treatment at their facility. It is to be hoped that, by incorporating the recommendations offered in this evaluation, that their efforts will continue to benefit their customers and the water-quality environment of all Pennsylvanians.

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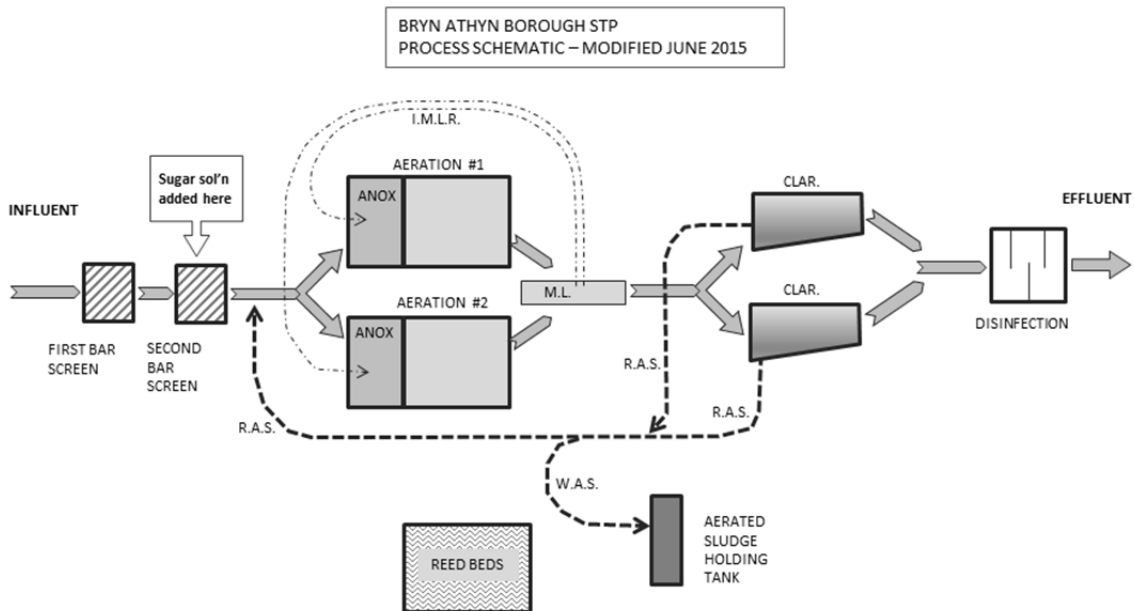
<sup>1</sup> The operator spoke of his intent to install replacement PD blowers adjacent to the aeration tanks, increasing room in the control building after the existing centrifugal blowers are removed.

## Background

The Bryn Athyn wastewater treatment facility consists chiefly of two 41,000-gallon aeration tanks operated in parallel with two 21,000-gallon secondary clarifiers. Each of the tanks may be operated independently of the other. Also, the facility includes a bar-screen headworks, and it has a disinfection system employing 12.5% sodium hypochlorite solution and a pair of chlorine contact tanks. Flow is measured at both inflow and out-flow. Process air is provided by two centrifugal blowers. Waste sludge is pumped to a reed bed, with ultimate disposal being removal to land fill. Besides use of hypochlorite for disinfection, the operators also attempt to balance process alkalinity using sodium bicarbonate addition at the aeration tank. A diagram of the designed treatment process follows.



The principal modifications made to ensure denitrification were the erection of baffle walls in the aeration tanks, each segregating approximately 13,000 gallons of capacity to anoxic pretreatment zones, with submersible pumps to provide anoxic mixing and additional pumps to provide up to 200% nitrate recycle. Supplemental carbon in the form of dissolved molasses sugar is introduced upstream of the screening facility, whereupon raw wastewater then flows into the anoxic zone, and mixed liquor flows from anoxic to aeration and thence to clarification. Return sludge is reintroduced at the anoxic zones through diversion channels. Following these modifications, the flow through then anoxic zones may approximate up to 4Q (four times the influent wastewater flow.) The modified process is shown below.



### **Wastewater Technical Evaluation:**

Early in 2015, U.S. EPA's Technical Outreach personnel from the Region III Office in Philadelphia began working with Mr. Reid Heinrichs, BBA Superintendent, on nutrient reduction strategies and process control programs. During the course of this work, Mr. Jim Kern of EPA brought in Mr. Thomas Brown of PA DEP's Technical Assistance group in consultation. As the project developed to focus on reducing effluent nitrate concentrations in advance of NPDES Permit requirements starting in 2016, the parties decided to convert one half of the aerobic reactors to modified Ludzack-Ettinger (MLE) process by subdividing space in the tank for an anoxic mixing zone. They estimated the size of this anoxic zone as being approximately 1/3 of the available space. Mr. Heinrichs contracted for the baffle wall to be built, using wood posts and impervious paneling, modifying the existing aeration header to suit a reduced aeration space. Different types of pumps were employed to provide for a nitrate recycle from oxic to anoxic zones.

Mr. Brown suggested that the DEP's WWTAP could lend instrumentation to the project, in order to optimize the MLE process. Mr. Neville, who performs instrument-based process optimization for WWTAP, brought his equipment to the site in late May and, after being briefed by the group, set up 24/7 recording instrumentation in the facility, excluding one of the aeration tanks which was being idled for the summer.

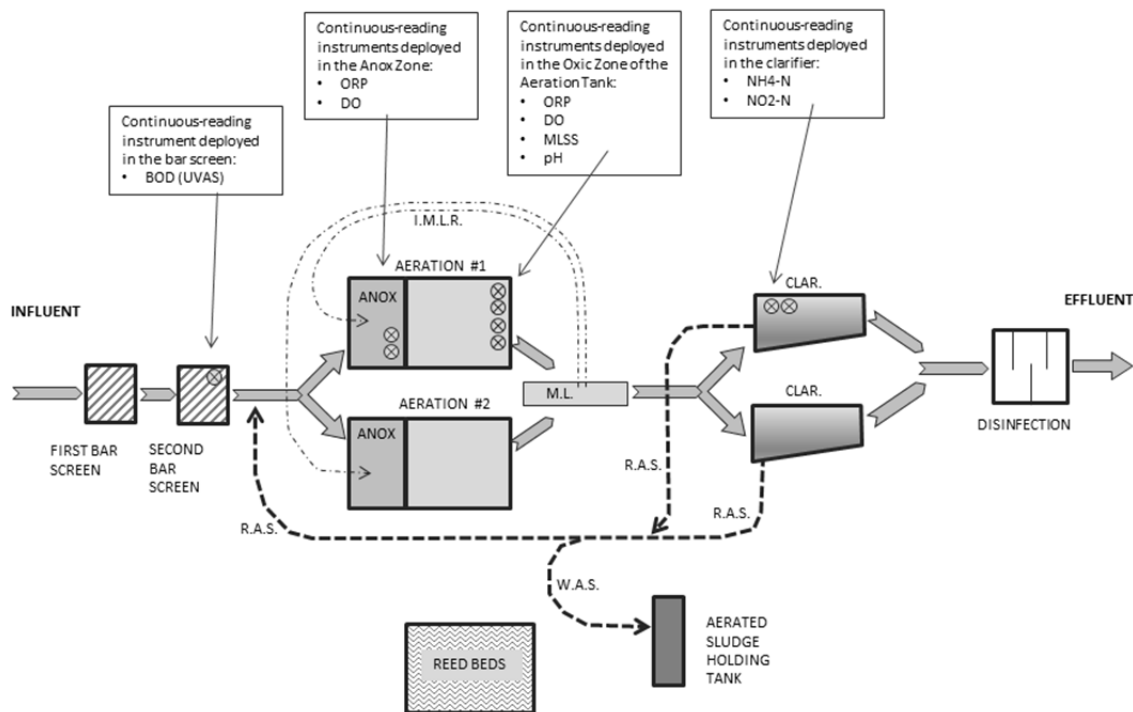
DEP staff discussed with the operators the advantages that would be gained by adding an equalization basin at the head of the plant to even out the diurnal and weather-related variability in influent flow and loading. In fact, the Borough once had plans for doing exactly this. A Part 2 permit was issued by DEP in 2010 for the construction of a 240,000 gallon influent equalization tank. This unit has not been built.

The permit limits for the facility are summarized in Attachment 3, following.

Meanwhile, EPA staff and DEP-SERO's David Burke worked with the operators to develop a more comprehensive understanding of activated sludge process monitoring and control, using the test methods developed by Albert West for EPA. The wastewater laboratory protocol includes daily required testing of

the effluent for dissolved oxygen, pH, temperature, and total residual chlorine. Process control testing has included Settlemetry, microscopy, and volumetric solids determination (by centrifuge.) With the addition of nutrient control, it is highly recommended that the protocol be expanded to include spectrophotometric determination of nutrient nitrogen forms. Further, EPA has been working with the operators to develop a process management program based on sludge solids inventory that results in operating the facility based on sludge age or cell-residence time. Some of this methodology is explicated in Attachment 2.

DEP's WWTAP installed its mini-SCADA network at Bryn Athyn during June. The location of continuous-reading instrument probes is shown in the diagram below. At the time of installation, two aeration tanks were in operation, but only one of them had an integral baffle wall and a dedicated anoxic zone. In addition to the baffle wall, the operators had trimmed the length of the tank's original aeration header and added several more diffuser connections to accommodate the reduced aeration tank volume without sacrificing aeration capacity. Meanwhile, the second aeration tank was taken out of service shortly thereafter, due to recess of the college, and work began to erect a baffle wall in that tank.



The mini-SCADA was set to record in one-minute intervals. As the program progressed, it was discovered that the ammonia probe head should be replaced and that the nitrate probe required seal replacement. These two items were done. In addition, with acquisition of a UVAS probe in July, staff began tracking the raw wastewater BOD<sub>5</sub> content using this uniquely calibrated spectrophotometer.

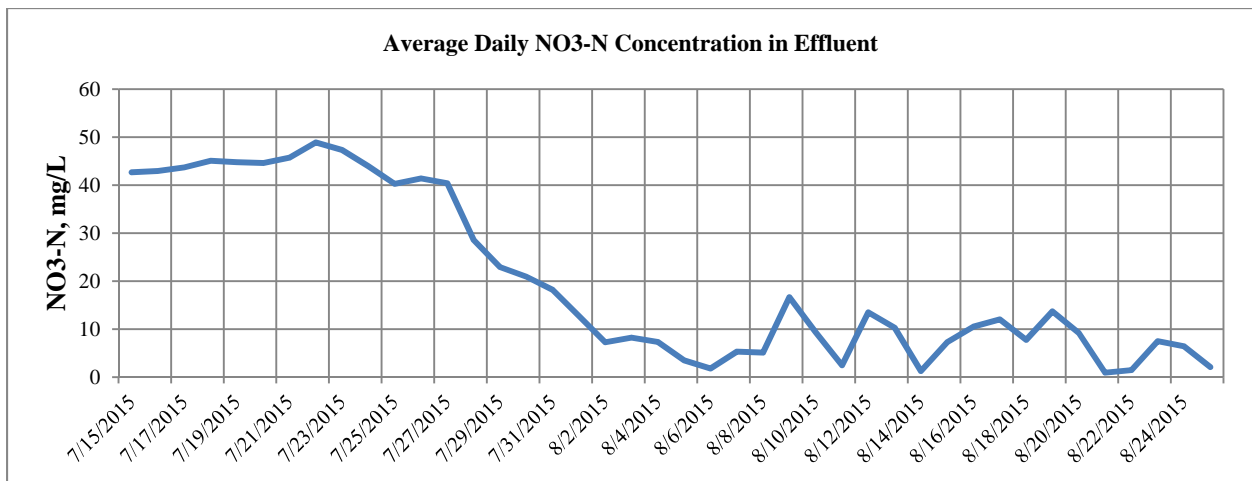
### **Monitoring and Testing:**

Initial testing demonstrated that process alkalinity was low, in the range of 50 mg/L where it ought to have been about 200 mg/L for biologically-mediated nitrification. The conversion of aqueous ammonia to aqueous nitrate ion consumes alkalinity. Successful denitrification (nitrate to molecular nitrogen gas)

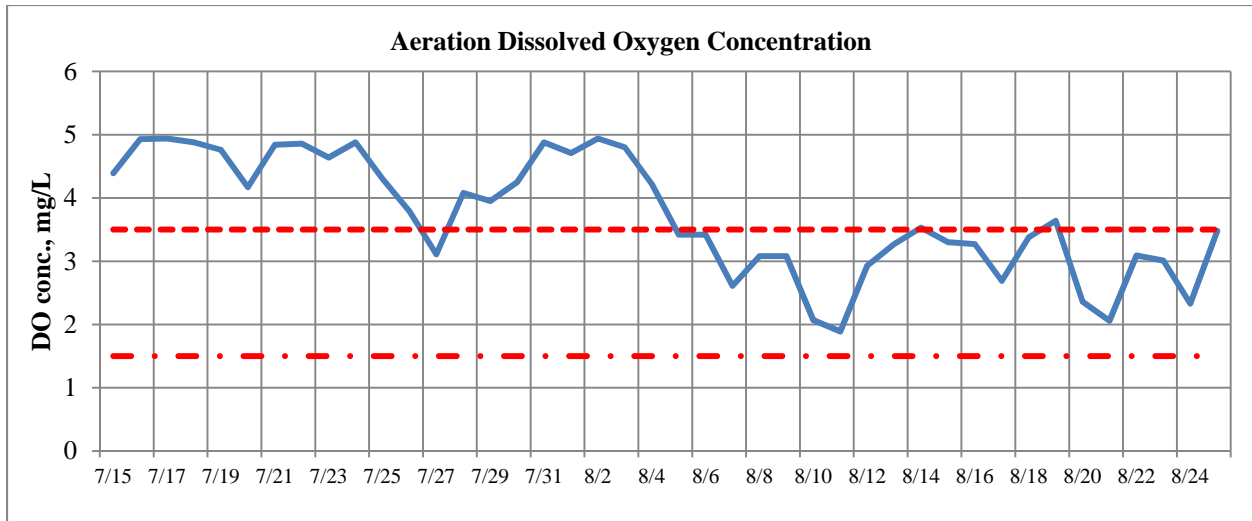
replenishes some, but not all, of that alkalinity, leaving the biomass deficient and thus open to acidification that inhibits the BNR process. Facility staff doubled the amount of sodium bicarbonate they had been adding, in an effort to improve alkalinity.

Following an initial period of data acquisition, DEP and facility staff concluded that the facility was severely deficient in waste carbon necessary to drive the BNR process, and this accounted mainly for the failure of the modified facility to denitrify. Subsequent efforts were taken to source and acquire an appropriate food waste additive, granulated molasses bottom sugars, which would be used to make up some 60 ppd of BOD5 needed for BNR to proceed. Mr. Heinrichs and his staff located mixing equipment and storage tanks for the supplemental carbon source and installed it during late July. Supplemental carbon addition began on July 24. The facility rapidly adapted to the new food source, and the effluent nitrate content diminished markedly.

