BOROUGH OF TOPTON
WASTEWATER TREATMENT FACILITY
LONGSWAMP TOWNSHIP, BERKS COUNTY, PENNSYLVANIA

NPDES # PA0020711

WASTEWATER TREATMENT EVALUATION

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

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Executive Summary:

From December 2016 through January 2017, EPA and DEP conducted a joint evaluation at Borough of Topton's (Borough) wastewater treatment facility located along Toad Creek in Longswamp Township, Berks County. This evaluation was an outgrowth of EPA's work with the Borough to secure competitive electrical energy for this facility. During the autumn of 2016, the facility operators observed an increase in fine solids ashing from the secondary clarifiers, and EPA sought use of DEP's in-line submersible probes for six weeks to monitor various treatment parameters in resolving this. The superintendent also expressed concerns that the facility's NPDES Permit, presently under renewal, may include a new limit on effluent nitrate-nitrogen, which has been implemented at other facilities located in the Delaware Bay watershed. As part of the evaluation, efforts were also made to reduce nitrate-nitrogen in the effluent.

Ashing of fine solids is of concern to Topton because the facility has a copper limit of 0.062 mg/L, and its treatment for copper produces a precipitate that is disposed of with total suspended solids (TSS) through sludge wasting. Fine solids in the effluent may lead to copper violations.

On the initial DEP site visit, DEP staff suggested that the SEQUOX two-stage treatment system was experiencing carbon starvation in Stage 2, causing the autodigestion of the biomass, resulting in problems with flocculation. Microscopic exam that day demonstrated that the microlife in Stage 1 was normal but that of Stage 2 was deficient. As originally designed, the aeration system has constant airflow in Stage 1 and selective, intermittent aeration of Stage 2.[1] DEP staff recommended that some of the raw wastewater be fed to Stage 2 in order to maintain its biomass. Because the system is not easily configured for step feed, plant staff theorized that briefly interrupting Stage 1 aeration would allow raw wastewater to "short circuit" across Stage 1 into Stage 2, supplying more food for maintaining the biomass there.

At the same time, EPA and DEP staff suggested that the use of intermittent aeration might reduce the concentration of nitrate-nitrogen in the facility effluent. Unknown to them at that moment, the manufacturer of this secondary treatment process had added similar aeration flexibility to its original design. Such flexibility would benefit the operators should they meet with nitrate limits during subsequent permit cycles. Although the facility is equipped with parallel centrifugal blowers of the same capacity, only one has typically been needed in order to run the plant. The blower is incapable of operating at a variable range of output and cannot be throttled. Thus, intermittent operation, in the absence of variable output and control valves on Stage 1 aeration, was the only available option at the time for controlling denitrification.

The results of the study suggest that intermittent aeration did improve the biomass quality in stage two. This was likely due to the presence of increased organic loading to this stage. Intermittent aeration also produced a 40% reduction of effluent nitrate-nitrogen loading and produced a potential energy reduction of 160,000 kWh per year.

[1] The updated design for this type of facility includes automatic air valves for Stage 1 treatment in addition to those for Stage 2, allowing the first stage also to be aerated intermittently. Additional improvements to the design allow for DO to be controlled within a range rather than using a set point.

Recommendations:

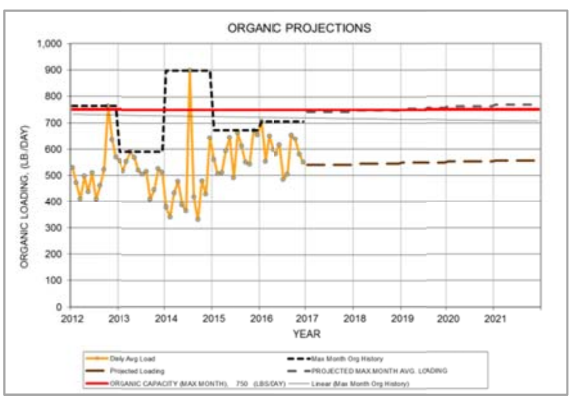
1. Consider adding the flexibility of a step-feed modification to secondary treatment in order to distribute influent wastewater throughout the process as an alternative to providing expensive supplemental carbon to Stage 2 to enhance denitrification.
2. Check the solids retention time (SRT) to assure that the facility is being operated within its design parameters. The biomass concentration (MLSS) is controlled through sludge wasting from aeration tank, wasting mixed liquor, unlike the wasting of settled solids from a clarifier. Thus, the wasting volume for this facility is calculated by dividing the volume of the aeration system by the target SRT, with the answer in gallons of mixed liquor, not pounds of volatile suspended solids. An easy way to track wasted sludge is by measuring depth changes at the digester, a known volume of space. It is not necessary to use flow metering or to determine sludge inventory in order to waste solids.
3. The facility engineer should evaluate energy efficient aeration blower upgrades to control excess dissolved oxygen in the secondary process and reduce energy consumption. DO sensors in the aeration tanks can be used to control aeration output, although the existing centrifugal blowers are not compatible with use of variable-speed motor drives. SEQUOX-PLUS is an enhancement of the existing system which allows, among other things, for automatic valves on the Stage 1 aerators, permitting this stage to be operated in aerobic or anoxic modes. A more recent enhancement, marketed as “DO2ptimizer,” to this design incorporates DO control with aeration blower operation and may eliminate some of the design costs necessary to modify the blower system.
4. If the Borough’s consulting engineer is evaluating a capacity upgrade of this Aero-Mod system, consider improvements to maximize biological nitrogen removal. The manufacturer could convert this plant from a two-stage extended aeration (nitrification) process to its SEQUOX-PLUS analogue for two-stage biological nitrogen removal (BNR).