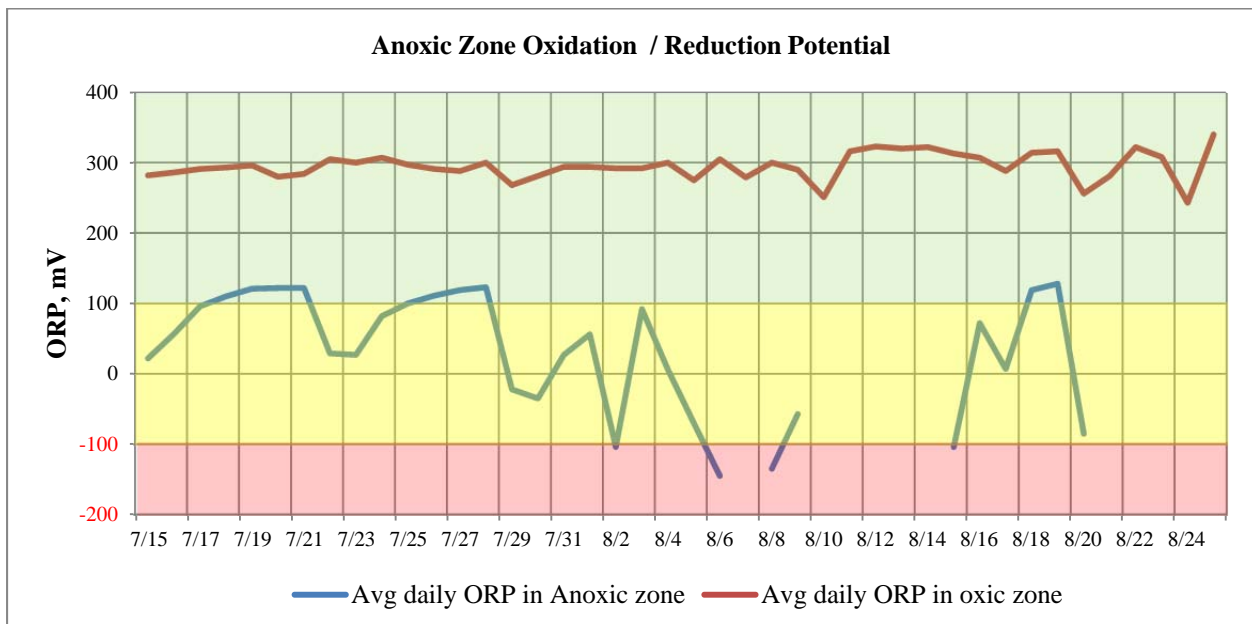
The instruments deployed by DEP recorded in-situ parameters every fifteen minutes. The following graphs are summaries of daily averages calculated from the continuous data. They demonstrate the water chemistry “before” and “after” the Ludzack-Ettinger Process modification:



**Graph 1:** Average Daily NO3-N concentration in Effluent, measured at the discharge end of the secondary clarifiers: This chart shows demonstrable reduction of effluent nitrate following activation of the anoxic denitrification zone with an effective electron source, the diluted molasses waste sugar. The nitrate concentration dropped from a quantity that suggests complete aerobic nitrification (c. 40 mg/L) to less than 7 mg/L, suggesting near-completeness of denitrification by the end of the evaluation.



**Graph 2:** This chart depicts the daily average dissolved oxygen concentration in the oxic zone tanks, where nitrification occurs. The average concentration remained high throughout the study, suggesting a potential for wasted energy once the DO level exceeds 3.5 mg/L. The gradual lessening of concentration over the course of the study is probably due to better regulation of the blower output; however, true control of aeration dissolved oxygen content cannot be attained using the existing blower system. Centrifugal blowers may not be throttled without damaging the compressors. A more modern approach is to replace the existing blowers with positive-displacement (PD) blowers that are controlled using variable frequency motor drives in conjunction with DO feedback loops employing digital DO probes in each of the two oxic zones. The recommended DO range for aeration is 1.5 mg/L to 3.5 mg/L. Any DO concentration higher than 3.5 mg/L represents useless excess DO and, by inference, wasted electrical energy, combined with unnecessary wear on the air compressors themselves.



**Graph 3:** This graph displays the oxidation/reduction potential (ORP,) in millivolts, of the aggregate biomass located in both the oxic and anoxic treatment zones of the modified Ludzack-Ettinger treatment process erected into Tank 1. The top brown line represents average daily ORP in the oxic zone, at or near



+300 mV for most of the evaluation. This is to be expected of complete nitrification under dissolved aeration of the mixed liquor, where the biomass has a net positive charge.

Equally instructive is the blue line representing the ORP of the anoxic denitrification zone. The acceptable range limits for denitrification are between +100 mV and -100 mV. Anything higher represents potentially aerobic conditions, where facultative bacteria will not use nitrate as a metabolic source for oxygen. Values lower than -150 mV represent anaerobic conditions, where facultative bacteria begin to use sulfate and phosphate as oxygen sources, and fermentative bacteria convert carbon to alcohols.<sup>2</sup>

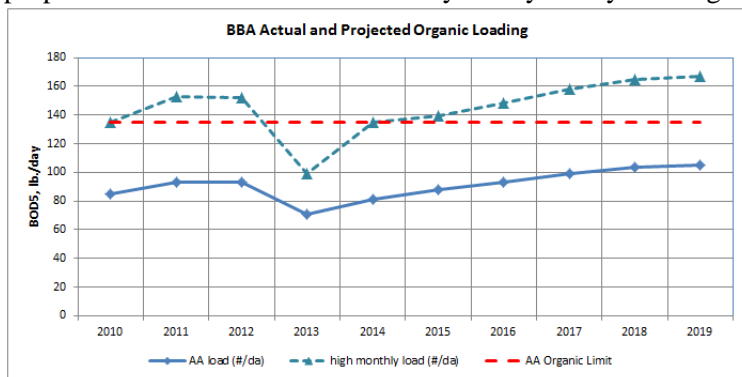
Construction of a baffle wall and aeration modification to the second aeration tank was completed during the second week of August, and the tank was placed into service before August 21, 2015. Solids levels in both tanks were rising to working levels when the field deployment ended on August 25. The facility operator reported that replacement of the original baffle wall with one of more permanent construction would likely occur the following summer, when the facility falls back to 50% operation once the college is dismissed.

In addition, work continues apace to complete the new housing for chemical storage and metering. The new shed will house the supplemental electron source for denitrification, automated conveyor for alkaline slurry, and possible space for precipitants to remove soluble phosphorus.

The facility will have permanently constructed facilities for the management and addition of supplemental carbon, and the facility should be able to meet its proposed effluent total nitrogen limits of 10 mg/L concentration and 1,979 lb./yr.

**Related Issues:**

The MLE adaptations at the BBA facility appear to be working well as of this writing. The operators continue to integrate process monitoring and control techniques as instructed by US EPA’s staff. However, the long-term sustainability of the BBA facility requires further consideration. In light of proposed increases in the student body of Bryn Athyn College and slower, more gradual growth in other



**Figure 4:** Historical and Projected Organic Loading

members of the BBA collection system, it appears that the facility is nearing its 135 lb./day rated organic load limit. This means that the facility may become overloaded within the next five years, resulting in regulatory curtailment of new connections to its collection system. The facility already reported organic overloading during May of both 2011 and 2012.

Reports and their projections for growth that include construction of another dormitory at the college

An analysis of the facility’s recent Municipal Wasteload Management

<sup>2</sup> It should be noted that ORP in the Anoxic Zone should never fall below -150 mV during denitrification: What exceptionally low readings actually represent is the presence of biological slime growing on the ORP probe head, shielding its sensor from the actual mixed liquor, resulting in artificially low ORP values that could be misinterpreted as anaerobic. The recommended practice is to wash the probe head twice per week when it is located in an anoxic process where mixing is less than ideal. The manufacturer also sells an “air-blast cleaning system” that employs compressed air to accomplish this *in situ*.

suggest that the MLE modifications at the facility, while buying time, may not avoid the inevitable requirement to expand, replace, or abandon the existing treatment works. The typical design life of sewage treatment systems is at least twenty (20) years, unless specifically designed for a longer period.<sup>3</sup> Facilities having relatively fixed service population may be designed for up to thirty (30) or forty (40) years; however, anticipated technological changes typically preclude such length of service. BBA's facility has been operating relatively unchanged since the 1970s.

Initially, it may be in the BBA's interests to have its present facility formalized in its NPDES Part II permit and have the current plant re-rated to a higher organic loading based on conversion from conventional treatment to MLE. The present design annual average organic loading could be exceeded as early as next year.

During the summer recess of the college, it was determined that operating ½ of the reactor space would require about 60 lb./day of supplemental carbon, increasing the overall organic loading to the facility. However, by contracting with an engineer to re-rate the existing facility, it may be possible to preserve some capacity for future connections.

The collection system's unique receipt of on-lot treated effluent from its residential customers is difficult to account for in the current Chapter 94 reports. An engineering study may have to be commissioned in order to more clearly define the average annual and the monthly maximum organic loads actually treated by this facility. As it now stands, customers in the collection system have their on-lot treated effluent further processed by the BBA facility. This reduces the highly ammonia and nitrate-rich quality of that effluent, protecting surface and groundwater supplies; however, this effluent water entering the BBA plant may mischaracterize the organic loading, which is based on raw sewage BOD5, not nBOD found in septic tank effluent.

In the future, it may be advantageous to do away with on-lot sewage treatment (septic tanks) and pipe all residential waste as raw sewage to a wastewater treatment facility. BBA ought to consider this if it is required to replace its current wastewater treatment facility as part of a solution to avoiding a future ban on new connections.

There are three options regarding BBA's treatment of increased loadings:

- Substantially replace parts of the existing facility with tankage and support systems sized to deal with increased flow and loading;
- Replace the existing facility with alternative technologies, such as
  - Sequencing Batch Reactors (SBR) that have integrated BNR phases;
  - Advanced wastewater treatment for nitrogen and phosphorus (Bardenpho, A2O, etc.);
- Conversion of the existing facility to a pumping station and contracting with an adjacent municipality or authority to treat its sewage at a larger, more regional facility.

Each of these options brings advantages and costs that must be carefully evaluated in the near future. The Borough would be encouraged to discuss such options with its consulting engineers and, perhaps, begin planning its future wastewater treatment program.

### **Process Monitoring and Control:**

During the evaluation, DEP and EPA staff worked with plant operators to develop strategies for process monitoring and control based upon tried and accepted methods. A variety of tests were demonstrated, along with calculations based upon those test results. Chief among these were the use of volumetric

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<sup>3</sup> p. 137, Tchobanoglous, George, Franklin L. Burton, (Metcalf & Eddy, Inc.) *Wastewater Engineering: Treatment, Disposal, and Reuse, Third Edition*, (McGraw-Hill, Inc., New York, 1991.) Print; also, *Recommended Standards for Wastewater Facilities, 2004 Edition*, (Health Research Inc., Albany, 2004.) Web. 12 Sept. 2015.

solids testing to determine West Sludge Age (AGE) and Food-to-Mass Ratio (F/M) for operational targets. The methods and references were provided to the operators with the expectation that experiential learning would provide baseline operating parameters for the existing and the modified operations. There are at least two AGE and F/M baseline set-points to consider: Warm-weather and Cold-weather operations. The idea is to control sludge wasting rates to achieve constant AGE or constant F/M balance where the operators' experience indicates that the individual facility operates best, with the least chance for plant upsets and with the highest quality of final effluent.

The operators already had some best-operating practices already in effect. Chief among these were their method of determining sludge settleability and settled sludge concentration by employing a digital camera to record settled sludge volume at regular intervals. In addition, the operators were using a centrifuge to determine sludge concentration by volume, which produces data necessary to determine sludge age.

Methods for determining sludge wasting rates and volumes are on-going. A more precise method of tracking wasted sludge loadings will help to accurately account for the operational sludge age and also for the ultimate disposal of biosolids. DEP staff strongly encourages these ongoing activities.

### **Best Management Practices:**

Attachment 9, following, includes evaluation comments on additional best-management practices that will enhance the operation and maintenance of the treatment works and its associated collection system. For example, recent regulatory changes enacted to protect wastewater plant operators require the use of written Standard Operating Procedures for and in-plant activities that affect effluent water quality. These SOPs must be signed by the facility owner's designated operator-in-responsible-charge ("operator") of process control decisions, and they are directed to be used by other persons operating the facility during times when the operator is off-site or off-duty. SOPs should be in place and available for review as part of routine operations. Other practices listed in the Attachment include provisions for spill control, waste sludge disposal planning, asset management and maintenance planning.

### **Recommendations:**

Based on the findings and discussion in this evaluation, DEP's WWTAP recommends the following:

- Continue efforts to operate the facility based on the results of regular process monitoring and control testing, with an eye toward employing accepted methods of sludge age, mean cell-residence time, or food-to-mass ratio.
- Obtain regulatory clearances including NPDES Part II permit amendment to allow facility to operate as a modified Ludzack-Ettinger process and finalize conversion of the facility begun during the optimization study;
- Have consulting engineer evaluate and re-rate modified facility for increased organic load, taking into consideration also the facility's intent to install flow equalization;
- Replace the temporary baffle wall in aeration tank #1 in summer of 2016;
- Secure and maintain one or two regular sources of supplemental carbon;
- Install monitoring probes and systems to permit better control of dissolved oxygen levels in the aeration tanks, including installation of in-line Dissolved Oxygen and Oxidation / Reduction Potential probes that will permit optimization of aeration, BNR, and energy consumption;
- Replace existing centrifugal blower units with positive-displacement blowers that are controlled with variable-speed drive and DO feedback technology;
- Establish standard operational procedures for maintaining regular process monitoring and control as described during on-site evaluation;
- Write a laboratory testing manual specific to the facility, instructing operators in standard methods for determining treatment parameters;

- Reorganize laboratory functional space to permit increased process monitoring<sup>4</sup>;
- Develop a sludge management plan having at least one backup facility available to receive and process waste sludge or reed bed wastes;
- Develop Spill Prevention Control & Counter-measures for chemicals and supplements used and stored on site;
- Examine and/or incorporate the use of asset management planning into the overall strategy for monitoring and replacing equipment on a cost-effective basis.
- Improve upon Municipal Wasteload Management Reporting with more accurate accounting of population trend's impact on organic loading, with clearer understanding of wastewater sources and types and their impact on the collection system hydraulics, and account for precipitation, inflow, and infiltration effects on hydraulic surges that necessitated approval of an equalization tank.

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<sup>4</sup> The operator spoke of his intent to install replacement PD blowers adjacent to the aeration tanks, increasing room in the control building after the existing centrifugal blowers are removed.

**ATTACHMENTS**

1. Evaluation Team
2. Operational Parameters / Dimensions / Design
3. Existing and Proposed NPDES Limits
4. Equipment List
5. Record Photographs
6. Example Graphs and Charts from WTE
7. Recommended Additional Equipment (process & monitoring)
8. Recommended Process Monitoring Parameters (Internal PM tests w/frequencies)
9. Recommended Documentation / Programs
  - a. Standard Operations Procedures
  - b. Laboratory Manual for Process Monitoring
  - c. Solids Management Plan
  - d. Spill Prevention, Control, & Countermeasures document
  - e. Asset Management w/ capitals planning
  - f. Municipal Wasteload Management Reporting

**ATTACHMENT 1**

**Evaluation Team**

Marc Austin Neville, Water Prgm. Spec.  
PA DEP WWTAP  
Rachel Carson State Office Bldg.  
POB 8774  
Harrisburg, PA 17105  
Tel. (717) 772-4019  
Eml. [mneville@pa.gov](mailto:mneville@pa.gov)

David Burke, Watershed Manager  
PA DEP Clean Water Program  
Southeast Regional Office  
2 East Main Street  
Norristown, PA 19401  
Phone: (484) 250-5822  
Eml. [daburke@pa.gov](mailto:daburke@pa.gov)

**US EPA Region III TA Program**

Jim Kern  
US EPA Region III  
Market Street  
Philadelphia, PA  
Tel. (215) 814-5788  
Eml. [kern.james@epa.gov](mailto:kern.james@epa.gov)

Walter Higgins  
US EPA Region III  
Market Street  
Philadelphia, PA  
Tel. (215) 814-5476  
Eml. [higgins.walter@epa.gov](mailto:higgins.walter@epa.gov)

**Borough of Bryn Athyn STP**

Reid Heinrichs—Superintendent  
Borough of Bryn Athyn STP  
2851 Buck Road  
Bryn Athyn, PA 19003  
Tel. (267) 358-0970  
Eml. [reidh@brynathynboro.org](mailto:reidh@brynathynboro.org)

ATTACHMENT 2Operational Parameters:

AADF:	0.065 MGD
Max Flow:	0.080 MGD
Daily Design BOD5 Load	135 lb./day
Average Monthly Flow (Summer):	0.045 MGD
Waste Sludge Pump Rate:	60 gal./min.