Wastewater Treatment Evaluation:

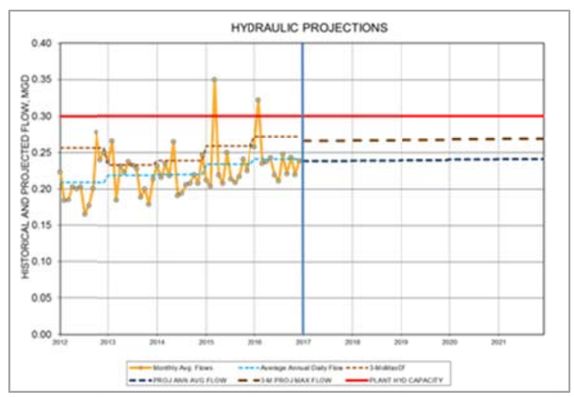
The Borough of Topton in Berks County owns and operates a modern sewage treatment plant (STP) to treat wastewater from domestic, commercial, and institutional sources. The treatment facility is located in Longswamp Township, east of the borough line. The Topton STP is an Aero-Mod 2-stage extended aeration activated sludge treatment process constructed in 2002. Flow in 2016 averaged 0.26 MGD. A schematic of the facility and probe placement diagram is found in Attachment B.

The Aero-Mod system replaced a *circa* 1962 contact-stabilization treatment plant whose footprint remains visible on the site. Treatment processes include rotary fine screening, copper precipitation, two-stage secondary aeration and clarification, followed by chlorine disinfection, phosphorus removal, and sulfonation prior to being discharged to Toad Creek in Watershed 2-C, a tributary of the Lehigh River in the Delaware River Basin. Biosolids are aerobically digested and then typically land-applied to agricultural sites. The plant has controls to operate in “normal” and “storm” modes, electronically controlled air valves for Stage 2 aeration to allow for denitrification there, and airlift pumps for return activated sludge (RAS). In 1990, Topton built four reed beds to provide additional capacity for management of waste sludge disposal. Consolidated biosolids from the reed beds are disposed of as landfill.

According to the recent Wasteload Management Reports (Chapter 94,) the existing facility is presently on the cusp of a chronic organic overload. Based on the five-year average of its monthly maximum-to-annual average organic loading, the facility will approach organic capacity within the next five years. It had also experienced high hydraulic flows in the past, due to inflow/infiltration in its collection system, but this is being corrected, and recent annual average daily flows have been lower. The consulting engineer for the borough has been investigating capacity especially in light of proposed residential development between Topton Borough and



Graph 1: Peak organic loading may be exceeded later in the decade, should additional regional development require capacity.



Graph 2: Daily and monthly flows in excess of 0.30 MGD will become more frequent, although the hydraulic projections do not indicate exceedances in the near term.

Mertztown village in Longswamp Township. The facility operators expressed concern about facility expansion being designed without their input.

In October 2016 Topton’s Facility operator contacted U.S. EPA Region III Outreach Staff to learn more about the energy outreach EPA and PADEP has been promoting. During a preliminary site visit by EPA and DEP staff on Nov. 10, 2016, the facility’s Superintendent discussed concerns over fine particles in the facility effluent (“fines.”) These fines appeared to be biological floc combined with copper precipitate that, while not rising to the level of a total suspended solids (TSS) excursion, could increase the effluent copper concentration above its permit limit of 62 ppb. He also discussed an interest to remove total nitrogen using his existing processes. A collective decision was reached to deploy DEP's process monitoring equipment (December 7, 2016 through January 31, 2017) and conduct an evaluation.

The Aero-Mod SEQUOX package plant is designed for biological nutrient removal (BNR), where Carbonaceous BOD is consumed and nitrification of ammonia and organic nitrogen occurs during Stage 1 treatment and denitrification of nitrates to molecular nitrogen gas occurs in Stage 2. It also has a small anaerobic selector zone for RAS from the secondary clarifiers. This zone promotes the destruction of filamentous organisms. As operated at Topton, whose NPDES Permit does not presently require total nitrogen (TN) removal, this plant has served mostly as an extended aeration nitrification plant. Many BNR plants require supplemental carbon to help drive the denitrification reactions.

DEP staff observed that in two-stage treatment systems, a potential exists for biomass in the Stage 2 treatment to become starved for carbon, which could cause degradation of biomass and ashing of solids. Usually, enough organic matter adsorbs to the cell surface of bacteria in Stage 1 to sustain it through its detention time; however, the baffle effect of the separating wall to Stage 2 appears to create two almost distinct biomass populations. One is well fed; the other, not so much.

Discussions of aeration system flexibility ensued, but there were two problems: first, there were no automatic valves at Stage 1 aeration that would allow the air to be shut down without depriving all other processes, including air-lift pumps, of compressed air; second, although the facility is equipped with parallel centrifugal blowers of the same capacity, only one has typically been used in order to run the plant. Centrifugal blowers do not operate with a variable output range the way positive-displacement (PD) blowers do. They cannot be throttled to reduce output by closing downstream valves without first providing for pressure relief.[2] Given these two conditions, EPA and DEP staff suggested that the use of intermittent ("on/off") aeration in the Stage 1 might permit raw wastewater to short-circuit across Stage 1 in order to feed Stage 2, although dedicated influent step-feed arrangement would make more CBOD available as a long-term solution.

The manufacturer of the SEQUOX process now offers automatic air valves on Stage 1 aeration branches. They also offer a form of energy-saving DO control that employs operating ranges rather than set-points, based on a DO feedback loop to variable-speed drives for positive-displacement (PD), rotary-lobe blowers. Thus, intermittent aeration operation for the whole facility, in the absence of these design enhancements, was the only available option at the time for getting CBOD into Stage 2 and for controlling denitrification.