Tank Dimensions:

Aeration Tanks, Original:	0.042 MG x 2 ea. = 0.084 MG
Secondary Clarifiers, Original:	0.025 MG x 2 ea. = 0.050 MG
Disinfection Contact Tank	0.011 MG x 2 ea. = 0.022 MG

Total capacity: 0.156 MG

Development of West Sludge Inventory:

In lieu of gravimetric solids tests, the facility may employ volumetric solids testing by centrifuge. The resultant concentration of solids is described in terms of percent-by-volume [ or % (v/v) .] Development of sludge inventory is based on multiplying the volume of the tankage by the percent solids by volume to produce a dimensionless quantity of sludge units (SU.) For example, in the pre-Ludzack-Ettinger Process facility, the quantities of sludge inventory are calculated thusly:

$$\begin{aligned} \text{Aeration Sludge Units (ASU)} &= \text{Centrifuge result (\%, v/v)} \times \text{Volume under Aeration (MG)} \\ &= 3.5 \%, \text{ v/v} \times 0.084 \text{ MG} = 0.294 \text{ SU} \end{aligned}$$

Because the quantity is dimensionless, it is much easier to understand if rationalized where volume is calculated in terms of thousands-of-gallons (kgal) instead of millions (MG):

$$= 3.5\%, \text{ v/v} \times 84 \text{ kgal} = 294 \text{ SU}$$

Likewise, clarifier sludge units (CSU) = 2.2% x 50 kgal = 110 SU

Waste sludge quantity is calculated based on % v/v of the Clarifier underflow, where the percent solids by volume of the return sludge is measured:

Waste Sludge Fraction (WSF %, v/v) = Centrifuge solids %, v/v, of RAS or WAS (depending on source; usually, the same pump conveys thickened sludge from the clarifier underdrain)

$$\begin{aligned} \text{Waste Sludge Units (WSU)} &= \text{WSC \%, v/v} \times \text{Volume wasted, in kgal} \\ &= 7.8\%, \text{ v/v} \times 2.58 \text{ kgal} = 20.12 \text{ SU} \end{aligned}$$

$$\text{Then West Sludge Age (AGE) becomes: } \frac{\text{Total sludge units in facility (TSU)}}{\text{Total sludge removed (WSU)}} = \frac{404 \text{ SU}}{20.1 \text{ SU/day}} = 20 \text{ day}$$

In this example, a 20-day sludge age places the operation in the “extended aeration” mode, where one would expect that both effluent BOD5 and effluent NH3-N would be almost fully consumed.

Post-Modification:

Following modification of the aeration tanks to accommodate the MLE process, the working dimensions of the tankage were recalculated:

Operational Parameters:

AADF: 0.065 MGD  
 Max Flow: 0.080 MGD  
 Daily Design BOD5 Load 135 lb./day  
 Average Monthly Flow (Summer): 0.045 MGD  
 Waste Sludge Pump Rate: 60 gal./min.

Tank Dimensions:

Anoxic Mixing Zone 0.014 MG x 2 ea. = 0.028 MG  
 Oxidic Treatment Zone 0.028 MG x 2 ea. = 0.056 MG Total: 0.084 MGD

The anoxic zone receives up to 4 Q of flow under normal operation. This includes Influent WW (Q,) RAS at 100% of Q, and IMLR at approximately 200% of Q. Given the variant of sources, it is suggested that the solids-by-volume of the anoxic zone be tested whenever the other centrifuge solids tests are performed. As a result, the calculation of AGE becomes:

- AnoxicSU = ASC Centrifuge result (% , v/v) x Volume under Aeration (MG)
- OxicSU = OSC Centrifuge result (% , v/v) x Volume under Aeration (MG)
- RSU = RSC Centrifuge result (% , v/v) x Volume under Aeration (MG)
- WSU = Usually, this is the RSF % , v/v x Volume Wasted from System, as a rate, (MGD)
- TSU = Σ (ASU, OSU, CSU)
- AGE = TSU ÷ WSU Result expressed in “days”

Location	SF %, v/v	Volume	SLU
Oxic 1	3.2	28	90
Anoxic 1	3.6	14	50
Oxic 2	3.3	28	92
Anoxic 2	3.5	14	49
RAS	7.8	84.4	658
WAS	7.8	2.0	16
Clarifier1	1.8	25	45
Clarifier2	2.2	25	55

TSU = 381 s.u.  
 WSU = 16 s.u.  
**AGE = 24.0 days**

**Table 2.1:** Calculations for West Sludge Age (AGE)  
 Ref. Activated Sludge, MOP-9, WPCF, 1987.



**ATTACHMENT 3**  
 Borough of Bryn Athyn NPDES PA0030023 Permit Limits

Effluent Limitations								
Discharge Parameter	Mass Units (lbs/day)		Concentrations (mg/L)				Monitoring Requirements	
	Average	Maximum	Inst. Minimum	Monthly Average	Weekly Average	Maximum	Minimum Measurement Frequency	Required Sample Type
Flow	Report	Report Daily Max	xxx	xxx	xxx	xxx	Continuous	Recorded
pH	xxx	xxx	6.0	xxx	xxx	9.0	Daily	Grab
Dissolved Oxygen	xxx	xxx	5.0	Report	xxx	xxx	1/day	Grab
Total Residual Chlorine	xxx	xxx	xxx	0.4	xxx	0.9	1/day	Grab
CBOD5 (05/01 – 10/31)	3.69	5.53	xxx	6.8	10.2	13.6	2/month	24-hr
CBOD5 (11/01 – 4/30)	7.37	11.6	xxx	13.6	20.4	27.2	2/month	comp
Total Suspended Solids	5.4	8.1	xxx	10	15	20	2/month	24-hr comp
Total Dissolved Solids	542	1,084 Daily Max	xxx	1,000	2,000	2,500	1/quarter	24-hr comp
Fecal Coliform 5/1 - 9/30	xxx	xxx	xxx	200 Geo Mean	xxx	1000*	2/month	Grab
Fecal Coliform 10/1 - 4/30	xxx	xxx	xxx	200 Geo Mean	xxx	1000*	2/month	Grab
Nitrate-Nitrite N	Report	xxx	xxx	Report	xxx	20	2/month	24-hr comp
Ammonia-N (05/01 – 10/31)	1.52	xxx	xxx	2.8	xxx	5.6	2/month	24-hr
Ammonia-N (11/01 – 04/30)	4.56	xxx	xxx	8.4	xxx	16.8	2/month	comp
Total Phosphorus	Report	xxx	xxx	Report	xxx	xxx	2/month	24-hr comp

\* Shall not exceed in more than 10 percent of samples taken. See Other Requirements, No. P

Table 3.1: Effluent Limitations through 12/31/2015

Effluent Limitations								
Discharge Parameter	Mass Units (lbs/day)		Concentrations (mg/L)				Monitoring Requirements	
	Average	Maximum	Inst. Minimum	Monthly Average	Weekly Average	Maximum	Minimum Measurement Frequency	Required Sample Type
Flow	Report	Report Daily Max	xxx	xxx	xxx	xxx	Continuous	Recorded
pH	xxx	xxx	6.0	xxx	xxx	9.0	Daily	Grab
Dissolved Oxygen	xxx	xxx	5.0	Report	xxx	xxx	1/day	Grab
Total Residual Chlorine	xxx	xxx	xxx	0.4	xxx	0.9	1/day	Grab
CBOD5 (05/01 – 10/31)	3.69	5.53	xxx	6.8	10.2	13.6	2/month	24-hr
CBOD5 (11/01 – 4/30)	7.37	11.6	xxx	13.6	20.4	27.2	2/month	comp
Total Suspended Solids	5.4	8.1	xxx	10	15	20	2/month	24-hr comp
Total Dissolved Solids	542	1,084 Daily Max	xxx	1,000	2,000	2,500	1/quarter	24-hr comp
Fecal Coliform 5/1 - 9/30	xxx	xxx	xxx	200 Geo Mean	xxx	1,000*	2/month	Grab
Fecal Coliform 10/1 - 4/30	xxx	xxx	xxx	200 Geo Mean	xxx	1,000*	2/month	Grab
Nitrate-Nitrite N	5.4	xxx	xxx	10	xxx	20	2/month	24-hr comp
Ammonia-N (05/01 – 10/31)	1.52	xxx	xxx	2.8	xxx	5.6	2/month	24-hr comp
Ammonia-N (11/01 – 04/30)	4.56	xxx	xxx	8.4	xxx	16.8	2/month	24-hr comp
Total Phosphorus	Report	xxx	xxx	Report	xxx	xxx	2/month	24-hr comp

\* Shall not exceed in more than 10 percent of samples taken. See Other Requirements, No. P

Table 3.2: Effluent Limitations through 1/1/2016 through expiration of Permit

**ATTACHMENT 4****Digital, Continuously Monitoring Probes  
Laboratory Equipment On-Loan**

The WTE employs several instruments with which to analyze and record data on the operation of the facility. Much of this equipment is the same as that being specified for the operation and maintenance of BNR treatment facilities. Oftentimes, it has been found that BNR facilities requesting assistance of WWTAP have had similar equipment specified by the engineers designing new or upgraded BNR facilities, but much of the instrumentation is either cut from the project in an effort to reduce overall costs, or the equipment that is provided is not sufficiently maintained by operators who are unfamiliar with the technology and the maintenance it requires.

Facility owners may find, following a WTE, that acquisition and implementation of similar monitoring equipment will enhance facility performance. While the Department of Environmental Protection cannot recommend any specific manufacturer or vendor, it does suggest that those facility owners wishing to implement this technology consult with their facility engineers on the proper specification and siting of this equipment.

All new monitoring equipment should be adequately maintained according to its manufacturer's recommendations. This may impose additional work requirements for treatment plant staff and should be accounted for in allocating and scheduling manpower. The Department also recommends that this and any new equipment be tracked using commonly available asset management programs to assure their timely maintenance and replacement.

**Digital, Continuously Monitoring Probes:**

- 1 – Laptop computer with signal converter
- 2 – SC1000s w/Universal Touch Display
- 1 – UVAS probe
- 2 – LDO probes
- 1 – Solitax probe
- 1 – pH probe,
- 2 – ORP probes
- 1 – AISE Ammonium Probe
- 1 – Nitrate Probe

**Laboratory Equipment On-loan:**

- 1 – Hach HQ40d handheld pH and LDO meter
- 1—Hach BOD dissolved oxygen probe
- 1 – DR2800 spectrophotometer with Environmental QA Lab  
TNTplus test vials for measuring Nitrate-LR, Ammonia-LR, Alkalinity, Phosphorus-  
Total-HR
- 1 – Digital Reactor Block
- 1—Phase-contrast, recording Microscope
- Laboratory Thermometer, Assorted glassware and sampling equipment

**Attachment 5**  
**Record Photographs**



**Figure 5-1:** Overview of STP from former Comminutor vault



**Figure 5-2:** View of Reed Beds and Influent Sampling Shack



**Figure 5-3:** Modified MLE Tank with WTE Probes Installed



**Figure 5-4:** Clarifier Effluent End with WTE Probes Installed



**Figure 5-5:** Influent Parshall Flume with BOD probe in well



**Figure 5-5:** Anoxic zone with SC1000 display and 2 probes



**Figure 5-7:** Overview of STP from former Comminutor vault



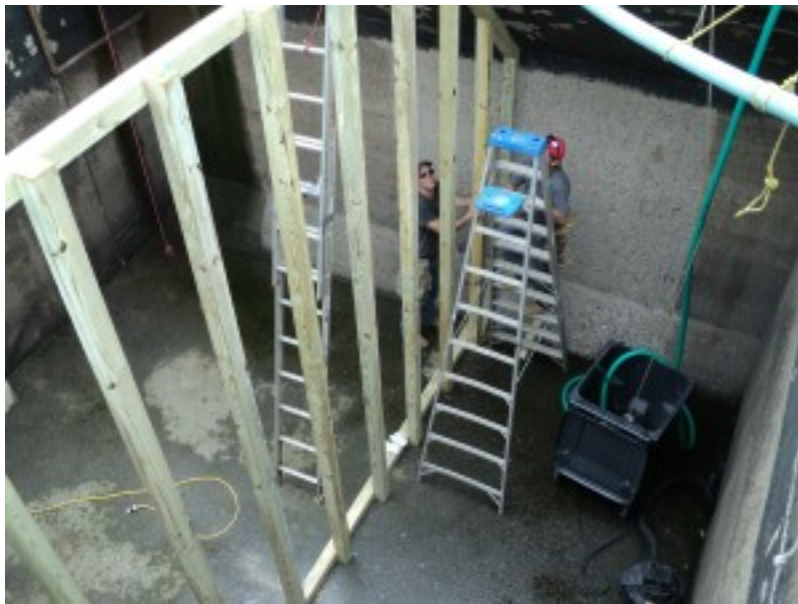
**Figure 5-8:** Downstream disinfection facilities & effluent sampler



**Figure 5-9:** Reciprocating sludge pumps



**Figure 5-10:** Original air header for Tank 2



**Figure 5-11:** Construction of Baffle Wall in existing aeration tank



**Figure 5-12:** Completed wall in place for oxic / anoxic zones



**Figure 5-13:** Foundation for supplemental carbon feed building



**Figure 5-14:** Temporary carbon feed arrangement & pump shed

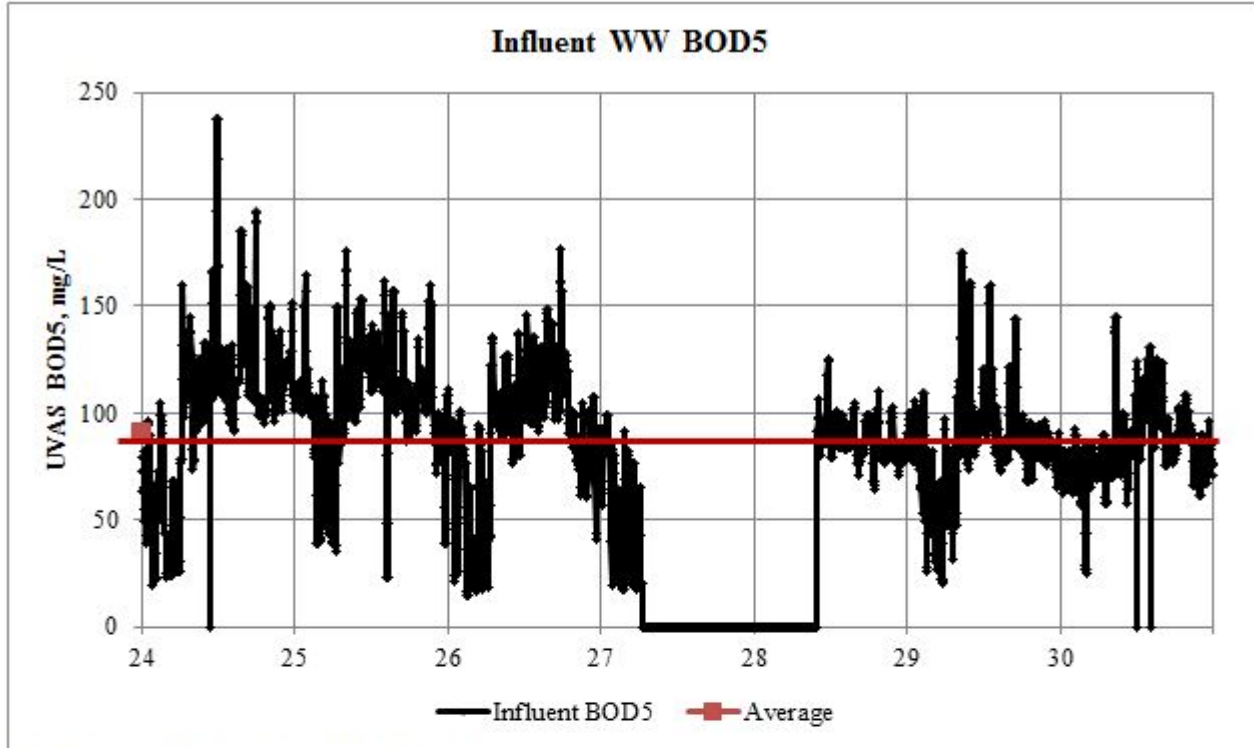


**Figure 5-15:** Aeration Header Separation in Process

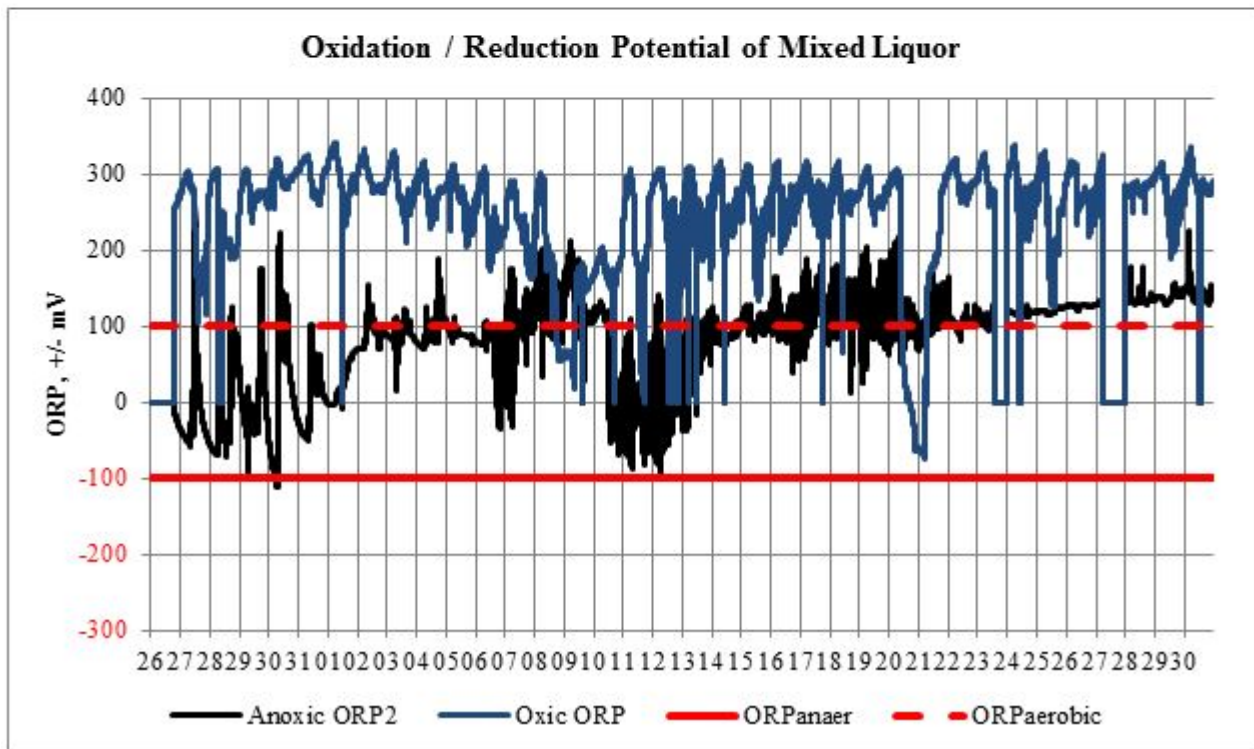


**Figure 5-16:** Settleometry Test Rig

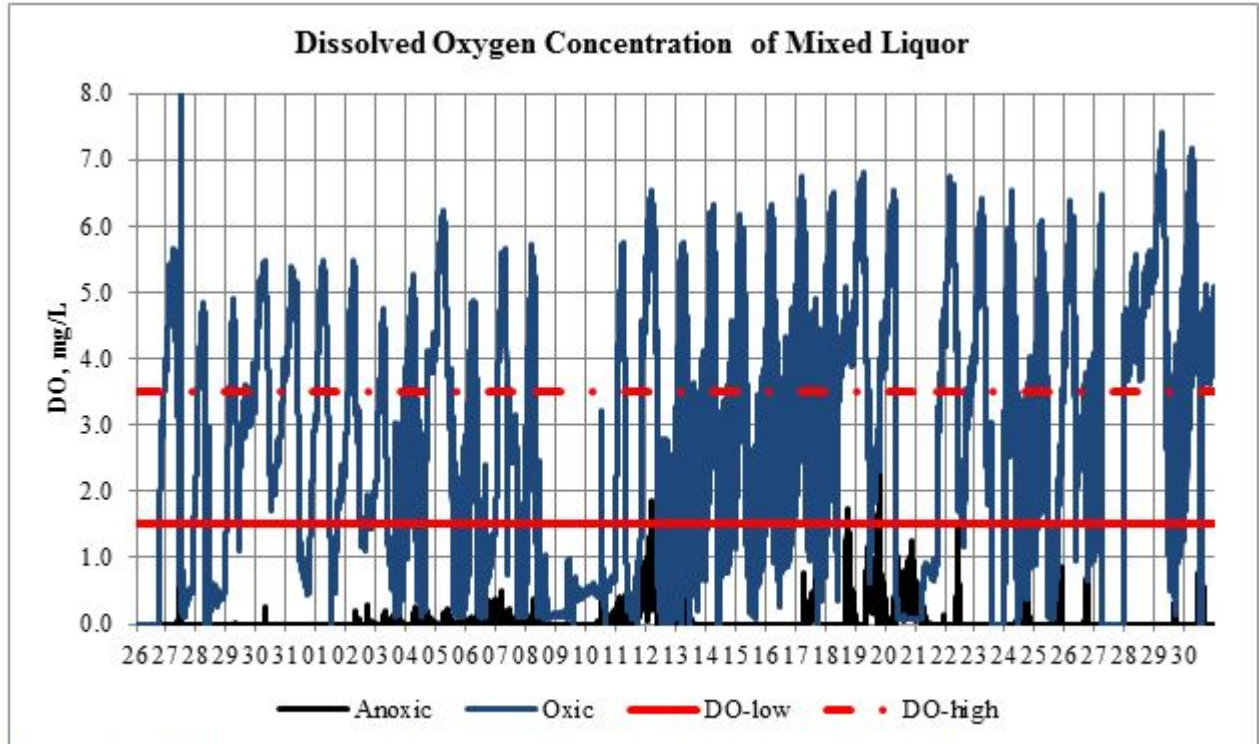
**ATTACHMENT 6**  
Recorded Graphs



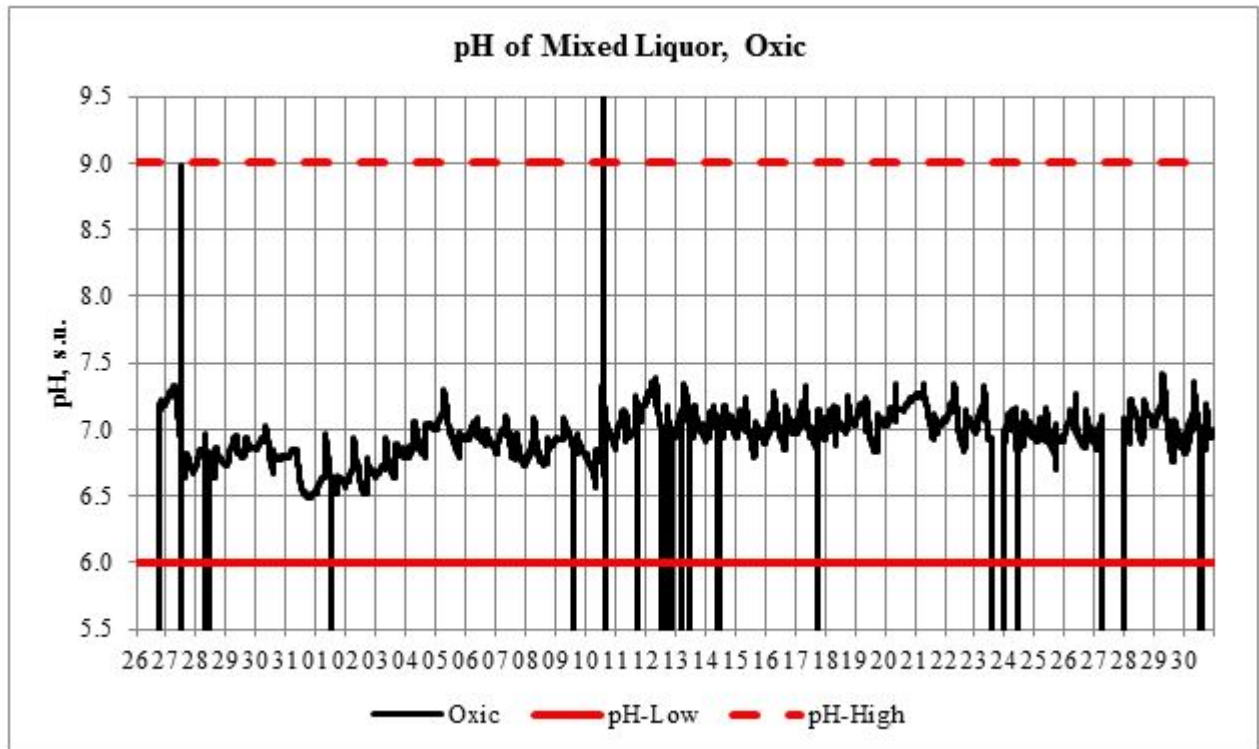
June 2015 Raw Wastewater BOD5 by UV Spectroscopy



June 2015 Oxidation / Reduction Potential in Oxic and Anoxic Tanks, before sugar addition (low denitrification rates)

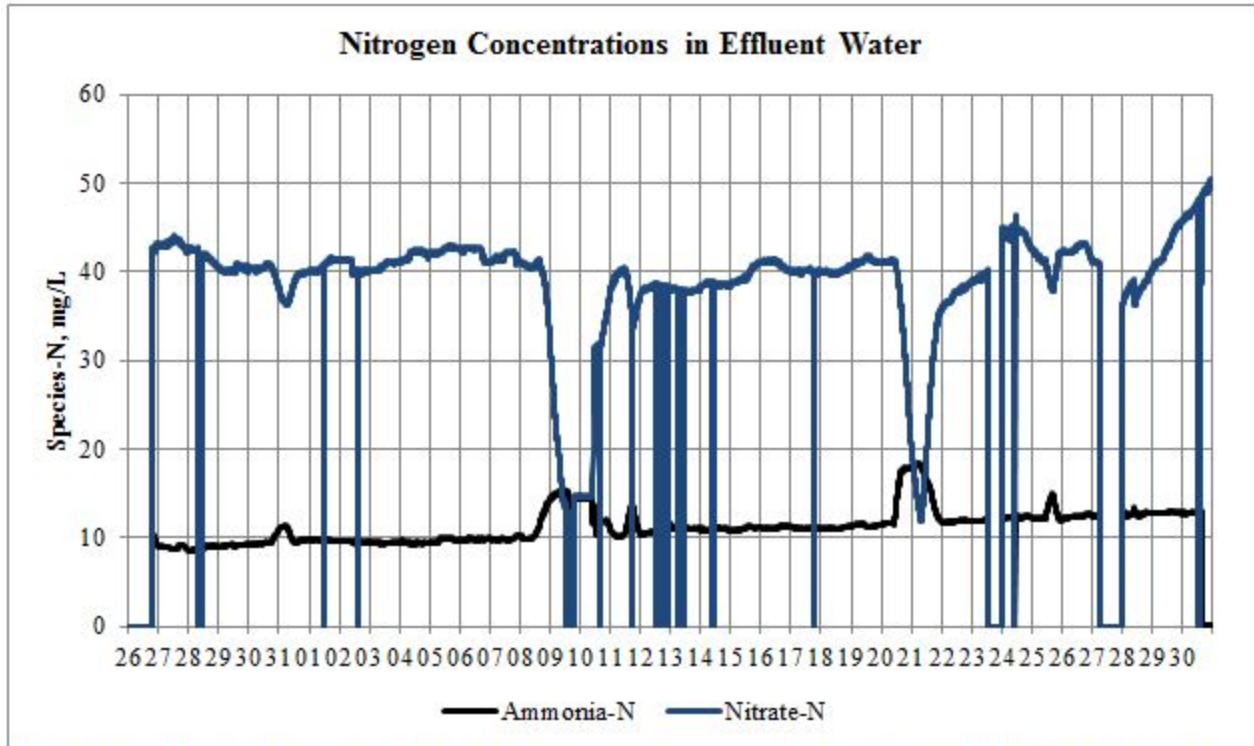


June 2015 Dissolved Oxygen Concentration in Oxidic and Anoxic Tanks: Note excess DO residual = wasted energy

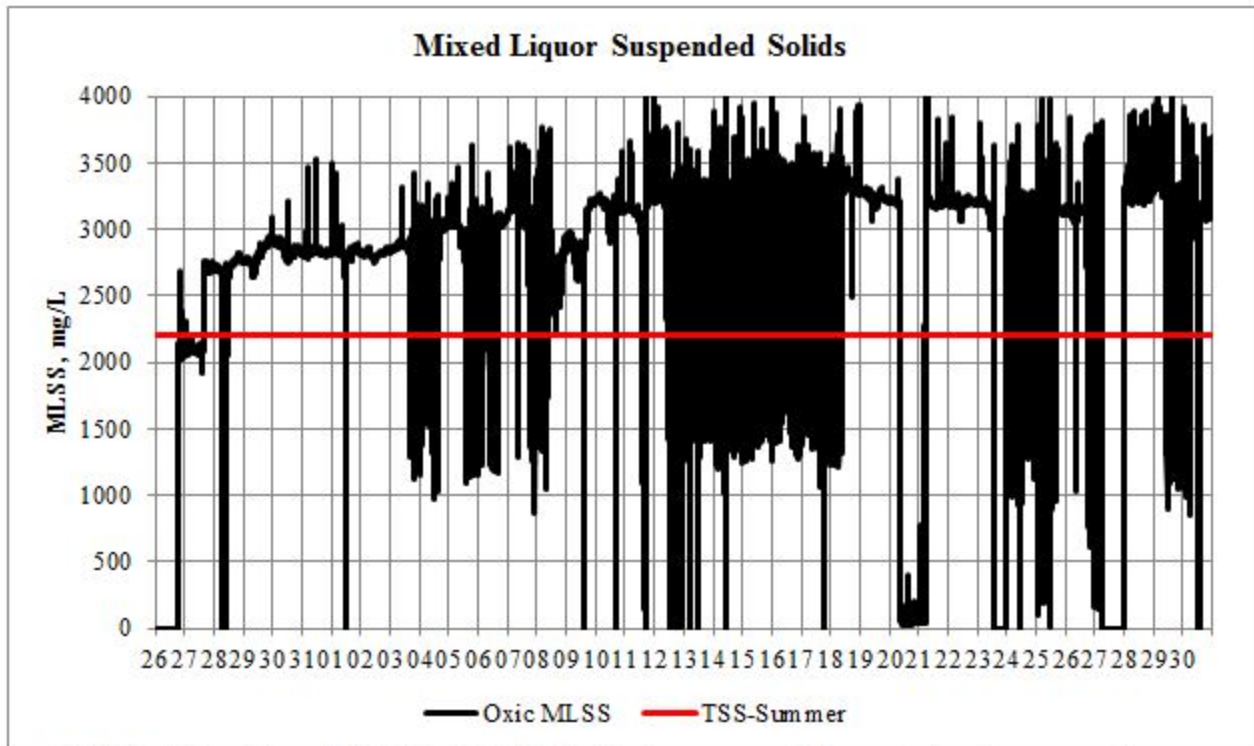


June 2015 Mixed Liquor pH in Oxidic Zone: High spikes represent calibration/ lows denote power outages