By mid-January, timers were added to aeration blower controls for the main blower and for a smaller PD blower used to re-aerate disinfected effluent. The blower run time for the main blower was reduced from continuous operation by up to eight hours, reducing energy consumption, without adversely affecting effluent quality. CBOD found its way into Stage 2 during the "off" periods, and the effluent nitrate load was reduced by almost 40% as a result of these changes, showing the benefits of intermittent aeration and of biological nutrient removal.

[2] The intake valve for a centrifugal blower can be throttled, but only to a point, after which the blower enters "surge" mode and its motor overheats. Were the output valve to be throttled, damage to the vanes, up to and including catastrophic failure, would occur.

1. Summary of Findings:

Working with some limitations to inexpensively modify existing equipment, Topton staff were able to resolve a problem with autodigestion of its Stage 2 activated sludge biomass and concurrently reduce overall nitrate and total nitrogen emissions to their receiving stream:

1.1. Issue #1 – Fine Solids Ashing in Final Clarifier: This could possibly cause the precipitated copper, from the chemical addition process, to be discharged causing effluent violations.

1.1.1. Using microscopy and SOUR tests, staff observed that the biomass in Stage 2 had been starved for BOD, relative to that in the Stage 1. The facility may have an acceptable overall F/M, but the F/M in Stage 2 appeared deficient. Biomass in Stage 1 aeration was consistently more active than in Stage 2, having a diverse population of indicator organisms. The soluble oxygen uptake rate (SOUR) test confirmed this, as there was a significant decrease in SOUR at Stage 2. The appearance of ashing in the secondary clarifier was more likely to have been the autodigestion of biosolids in Stage 2 with the consequent inability to flocculate well in the clarifiers.

1.1.2. Other potential causes were considered less likely. These included:

1.1.2.1. Presence of surfactants or disinfectants in the raw wastewater, possibly from the Lutheran Home, an assisted-living care facility: Staff from the home denied the use of any adverse cleaning products, and sample testing did not show the presence of surfactants or toxicants.

1.1.2.2. Rapid settling due to chemical use for copper precipitation: Although mixed liquor samples settled rapidly during Settleometry, the floc appeared to be well-formed and without excessive straggler or pin floc.

1.1.2.3. During December, the plant operator noted that a broken finished water valve at the area's water treatment plant had resulted in an undetected discharge of approximately forty thousand gallons of finished water with a chlorine residual of approximately 1.5 mg/L. After repairing valve, the turbidity did not appear to decrease.

1.2. Issue #2 - Energy Conservation: The facility would benefit from installing controls and blower upgrades that would reduce electrical consumption while also providing a path to lower nitrate concentrations in the effluent. Such improvements are known to have reasonable return-on-investment.

1.2.1. Power logging the energy use of the facility's 100 h.p. main blower showed potential savings from using the new aeration regime (or if DO control was installed.) Intermittent aeration maintained DO closer to the target of 1-3 mg/L and could save the Borough approximately 160,000 kWh ($15,000) in energy annually if permanently implemented.

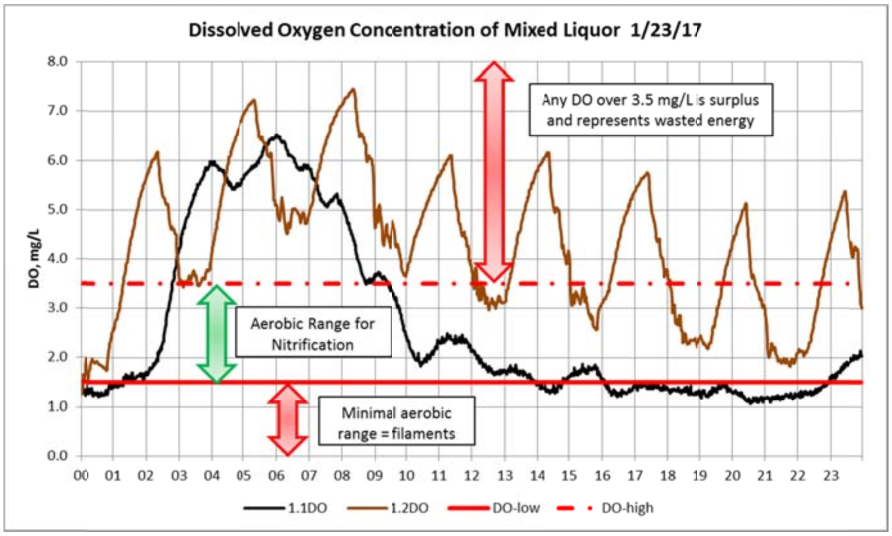
1.2.2. Power consumption for the 7.5 h.p. post-disinfection blower was logged to determine if there would be a useful payback to installing DO control to this blower. The log showed that intermittent, timed operation would account for 4 months (120 days) reduction of electrical consumption per year. The electric savings would be about 7,200 kWh or $600 annually.

2. Data and Laboratory Analysis:

2.1. Analysis of in-line probe data: (Charts of the data are displayed in Attachment C.)

2.1.1. Throughout the study there were no obvious signs of toxic loads. A toxic load may cause a DO increase significantly throughout both secondary stages concurrently with significant changes in pH and ORP. This had not been observed during this evaluation.

2.1.2. The dissolved oxygen rises well above the textbook maximum of 3.5 mg/L often during periods where organic loading is reduced. This is a waste of energy; excessive aeration can disrupt floc formation, causing pin floc in the clarifiers.



Graph 3: This typical graph shows the diurnal effect of loading on Stage 1, and it could be interpreted as "overloading" this stage at the expense of Stage 2, where very high DO residual suggests insufficient BOD availability & biological activity. The "jaggedness" of the line is evidence of cycling the blower on and off.

2.1.3. On January 9, the superintendent began experimenting with cycling the aeration blower. At the end of the study the blower was off approximately 8 hours per day (originally 24 hours per day). This aeration cycling helped keep the DO closer to the target of 1.5-3.5 mg/L and will save the Borough approximately 160,000 kWh ($15,000) in energy annually.