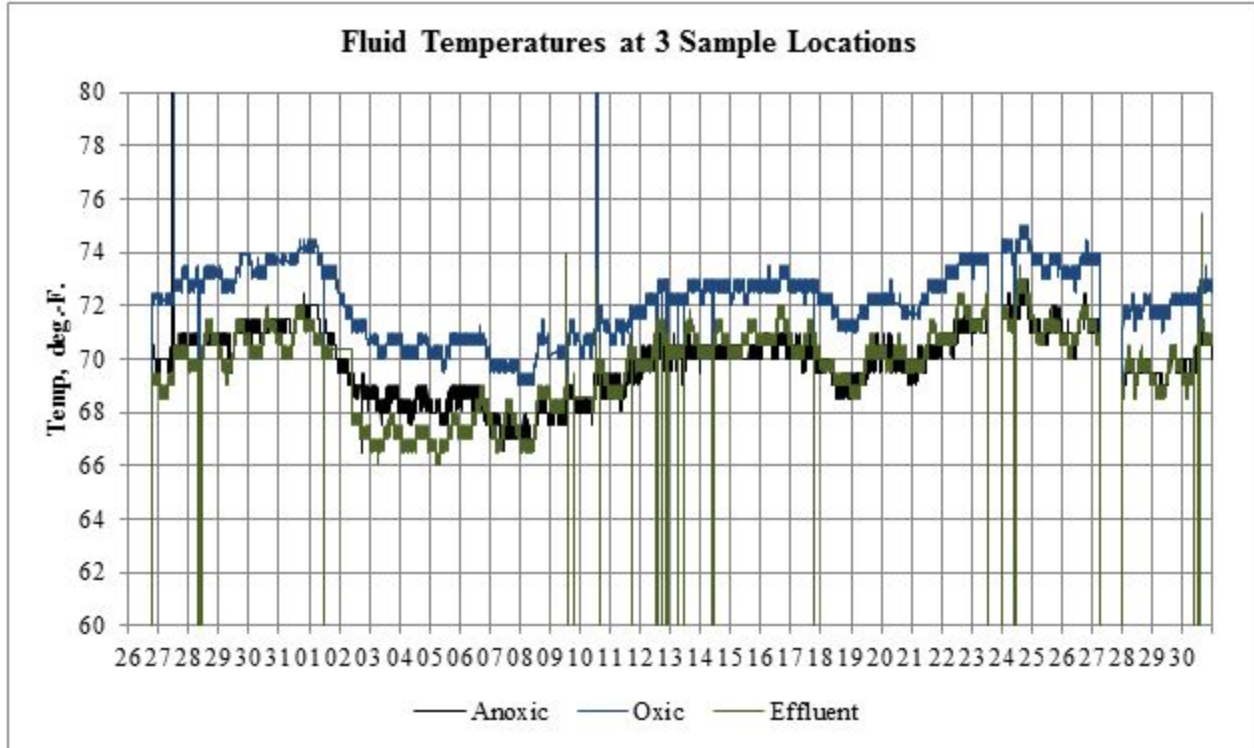




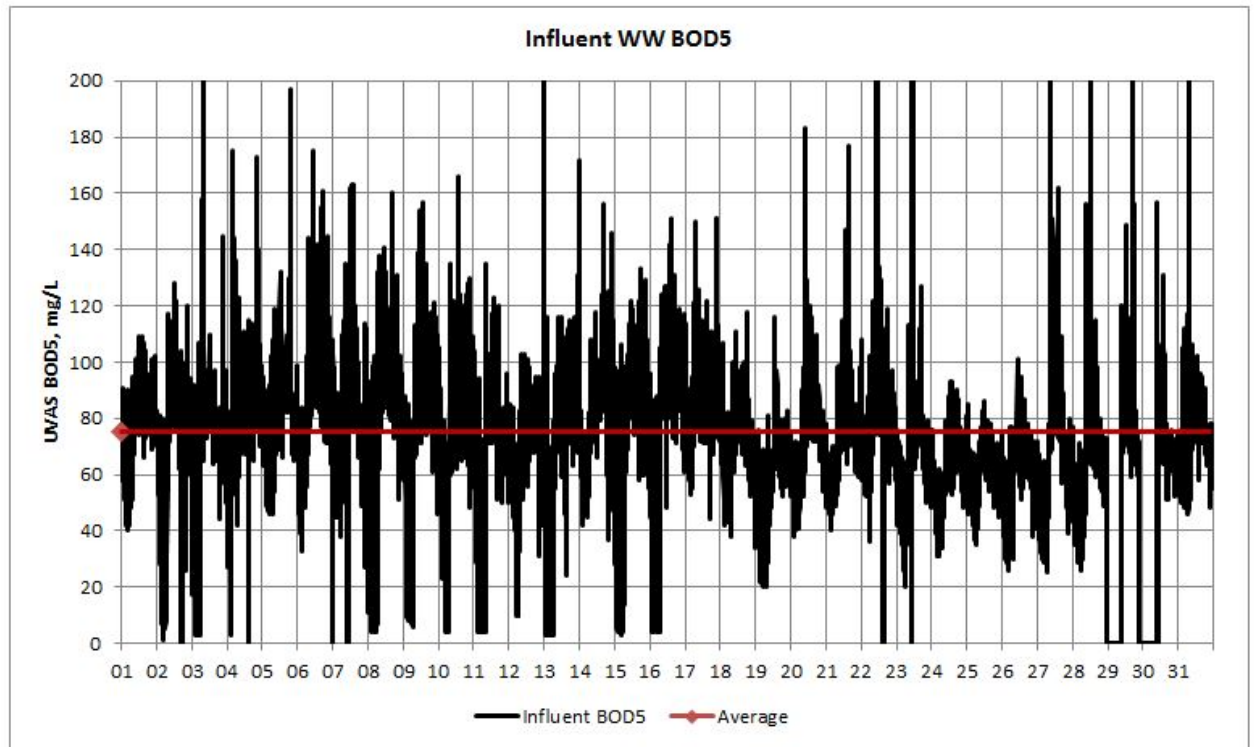
June 2015 Ammonia-N and Nitrate-N in Clarifier Effluent: note: ammonia-N of 10-12 mg/L and high nitrate-N at 40-50 mg/L



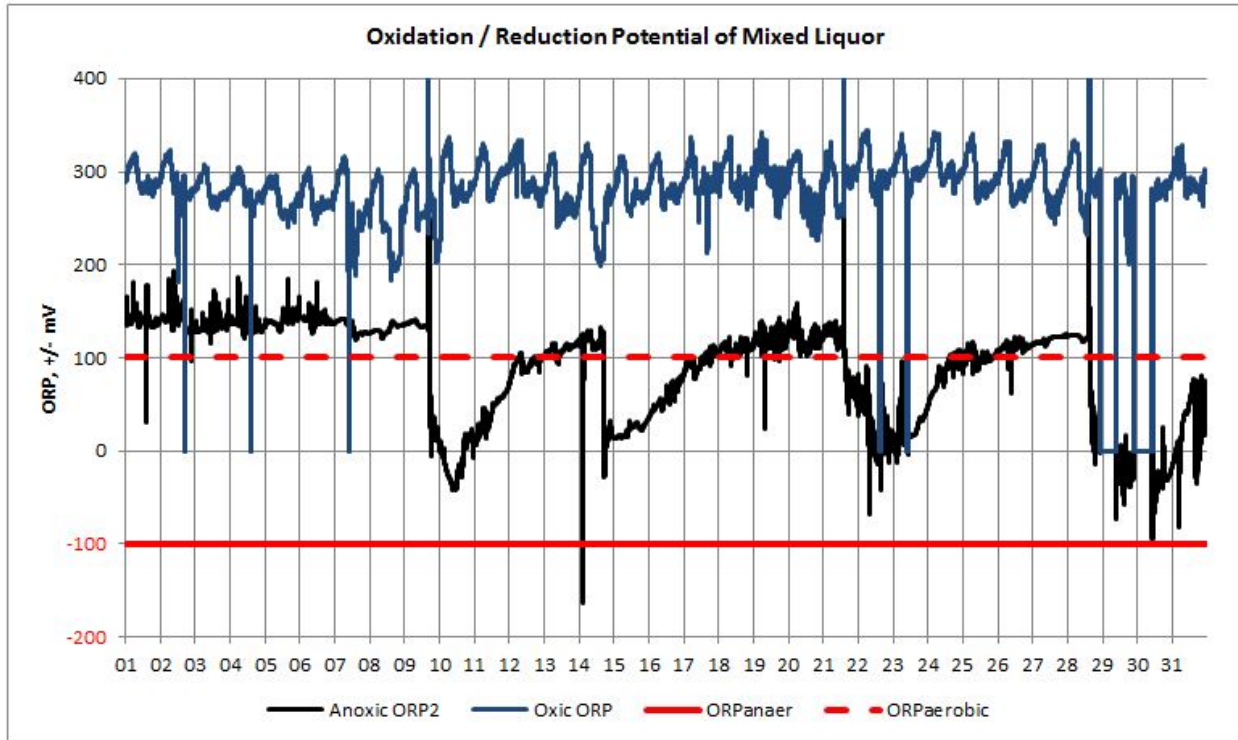
June 2015 Mixed Liquor Suspended Solids in Oxidic Tank, by IR, above recommended concentrations for warm weather



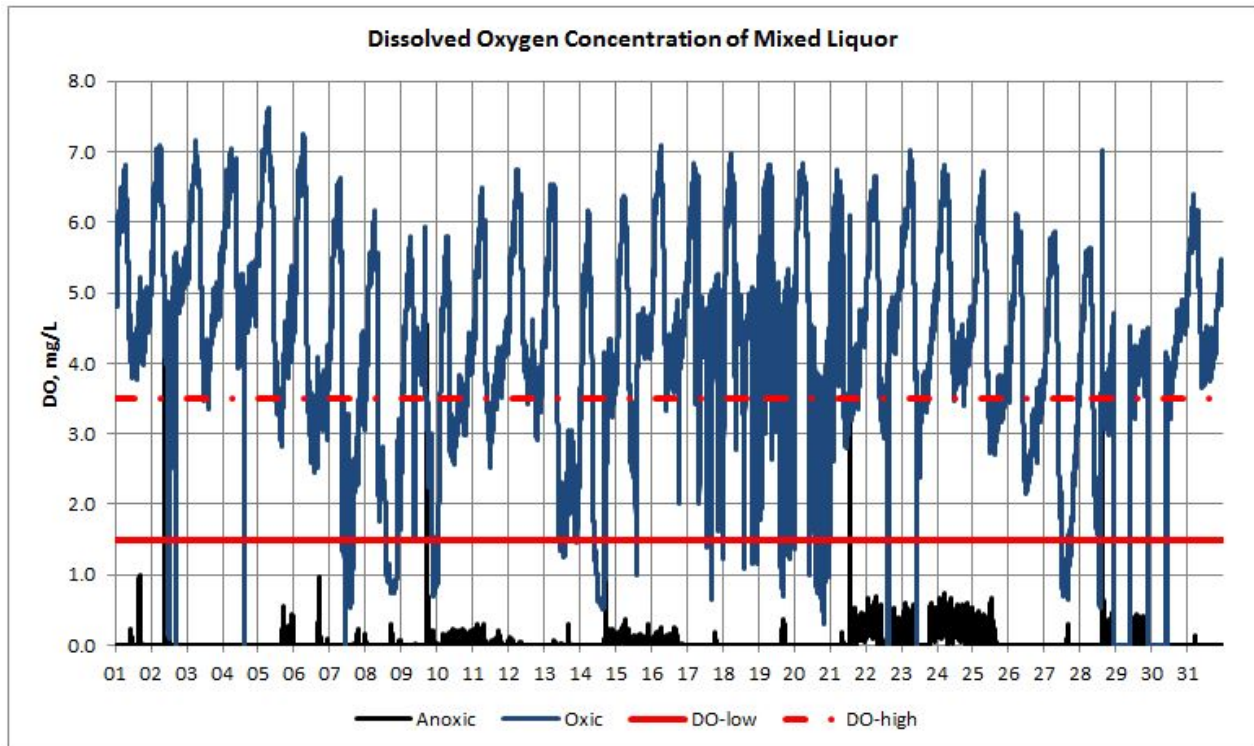
June 2015 Fluid Temperatures at Anoxic, Oxic, and Clarifier Effluent Tanks



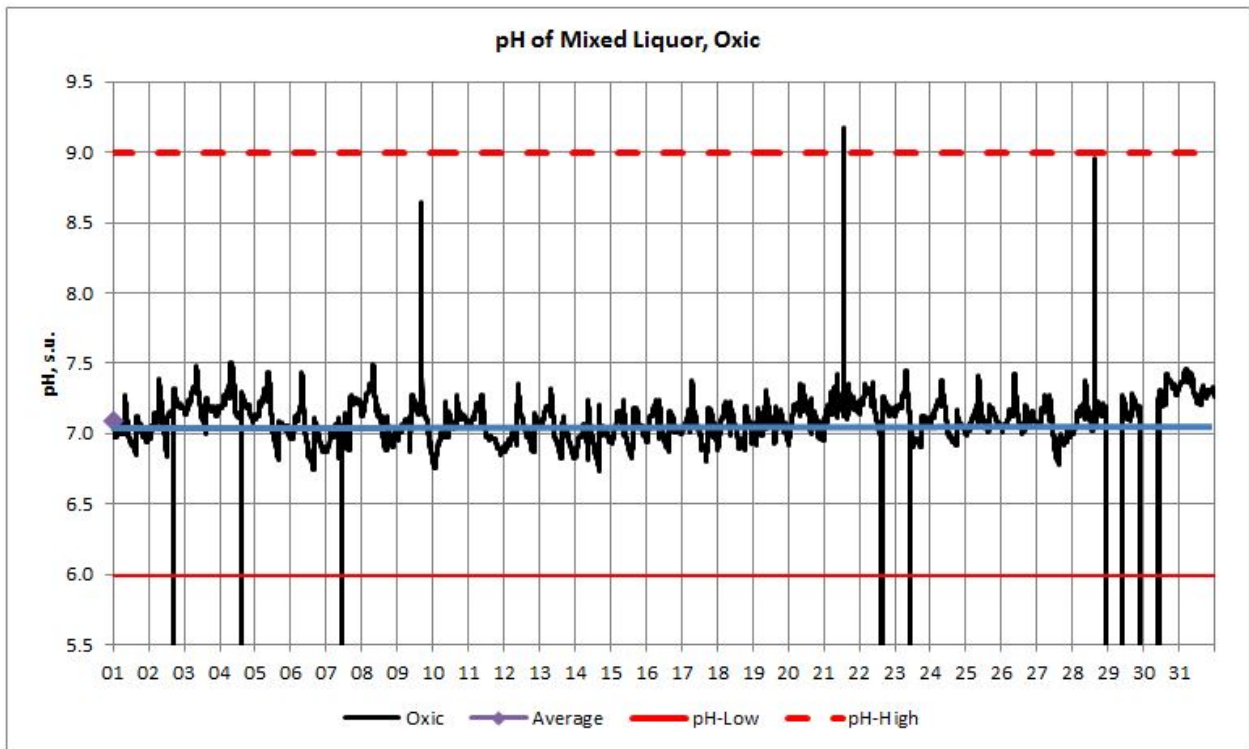
July 2015 Raw Wastewater BOD5 by IR Spectroscopy