2.2. Analysis of process monitoring results:

2.2.1. Alkalinity was consistently within normal operating conditions and a little high, even, in the effluent.

2.2.2. Settleability is fairly rapid because of treatment chemicals used to remove copper.

2.2.3. Microscopy showed that from the beginning of the study to the end, the indicator organisms increased significantly indicating a healthier biomass. The principal indicators were free-swimming, crawling, and stalked ciliates and rotifers.

2.2.4. NO3-N effluent load was reduced approximately by 40% (38 lb/day to 23 lb/day) during the study. This was due to intermittent aeration in the absence of anoxic mixing, nitrate recycle, and supplemental carbon addition.

2.2.5. SOUR results of MLSS Stage 1 and Stage 2:

2.2.5.1. SOUR tests initially indicated very little activity in Stage 2 compared to Stage 1

2.2.5.2. After the new aeration cycling pattern was established on January 9, the SOUR tests showed little change in activity in Stage 2.

2.2.6. All permit limits were consistently met (pH, NH3, cBOD, Cu, TSS, TRC)

2.3. Analysis of power logging:

2.3.1. EPA staff connected the Borough with Met-Ed Power's Energy Efficiency Program representative and assisted with compiling data needed by the power company to determine eligibility for DO control projects (main and post-disinfection air blowers).

2.3.2. Field staff logged the 100 h.p. main centrifugal blower energy use to determine the savings by using the new aeration regime or if DO control was installed. This aeration cycling helped keep the DO closer to the target of 1-3 mg/L and will save the Borough approximately 160,000 kWh ($15,000) in energy annually.

2.3.3. The 7.5 h.p. post air blower was logged in order to determine potential savings from installing DO control on this PD blower. If the blower was off approximately 4 months (120 days) out of the year the savings would be about 7200 kWh or $600 annually.

2.3.4. EPA staff introduced the Borough to the COSTAR program to purchase electric at a wholesale rate. The Borough may save approximately $4000 in 2017 compared to the original $kWh rate.

3. Conclusions

3.1. Stage 2 MLSS settles better and appears healthier when cBOD is allowed to short circuit across Stage 1 into Stage 2 using an intermittent aeration regime. A permanent step feed configuration could be installed to deliver sufficient BOD to Stage 2.

3.2. The facility is capable of denitrification using intermittent aeration, but this will not consistently remove NO3-N to <10 mg/L. The minimum concentration of nitrate recorded during the evaluation was 9.6 mg/L, while the average had been 18.5 mg/L. Removing nitrate to <10 mg/L, or to accomplish BNR generally, the Borough may have to invest in additional aeration and pumping equipment along with automation and controls. Additionally, the existing process may have capacity issues, and the engineer's upgrade recommendations may suggest alternative secondary treatment systems, thus negating the value of improvements to the present one if the return on investment period cannot be achieved.

3.2.1. Facility staff felt that the real-time DO information was extremely useful to have when making process control decisions. The Borough plans on installing similar equipment to monitor certain stages of the plant.

3.2.2. Local industries need to be monitored and educated frequently.

3.2.3. Changes in the aeration process and post air process can save the Borough a significant amount of money on energy.

3.3. It is conceivable that this Aero-Mod package plant can be easily and inexpensively upgraded from extended aeration to a BNR plant.

3.3.1. Doing so would probably be a more practical approach to reducing effluent nitrate than by using intermittent aeration as described in this report.

3.3.2. Such an upgrade would easily account for improvements to the aeration blowers and incorporate the necessary instrumentation and automation necessary for BNR to operate efficiently and effectively.

3.3.3. This does not address the capacity issues facing the Borough in the near future; however, the design of this facility allows for easy replication of the Aero-Mod SEQUOX footprint onto adjacent vacant or repurposed land within the facility.

ATTACHMENT A: EVALUATION TEAM

--for the Borough of Topton STP	
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--for PA Dept. of Environmental Protection	
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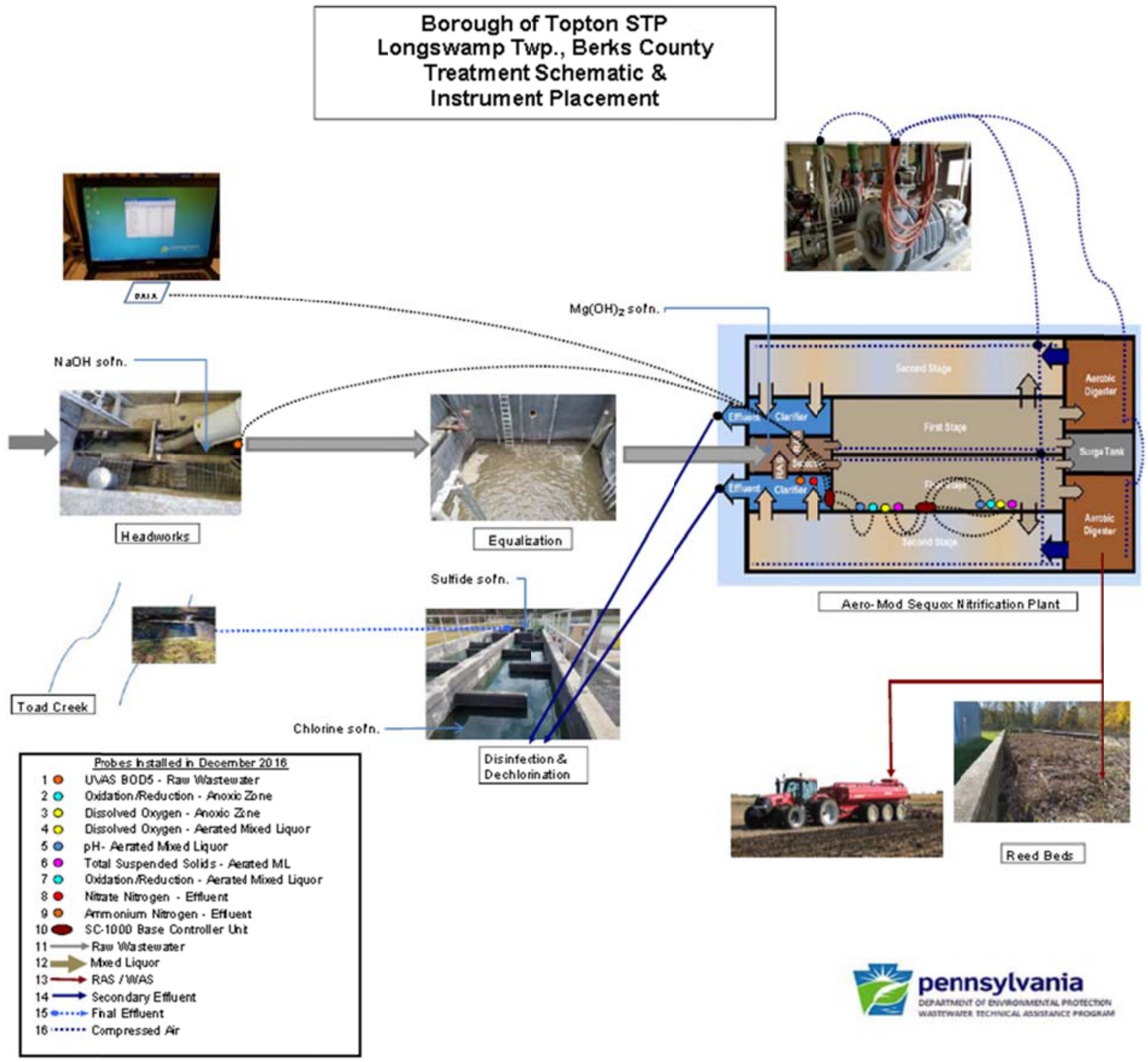
ATTACHMENT B: EQUIPMENT PLACEMENT SCHEMATIC



Equipment Deployed:

2 SC1000 Controller w/Display Unit
2 Hach LDO2 Probes
2 Hach DPD-1P1 pH/Temperature Probes
2 Hach DRD-1P5 ORP Probes
2 Hach Solitax sc TSS Probes
1 Hach UVAS sc TOC Probe
1 Hach Nitratax sc 2mm Nitrate Probe
1 Hach AISE sc Ammonium Probe
1 Adam Digital / Analog Data Converter
1 Dell Latitude e5400 Notebook Computer
1 Hach DR2800 Spectrophotometer
1 Hach DRD200 Heating Block
1 Hach HQ40d Meter Base with BOD Probe
1 Raven Environ. TSS Centrifuge & tubes
3 Raven Environ. 1.4 L Settleometers
1 USB Oil-immersion Microscope
1 Fluke Power Logger

ATTACHMENT C: GRAPHS

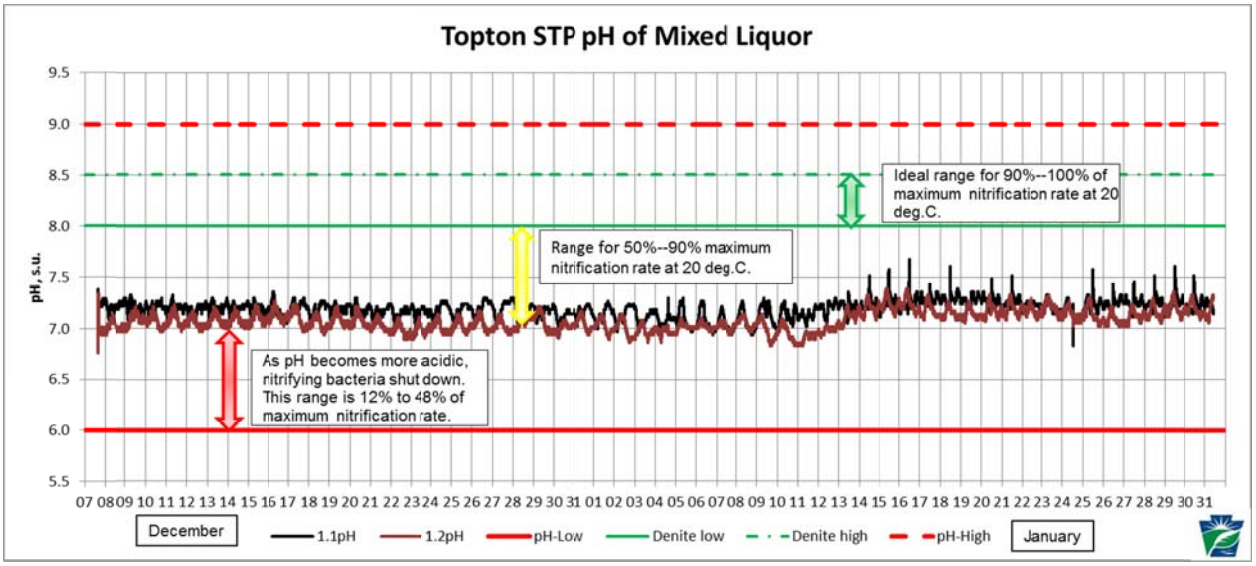


Chart 1: pH record shows that pH is between 6.8 and 7.3 s.u. It may be due in part to the chemicals used to remove copper, but lowering pH is primarily a side-effect of nitrification. The lower pH in Stage 2 suggests that more nitrification is taking place there than in Stage 1 and that the nitrifiers are doing their job. Alkalinity is important because it provides a buffer against acidification of the mixed liquor during nitrification.