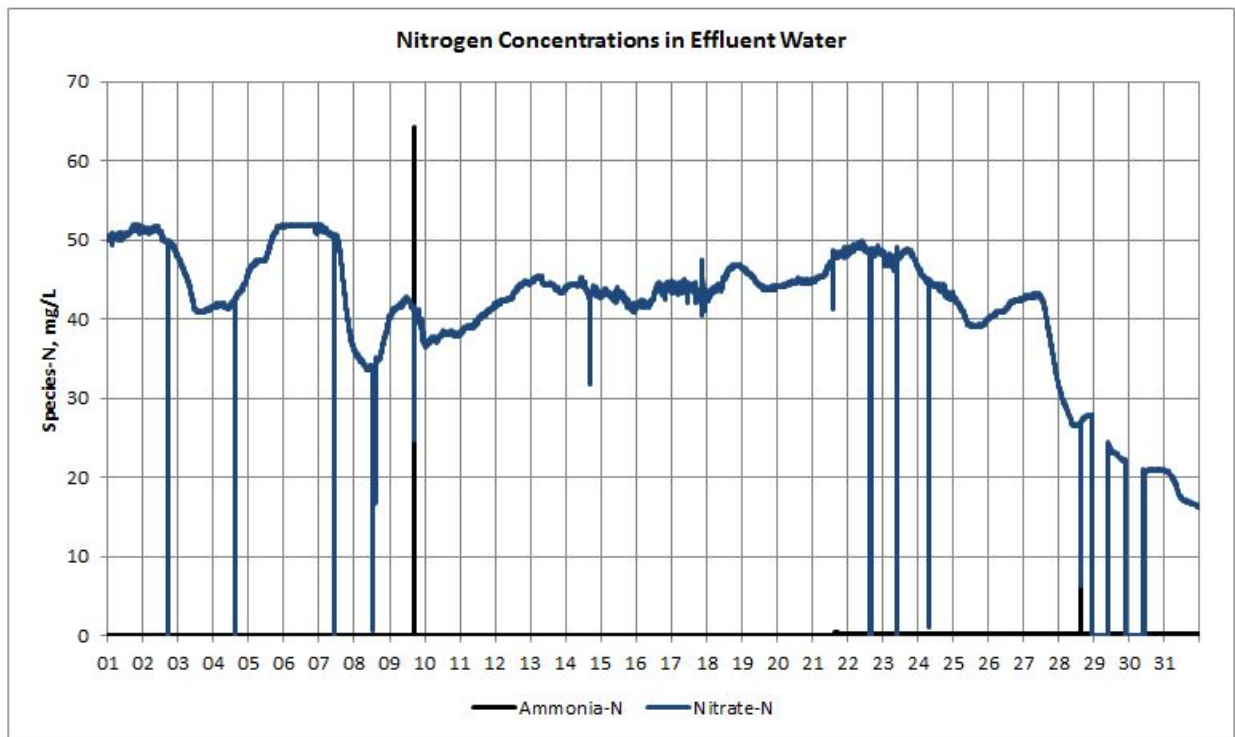
July 2015 Oxidation / Reduction Potential of Anoxic and Oxidic Tanks



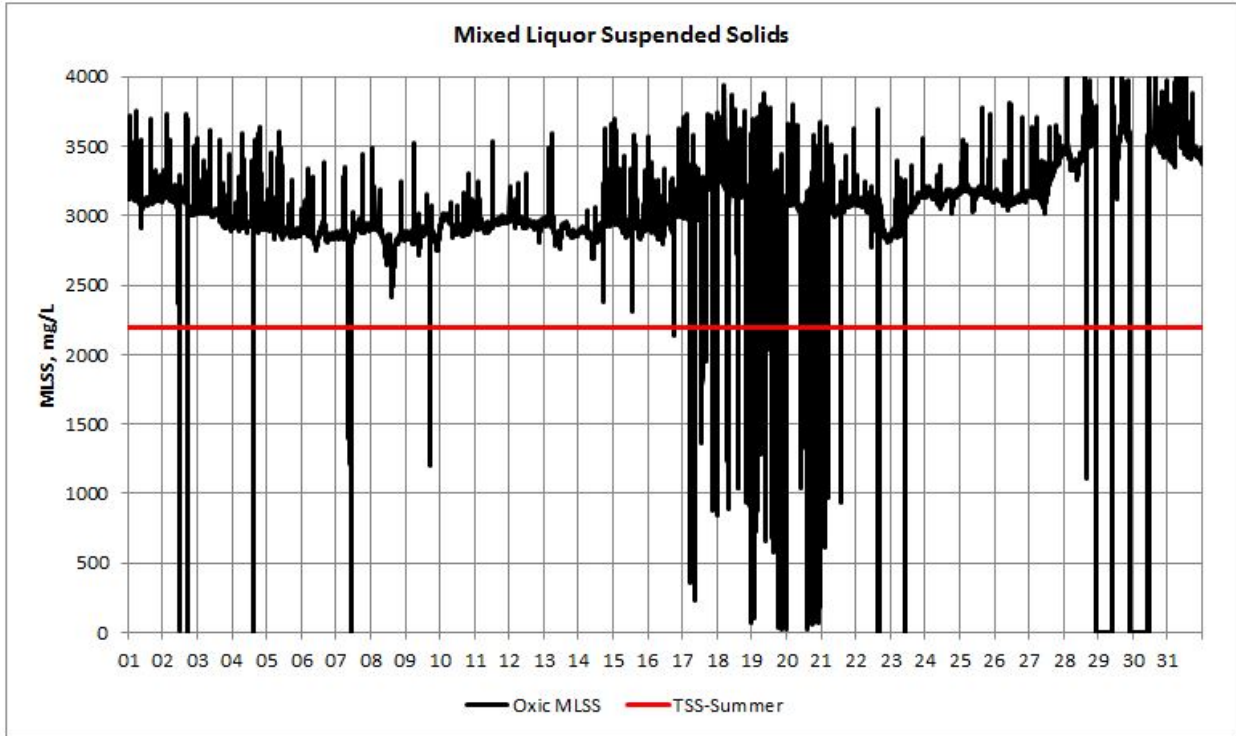
July 2015 Dissolved Oxygen Concentration of Anoxic and Oxidic Tanks



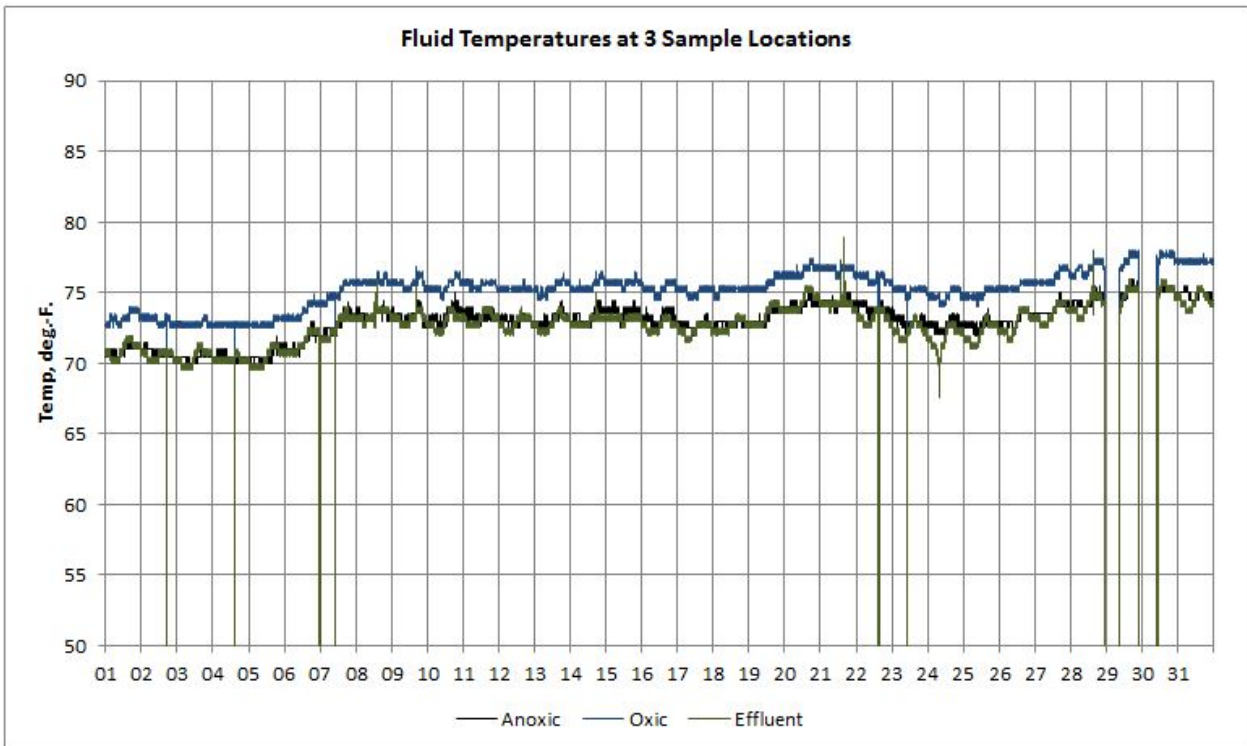
July 2015 pH of Mixed Liquor in Oxid Tank



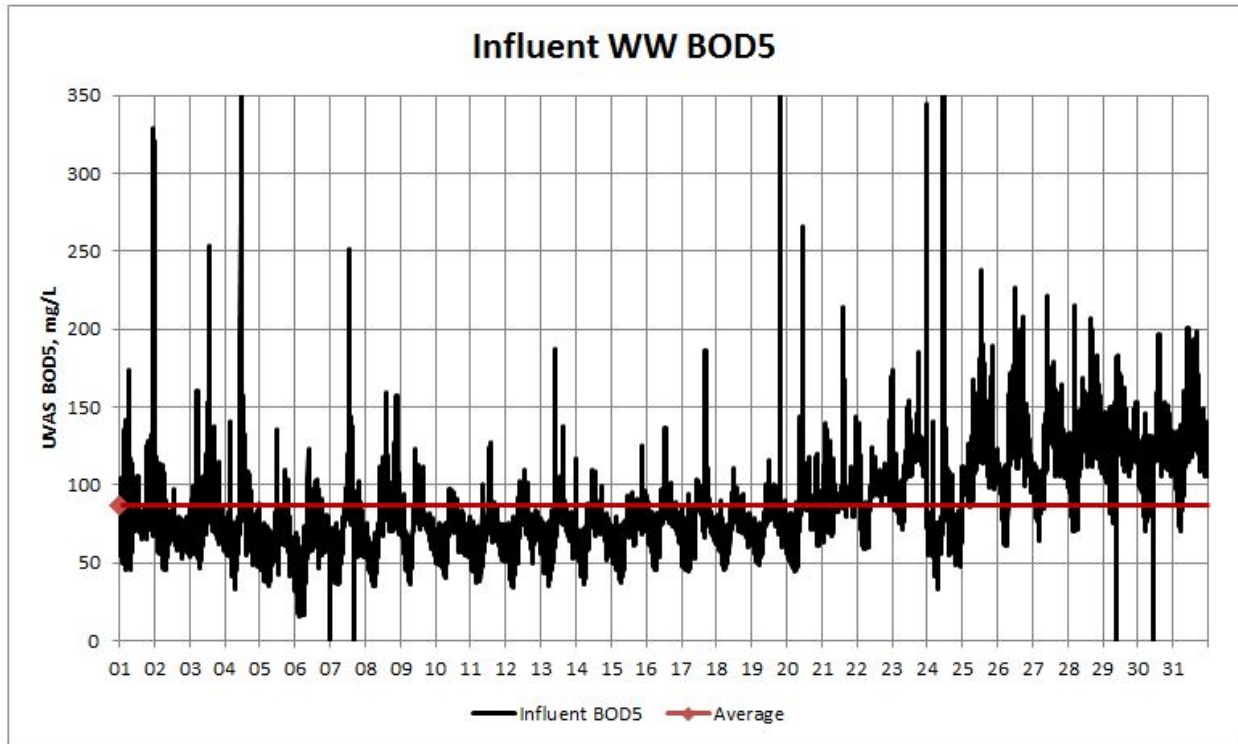
July 2015 Ammonia-N and Nitrate-N Concentrations in Clarifier Effluent: Note ammonia probe out of service July 1 through July 22



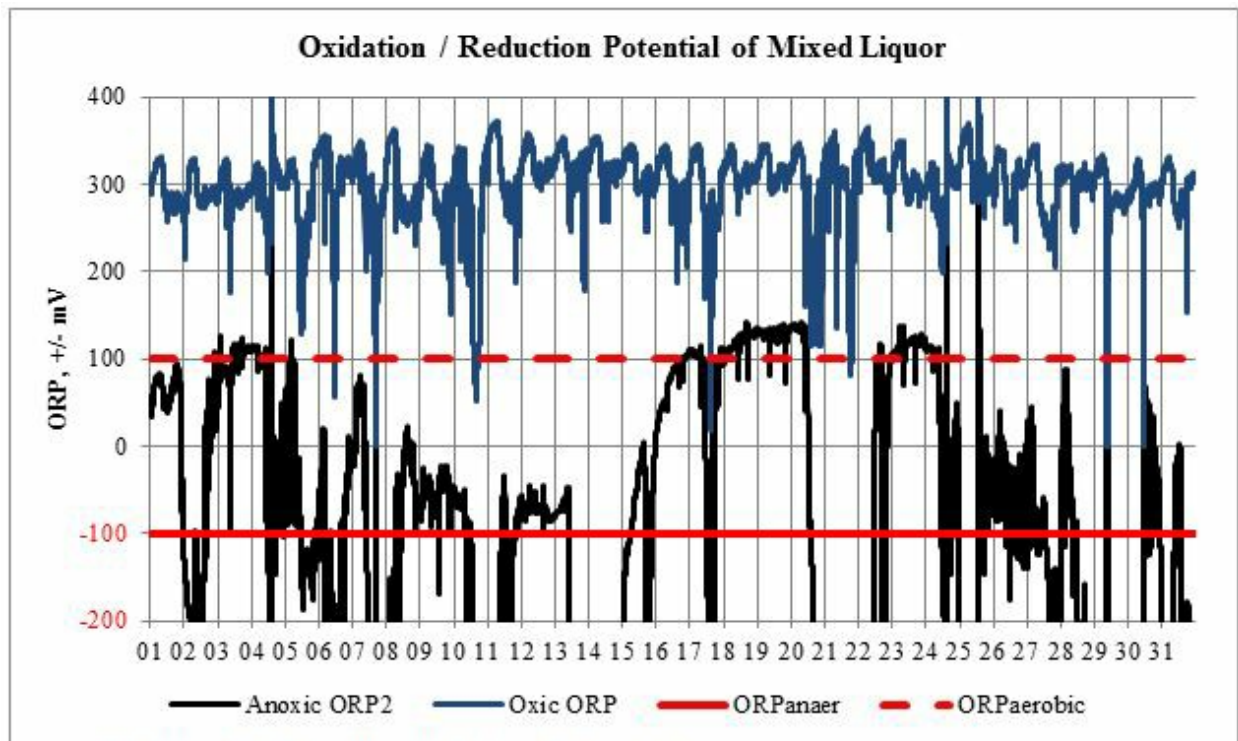
July 2015 Mixed Liquor Suspended Solids in Oxic Tank, by IR Spectroscopy



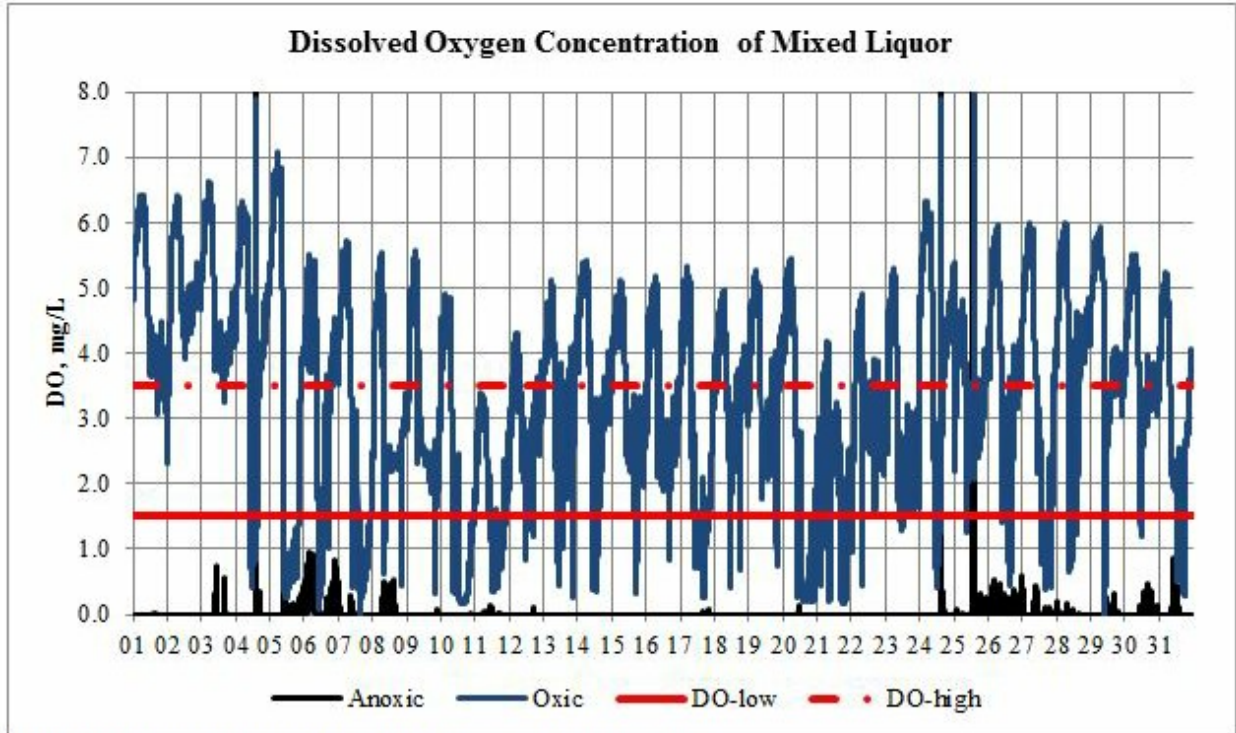
July 2015 Fluid Temperatures in Anoxic, Oxic, and Clarifier Effluent



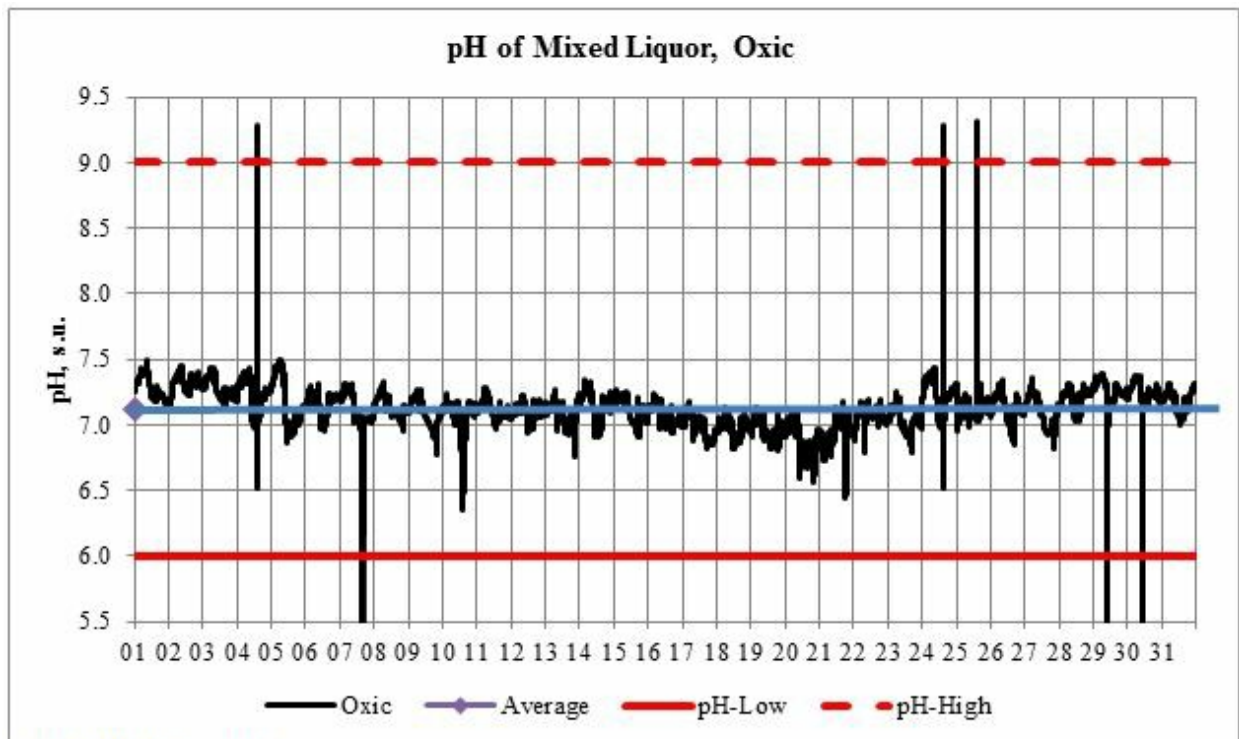
August 2015 Raw Wastewater BOD5, averaging about 80 mg/L



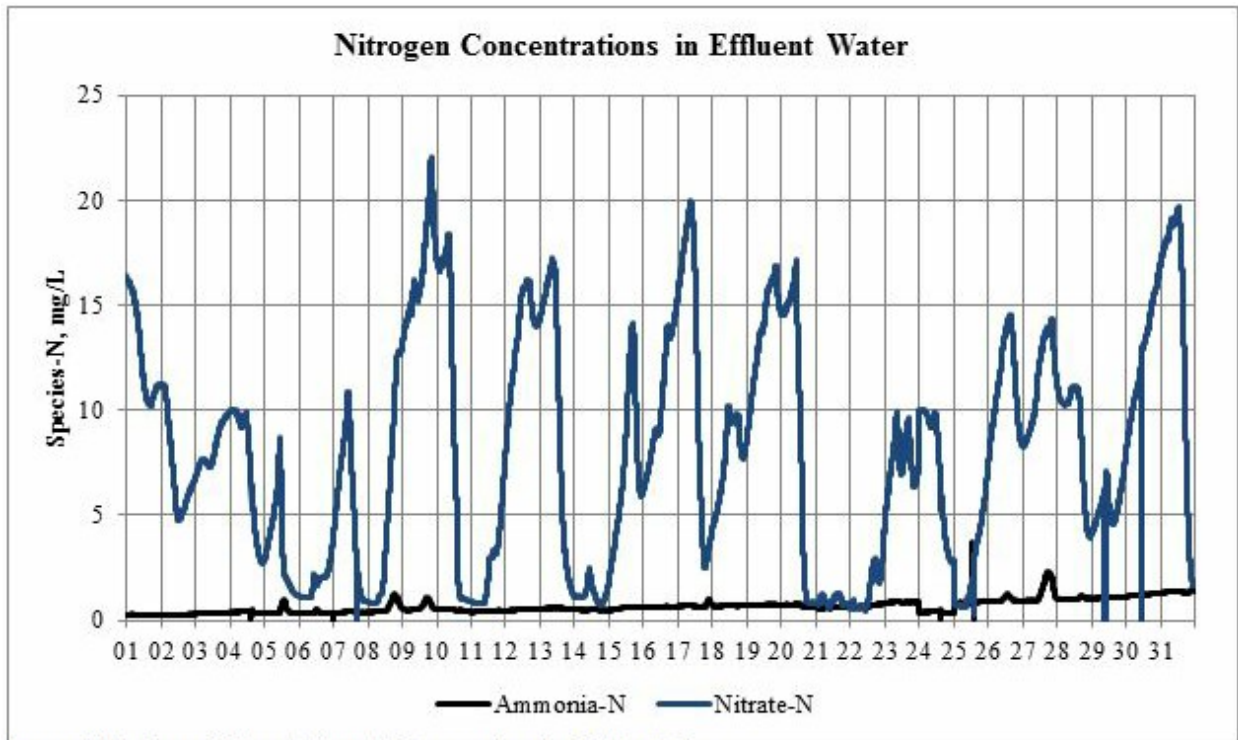
August 2015 Oxidation / Reduction Potential in Oxic and Anoxic tanks



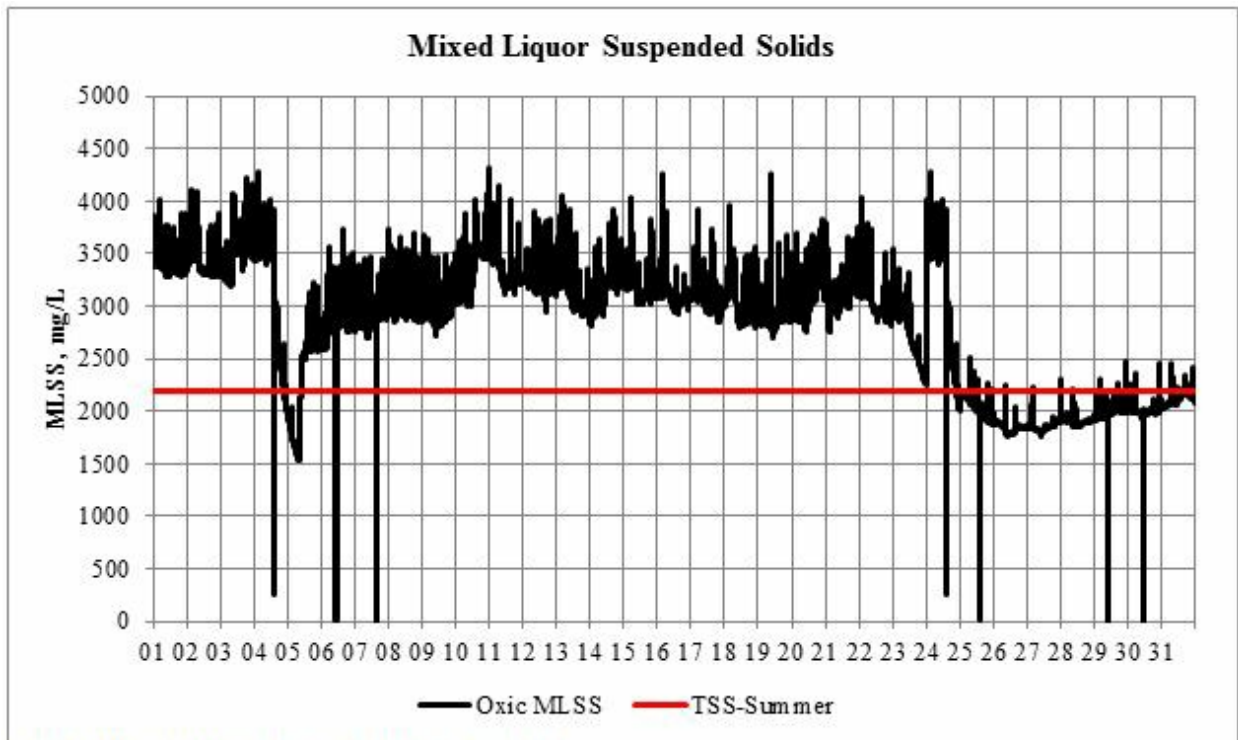
August 2015 Dissolved Oxygen Concentration in Oxic and Anoxic tanks



August 2015 pH in Oxic tank

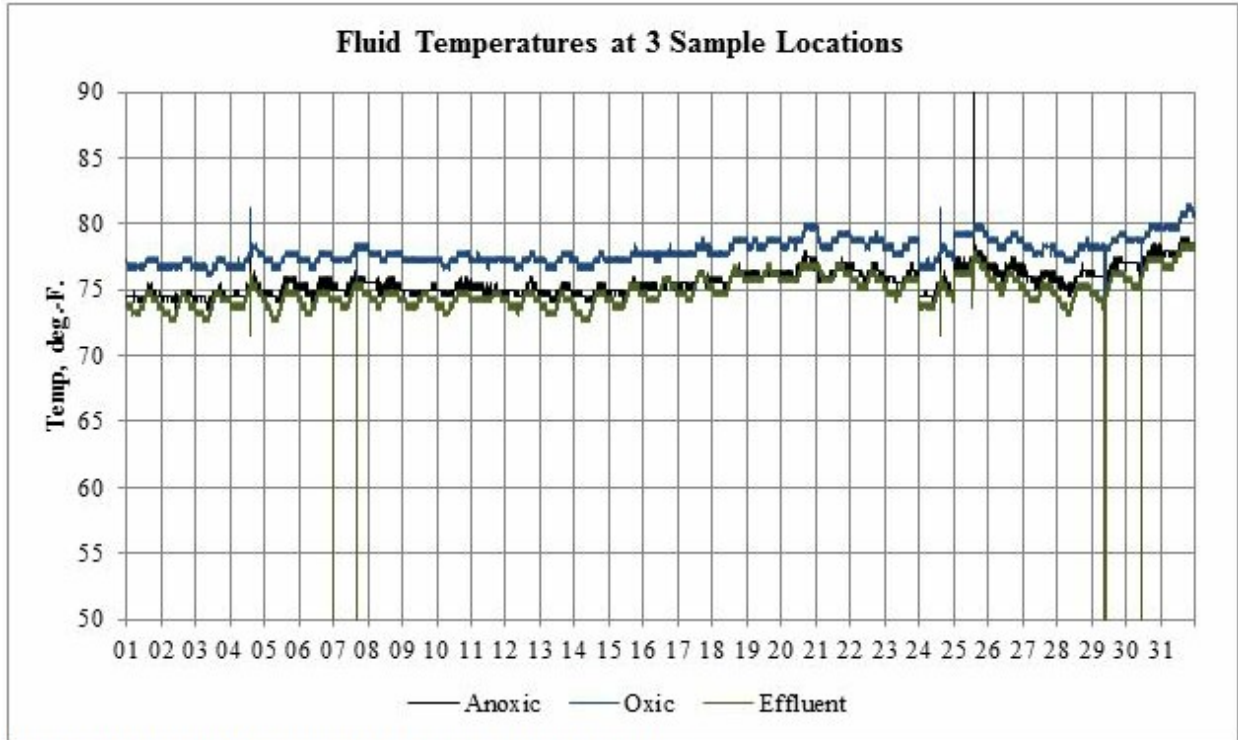


August 2015 Ammonia-N and Nitrate-N Concentrations in Clarifier Effluent



August 2015 Mixed Liquor Suspended Solids in Oxidic Tank





August 2015 Fluid Temperatures in Oxidic, Anoxic, and Clarifier tanks

**ATTACHMENT 7**

## Recommended Additional Equipment (process &amp; monitoring)

During the WTE, the operators discussed purchasing additional equipment that would enhance the quality of data used for process monitoring and control. DEP staff recommended the use of equipment similar to that employed by the agency for its WWTAP projects. However, DEP can make no specification for brand nor technological method, as it may not prefer one vendor over another, but the client site operators are encouraged to research the different brands and technologies available.

Vendors of equipment used during the WTE included Hach, YSI, Raven Environmental Products, Blue Book, VWR International, and Pollard Water.

For the control of dissolved oxygen, DEP staff recommended the following:

- Dissolved Oxygen Probe, by continuous immersion
- Probe Controller, a 24-volt I/O PLC (programmable logic circuit) which signals the blower output to vary according to the DO level in the aeration tank.
- Variable Frequency Drive, a system which controls electrical motor speed in response to the signal received by the Controller. VFDs regulate the power supplied to a modern electrical motor in such a manner that operating output of the motor rarely exceeds 80% of maximum capacity. This preserves the motor from abnormal wear (instant “on”/ instant “off”) and permits the motor to gradually ramp up to operating speed.
- Positive-Displacement (or “Rotary Lobe”) Blowers, mechanical air compressors that are capable of producing output at variable lobe speed. (As opposed to Centrifugal Blowers, where the output is regulated only by controlling the air-intake valve: the vanes of a centrifugal blower must operate at a constant rpm in order to produce compressed air. Throttling the output of a centrifugal blower will damage the blower to the point of destruction.)
- Sound-proof Blower Housing, which provides better muffling effect on PD blowers than simply using muffler pipes. PD blowers can be very noisy at maximum speed. Modern blower housings allow for placement of the blowers nearer to the aerators, instead of within dedicated stick-built structures.

In specifying a control/feedback PLC system for maintaining aeration dissolved oxygen within the recommended concentrations of 1.5 mg/L to 3.5 mg/L, it is highly recommended that the vendor provide for continuous monitoring or recording of sensor output, such as was demonstrated by DEP during the WTE: A recording notebook computer saved probe output at one- and at fifteen-minute intervals, permitting data to be graphically represented in graphs. These graphs allow the operators to observe trends and treatment conditions occurring especially when the facility is not actively attended (second and/or third shifts) and permit experienced operators to predict the potential of plant upsets based on observed trends. While many control systems are installed solely to operate equipment, DEP has advised that the recording of data is tantamount to maintaining a sound operation.