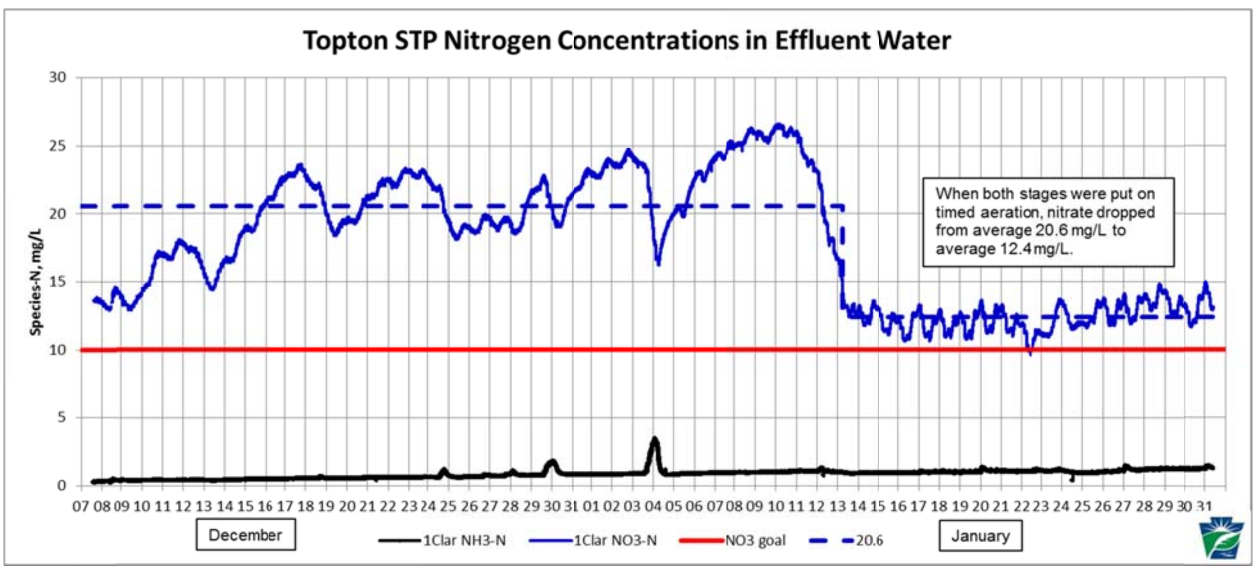


Chart 2: The nitrate probe located in the clarifier effluent of treatment train 1, shows a reduction in nitrate following start of the timed blower sequence, where denitrification occurred during periods where the dissolved oxygen was fully depleted. There was a 40% reduction of concentration and effluent loading after starting intermittent aeration.

The ammonium probe typically tracks higher than laboratory results for NH3-N, due to interferences in the water chemistry. It is used more for trending than analytical work. However, plant operating records show that 8 out of 9 NH3-N test results were “non-detectable” during this period.