For the operation of the MLE Process, DEP staff recommended the following:

- Oxidation / Reduction Potential (ORP) probe, by continuous immersion, and controller: The ORP probe measures biomass performance in anoxic zones after all available oxygen has been depleted (i.e., after the DO probe registers null or near-zero values.) The recommended ORP ranges for both oxic and anoxic treatment are summarized in the diagram, below, where optimal denitrification occurs when the net-potential charge of the biomass is between +100 mV and -100 mV.
- ORP probe may also be used to optimize nitrification in the aerobic or oxic treatment units. The recommended ORP for nitrification is over +150 mV, typically +250 mV to +300 mV in well-oxidized biomass.

For the maintenance of proper alkalinity, *in situ* pH probes may be employed. The probe used during the WTE was a continuous immersion probe placed in the oxic zone of secondary treatment. The recommended pH range for nitrification is > 7.0 s.u. through 8.5 s.u. Typically, a pH of 7.8 s.u. will indicate good conditions for nitrifying bacteria that convert ammonia-nitrogen and organic-nitrogen to nitrate-nitrogen. A nitrate-rich IMLER is necessary for providing a continuous source of nitrate to the denitrifying bacteria within the anoxic mixing zone. Nitrate in a well-oxidized biomass is typically between 30 mg/L and 40 mg/L, also indicated when final effluent ammonia-nitrogen and total Kjeldahl nitrogen concentrations are at or below the NPDES permit limits.

During the WTE, DEP staff deployed a nitrate-sensing UV probe. This is a very expensive piece of equipment, and it is not recommended for use at the Bryn Athyn facility due to cost. As a useful substitute, DEP staff recommended the use of a portable nitrate test kit by a familiar vendor, where a sample is treated with indicating chemicals to produce a colorimetric test result that is read by a “mini” spectrophotometer that is optimized to the proper light wavelength for determining nitrate-nitrogen. The cost for this test kit was \$473 for the device and \$140 for the test standards and reagents (300 tests.) It was recommended that the nitrate concentration of the oxic-zone mixed liquor or of the IMLER be tested at least three times per week to assure that the oxic zone is completely nitrifying ammonium.

During the winter months, cold weather inhibits the nitrifying bacteria in wastewater treatment. When the temperature of the mixed liquor falls below 10 Celsius (59 degrees F.), nitrification will cease to occur. This may lead to effluent ammonia violations. It is therefore recommended that the facility regularly test its effluent for ammonia-nitrogen. Similar photometric test kits are available for this purpose.

In the event that nitrification fails to occur, or if it becomes inefficient, the literature typically recommends seeding the mixed liquor with commercial preparations of *Nitrobacter* and *Nitrosomonas*. Purchasing this bacterial seed can be expensive. Alternatives to doing so include re-seeding the aeration tanks using mixed liquor or return activated sludge from a nearby treatment facility, incurring shipping costs, or a bacterial preparation rich in nitrifiers may be formulated on-site. The operators should have available

- 1 or 2 each 55-gallon food-grade plastic drums (never used for chemicals or disinfectants)
- Un-treated secondary effluent
- Top soil from 0” to 18” deep excavation (no clay)

De-head the drums and fill them approximately 1/3 with loosely packed top soil dug from the treatment plant lawns. (Do not use the contents of the reed beds, because the root structure of the reeds will make it too difficult to obtain the appropriate amount of soil.) Bring the drums indoors (ambient temperatures over 10 C, preferably 17 C to 20 C) and fill them to near-full with un-disinfected secondary effluent.

Gently mix the soil and water during filling of the drums. Allow the mixture to stand overnight, creating a “tea” of the soil. What is taking place is that the naturally occurring nitrifying bacteria in the soil is being released into the secondary effluent. After about sixteen to twenty hours, decant the liquid from the drums and add it directly into the oxic zone or aeration tank. (Do not mix it into the oxygen-deficient RAS flow.) This effectively seeds nitrifying bacteria into the mixed liquor without the expense of purchasing seed bacterial preps from a commercial vendor.

Use the soil portion only once and return it to the grounds. If further seeding is necessary, repeat the process until the mixed liquor water temperature rises above 10 C or until nitrification is restored. (Verify this by testing for both ammonia-nitrogen in the effluent and nitrate-nitrogen in the IMLER.)

**ATTACHMENT 8**

**Recommended Process Control Tests, Observations and Calculations**

The following is suggested for proper process control. The actual testing and how frequently it is done will be based upon facility circumstances. If unsure, consult the design engineer and state regulatory officials. It is important to do testing on the influent wastewater in order to determine loadings and efficiencies of all treatment units. Influent testing also provides valuable information for chapter 94 reports as well. At a minimum test the influent wastewater each time samples are collected for effluent compliance testing (NPDES Reporting). The operator should also note weather conditions on a daily basis Hi/Lo temperature and amount (if any) precipitation. (This is critical where Inflow/Infiltration affects the collection system flow into the plant.)

The following describes the parameters you should be monitoring (at a minimum) in regard to influent wastewater. Depending on your facility, additional parameters may need to be monitored especially if you facility treats industrial or trucked in waste.

<b>Influent Wastewater Recommended Parameters</b>	
<b>cBOD<sub>5</sub></b>	24 Hour Composite
<b>Total Suspended Solids (TSS)</b>	24 Hour Composite
<b>Ammonia-Nitrogen (NH<sub>3</sub>-N)</b>	24 Hour Composite
<b>PO<sub>4</sub></b>	24 Hour Composite
<b>pH</b>	Grab
<b>Temperature</b>	Grab
<b>Alkalinity</b>	Grab
<b>Flow (MGD)</b>	Continuous monitoring
<b>Visual/Aromatic Observations</b>	Document unusual conditions

Following are the monitoring parameters, calculations, and observations for this type of facility. The frequency of these depends on the variability of the waste-stream and other factors. Ideally, a full set of Process Monitoring tests is performed each week for a facility of this size; whenever process adjustments are made, a set of test should follow by a day or two to assure system stability.

<b>Process Monitoring Test</b>	<b>Description / Recommendation</b>
<b>Dissolved Oxygen</b>	Best done with continuous monitoring within the reactor. Calibration of DO sensors should be checked weekly.
<b>Oxidation Reduction Potential (ORP)</b>	Best done with continuous monitoring within the reactor. Very important for anoxic and anaerobic zones.
<b>Nitrate (NO<sub>3</sub>)</b>	Best done with continuous monitoring within the reactor. Occasional grabs (to check calibration) during each cycle. Portable kits similar to TRC test are available for this.
<b>Nitrite (NO<sub>2</sub>)</b>	Can be a grab sample at various intervals. If you are having problems maintaining chlorine residual excess nitrite can be a factor. Nitrite can be associated with incomplete nitrification or incomplete denitrification
<b>Ammonia-Nitrogen (NH<sub>3</sub>-N)</b>	Best done with continuous monitoring within the reactor. Occasional grabs (to check calibration) during each cycle.
<b>MLSS &amp; MLVSS -or- TSS by Centrifuge (Percent-by-Volume)</b>	This test is essential for determining the lb. of solids you have under aeration. The use of a centrifuge spin can provide quick and reasonable estimates of solids under aeration. With an increase in MCRT, the MLVSS should decrease.
<b>Mean Cell Residence Time</b>	MCRT is a calculation. lbs of solids in the system Solids leaving the system (WAS & Effluent)

Process Monitoring Test	Description / Recommendation
<b>Food to Microorganism Ratio</b>	F/M is a calculation ( be aware of SWD). FOOD (BOD) coming into system lb. of solids under aeration
<b>Sludge Volume Index (SVI)</b>	SVI is a calculation 30 Minute Settleability Result ml/L MLSS mg/L / 1000
<b>Microscopic Examination</b>	Microscopic observation of the biomass to determine the relative predominance of organisms and to spot troublesome filamentous organisms. Use a count-chart to tally different types of bugs, for comparison to ideal operating conditions.
<b>30 Minute Settleability</b>	To help quantify the amount of sludge in the system and to determine settling characteristics. Must be used in conjunction with MLSS to determine SVI.
<b>Alkalinity</b>	This can be a grab sample, should not drop below 50 mg/l at any point in the system especially for facilities that must nitrify. Some resources note that Alkalinity in mixed liquor should be 180 to 220 mg/L. Would like to see 100 mg/l in effluent after complete nitrification.
<b>pH</b>	This can be done through continuous monitoring or through a grab sample. Alkalinity is more important. Drastic changes in pH will occur when alkalinity has been completely consumed.
<b>Temperature</b>	The temperature will determine how lively your biological activity will be every 10 degree C change in temperature results in biological activity either doubling (warmer temps) or cutting in half (for colder temps).
<b>Oxygen Uptake Rate(OUR)</b>	Useful test for determining the respiration rate of the biomass. Can be used to determine treatability of waste.
<b>Respiration Rate (RR)</b>	Calculated: Divide the OUR by the MLVSS value and multiply by 1000 to get the answer in mg. O <sub>2</sub> per hour per gm. VSS
<b>Amount and concentration of sludge wasted from each SAR</b>	We must be able to quantify the amount of sludge removed from the system in order to maintain a proper mass balance. This may require more attention be paid to each process train as an individual entity.
<b>Recycle flows</b>	Nitrate recycle is critical in BNR. Start with 200% and work upward. This could include flows such as supernatant from aerobic digesters or filtrate from dewatering or thickening activity. These recycle flows can be high in nutrients (phosphorus and nitrogen) as well as BOD.
<b>Waste Sludge Solids &amp; Digester Solids (Total Solids as %)</b>	Critical to solids management is knowing the total solids content of the sludge when it is shipped from the facility. One should not always trust the hauler tests to be accurate. Whenever the viscosity of the sludge changes, that is, after decanting or adding WAS to the digester, use the centrifuge to spin down a sample. Gravimetric analysis (25 ml. sludge into a dish, dried at 100 C overnight and weighed the next day) will give total solids by weight/volume percent.

**ATTACHMENT 9**

## Recommended Documentation / Programs

**a. Standard Operations Procedures**

The recent changes to the operator certification law and subsequent regulations delineated the responsibilities of facility owners and of facility operators in a way to provide protection for licensed operators against inadvertent consequences of NPDES permit violations that were beyond their control. The regulations require that the owners of each licensed facility designate at least one operator in charge of the facility, a licensed person in whom rests the responsibility to make and enact process control decisions. Since most facilities have only one operator-in-charge, and because that person cannot possibly operate the facility at all times, the regulation calls for the establishment of written Standard Operations Procedures (SOP) that instruct other persons how to perform operational tasks in his stead. These procedures should be as detailed as necessary in order for any reasonable person to understand and enact the tasks described in the SOP. SOPs must also be regularly updated whenever there is a change to a procedure, and they must also be signed by the designated operator-in-charge.

Examples of SOPs for wastewater operations are available on-line through routine document search. The correct way to write an SOP is to include the topic title (e.g.: Sludge Wasting) and a brief explanation of what is being done, followed by a step-by-step procedure for carrying out the task. It may be necessary, when writing these, to walk through the process, clipboard and pen in hand, and record as much detail as necessary for another plant operator with no prior knowledge of the facility to effectively complete the task. The SOP header should include a date written, a date revised (if done,) and a revision number. Each SOP should be signed by the Operator-in-Charge. If the SOP is a reprint with the signature copied, then the operator should write his initials next to the printed signature copy.

**b. Laboratory Manual for Process Monitoring**

Even if the wastewater laboratory is not state-certified, there should be a Laboratory Manual for Process Monitoring that describes the routine tests and procedures used by the plant operators to determine what actions they will take to provide Process Control of the facility. The laboratory manual would list the equipment used, the test methods routinely performed, the purpose of those tests, and a brief interpretation of what the test results require an operator to do in terms of controlling the facility. Test procedures may be adapted from a standard source, but they should be customized to the specific facility's needs. (e.g.: If the operator uses Mason jars for sludge Settlemetry tests, the procedure should say so and note how the bottles are marked or how the test result is interpreted for his operation.) The lab manual should contain a listing of supplies and their sources, being kept up-to-date with regular revisions, either when the test or materials change or, for example, on an annual basis.

Most facility operators maintain calibration logs for equipment used in effluent monitoring. These documents are best maintained separately and independently from the laboratory manual.

**c. Solids Management Plan**

Each well-operated facility should have a written solids management plan. This document, or procedure manual, should include "cradle-to-grave" information on sludge holding, digestion, treatment, and disposal. For example, the Bryn Athyn facility maintains reed beds for the intermediate disposal of waste sludge. There should be written procedures for maintenance of the pumping equipment and the reed beds, and there should be at least two resources (main and stand-by) listed for the disposal of reed bed contents when the beds become full. There should be an alternative disposal method listed should the existing method be inoperable: for example, if

the sludge wasting pumps fail, there ought to be an alternative method for moving sludge to the reed beds, and if the reed beds are out of service, there should be an alternative disposal method, such as sludge hauling by an approved vendor to an alternative facility for treatment and/or disposal.

Because reed beds are seasonally operated, there should be written management procedures based on time-of-year.

d. **Spill Prevention, Control, & Countermeasures document**

This documentation is not usually found in municipal wastewater treatment plants; however, it is always a good form of insurance should chemical spills occur (and they will.) At its most basic, this document describes the type and location of any chemicals or supplements stored and used at the facility, most notably disinfection chemicals and machine lubricants. Unforeseen weather events or structure fires can cause environmental releases of chemicals, and there is always the potential in such events for the adverse reactions of spilled chemicals and fuels.

A well-formulated SPCC plan lists all emergency contacts, including the facility owner, operator-in-charge, laboratory and maintenance persons. It lists nearby institutions and public assemblies that may be adversely impacted by environmental releases, as well as downstream users to be notified during a pollution event. Local emergency numbers, local hospital addresses and numbers, are also useful. The SPCC should also include as appendices the MSDS sheets for all chemicals used and stored on site, a map of their locations, and incident management forms to use in event of a release.

Copies of the SPCC should be maintained at the site, at the facility owner's remote office, and in the motor vehicle of the operator-in-charge. Where required by state law, SPCC copies are also sent to the local fire company and to the county emergency management agency.

e. **Asset Management w/ Capitals Planning**

All of the facilities and equipment used at municipal wastewater treatment facilities are public assets, deserving of proper care and maintenance. The maintenance and replacement of such assets should be carefully managed and planned, and there are many low-cost and inexpensive (even *gratis*) software tools available for keeping track of these assets.

Asset management software allows the facility owner or operator to track the life cycles of most of the equipment within the facility. It permits long-range planning for the financing of replacements and upgrades. Some programs assist with rate calculations for the entire utility. Another feature is some allow the operator to develop, issue, and track preventative and reactive maintenance work orders, with attached reference to parts and supplies.

The US EPA offers a *gratis* asset management software package called "Check-up Program for Small Systems" (CUPSS) at its website:

<http://water.epa.gov/infrastructure/drinkingwater/pws/cupss/software.cfm>

Originally developed for small drinking water systems, the program allows the user to select a format for small wastewater treatment facilities, as well. The program has a financial asset management subdivision and an equipment management subdivision.

After first populating the database with relevant data from one's own treatment facility, the program user can manage maintenance schedules, work orders, equipment parts, vendors, and labor as part of the overall asset management program.

Since populating the database seems to be the most critical hindrance to using an asset management program, DEP staff have recommended that the operators start creating an asset management database with the first one or two pieces of equipment purchased going forward. A good example is to begin with the supplemental carbon feed system for the MLE modifications completed this summer. Planning ahead, the operators could then enter data for the PD blowers they propose to add when budgeting and planning permit this.

f. **Municipal Wasteload Management Report**

The Borough of Bryn Athyn is in a unique position with respect to completing the annual Municipal Wasteload Management (“Chapter 94”) Report. The wastewater treatment facility exists primarily to serve the educational institutions nearby, and to collect on-lot treatment system effluent from some 300+ collection system users in the Borough. When the schools are out-of-session during the summer, wastewater quantity and loading characteristics change considerably, affecting how the plant is operated. In addition, because on-lot treatment system effluent is quite chemically distinct from raw sewage, the usual planning tools for determining the sufficiency of the wastewater collection and treatment system may not produce the most reliable planning tool.

It is suggested that the operators work with their DEP regional staff to determine more accurate modeling of the facility’s performance with regard to managing existing and planning new connections.