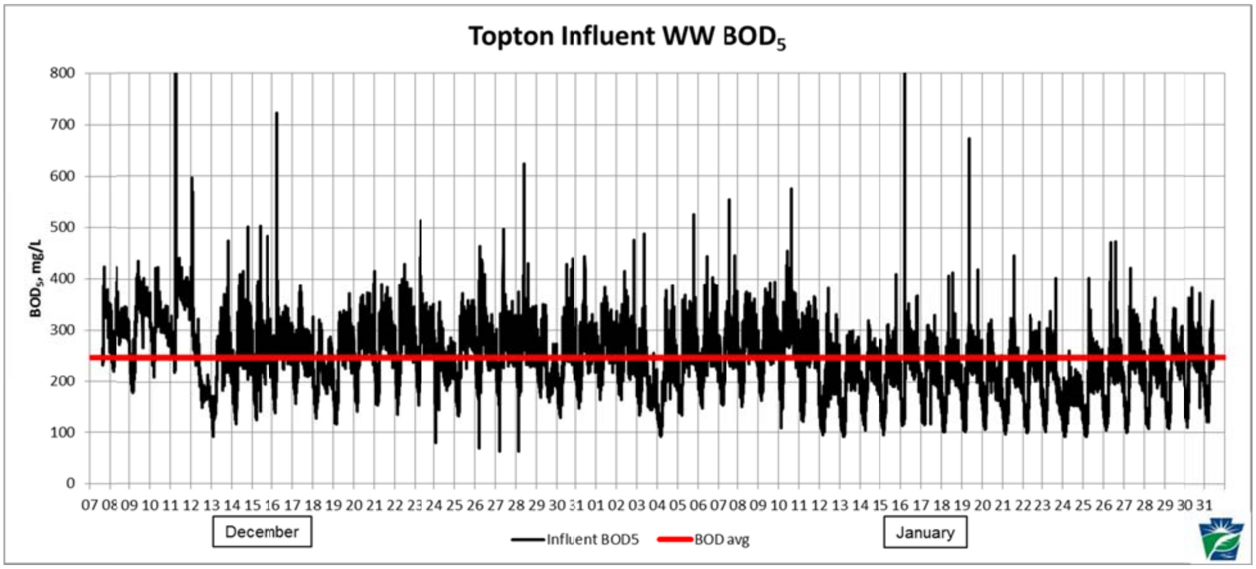
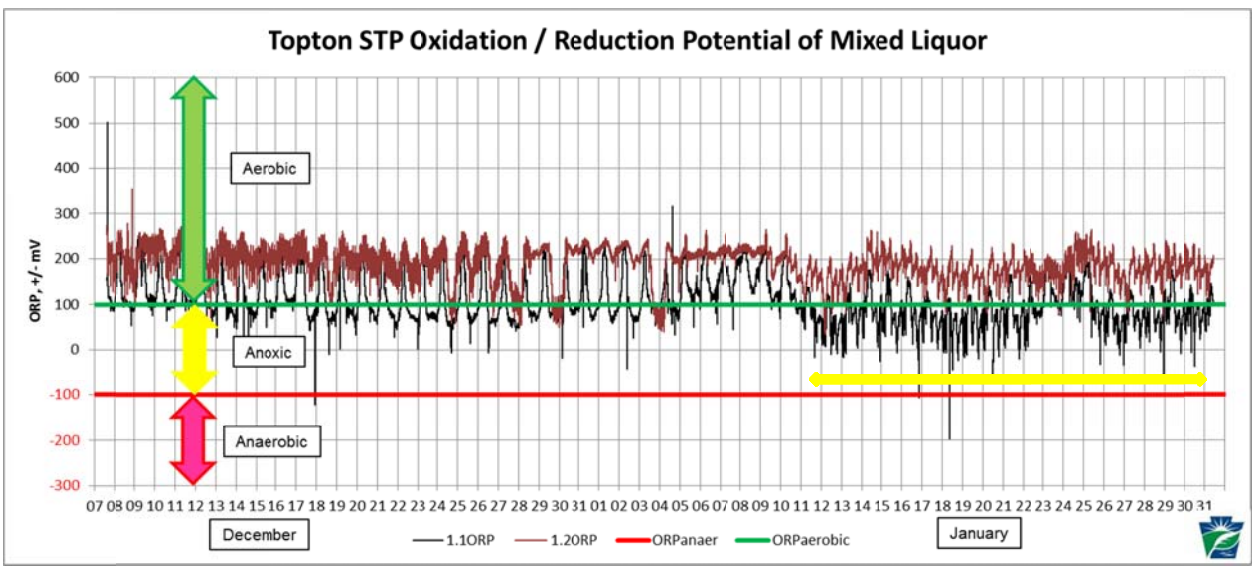
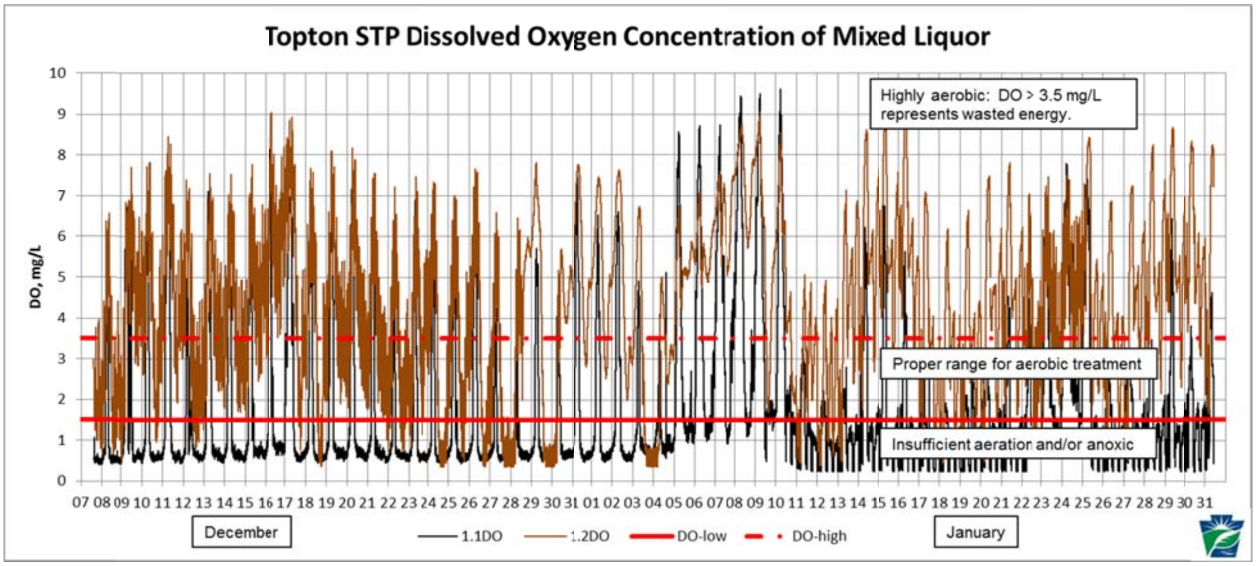


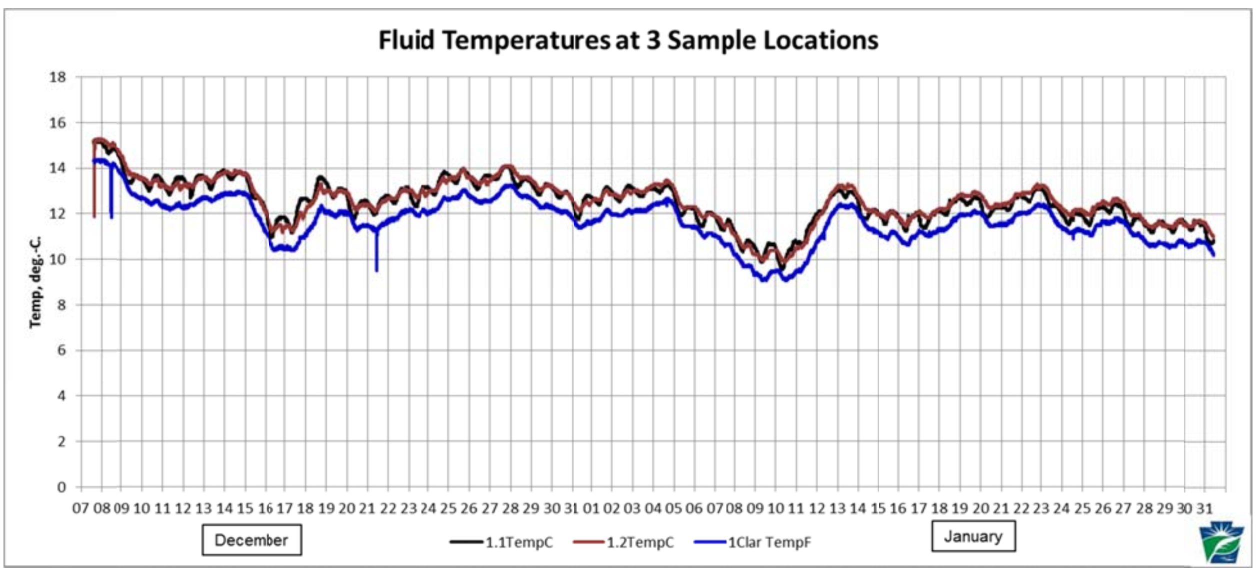
Chart 3: Raw wastewater BOD5, as measured with a total organic carbon probe calibrated for BOD5: This shows diurnal variations in facility loading, with the average BOD being 247 mg/L, within range for domestic wastewater. The instantaneous high readings on the graph are likely due to solid material obstructing the probe window and should be disregarded.



Graph 4: The oxidation/reduction potential (ORP) for Stage 1 and Stage 2 are displayed here, with the activity ranges labeled. Prior to regulating the blowers, the average ORP was well within the aerobic range, showing good nitrification. In January, the ORP readings showed that denitrification was occurring while the aeration blower was cycled off.



Graph 5: The dissolved oxygen graph shows that the mixed liquor often experiences excessive aeration, above 3.5 mg/L, which represents wasted energy. Control of aeration through the use of DO probes will lower operating costs while also reducing the potential for floc shear of the biomass.



Graph 6: The temperature profile for the facility during December and January is displayed. Nitrification occurs best above 15 deg.-C. (90% nitrification) and tends to be very inefficient below 10 deg.-C (< 50% nitrification.)

ATTACHMENT D: RECORD PHOTOGRAPHS

Photo 1: Overall view of facility

Photo 2: 2-Stage Sequox Package Plant, 2 trains

Photo 3: TOC probe at end of Raw WW channel, beside Raptor fine screen and line for NaOH addition

Photo 4: Immersion probes in Train 1, both stages

Photo 5: Nutrient immersion probes in clarifier

Photo 6: Instantaneous Probe Readings

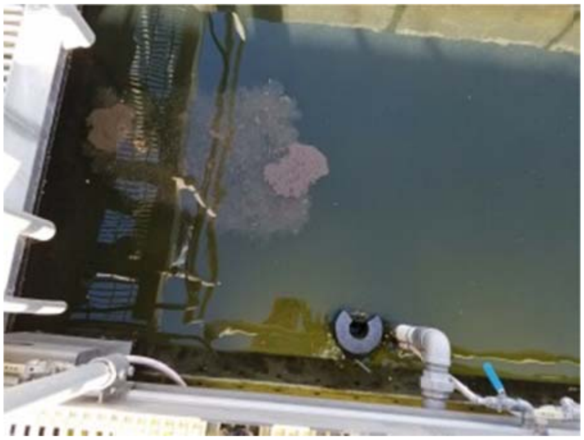


Photo 7: Denitrifying Solids in Clarifier

Photo 8: Settling in Tank 1.1 during Off-cycle

Photo 9: Raw WW Equalization Tank

Photo 10: Main Aeration Centrifugal Blower

Photo 11: Power Logging at Main Blower Controls (note new timer box on blower motor starter's door)

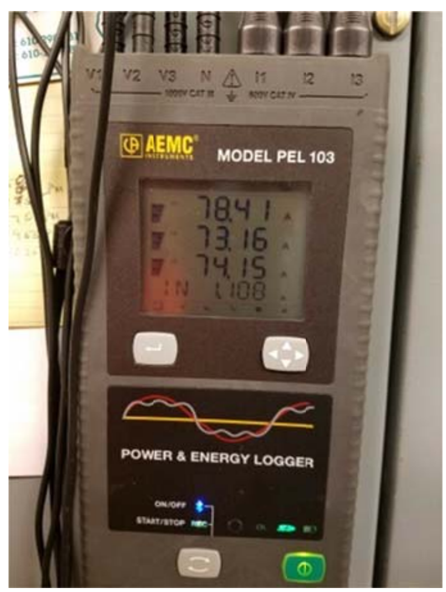


Photo 12: Amperage reading for running blower motor

Photo 13: Sequox Control Panel

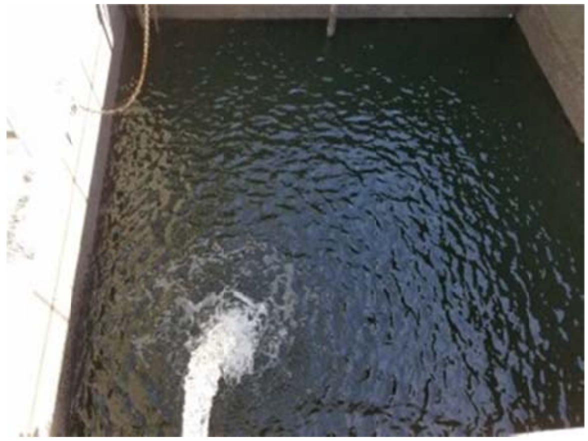


Photo 14: Post-treatment Equalization Tank

Photo 15: Disinfection Process

Photo 16: Gas Chlorinator

Photo 17: 7.5 h.p. Blower for Effluent Freshening

Photo 18: Outfall 001

Photo 19: A Digester in Sequox Package Plant

Photo 20: Reed Beds & Solids Loading Station

Photo 21: Stage 1 Aeration

Photo 22: Stage 2 Aeration