PA DEPT. OF CONSERVATION AND NATURAL RESOURCES BALD EAGLE STATE PARK
BALD EAGLE SP WASTEWATER TREATMENT FACILITY
LIBERTY TOWNSHIP, CENTRE COUNTY, PENNSYLVANIA

NPDES # PA0032492

WASTEWATER TREATMENT EVALUATION

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM

JULY 2018

Executive Summary

Technical Assistance staff from PA Dept. of Environmental Protection (DEP) conducted an evaluation of the Bald Eagle State Park Sewage Treatment Plant (STP) in Centre County from May through July 2018. DEP staff visiting the facility during 2017 concluded that nitrite-lock was the probable cause of effluent fecal coliform violations, occurring because chlorine for disinfection was being consumed instead by products of incomplete nitrification. DEP determined that the instrumentation provided during the BNR upgrade was not performing well in its current state. The evaluation produced some findings and recommendations that may enhance plant performance while reducing monthly operating costs, if enacted.

The facility consists of two parallel treatment trains of aerobic and anoxic BNR zones retrofitted into existing aeration basins, based on the Modified Ludzack-Ettinger (MLE) process. Submersible electromechanical pumps provide nitrate recycle, and the anoxic zones are equipped with surface mixers. Secondary clarifiers for each train employ no skimming system, and both return activated sludge and surface scum are ejected using air-lift pumps. Downstream from the clarifiers are parallel chlorine contact tanks followed by a long outfall sewer that discharges effluent through a sidewall incursion into the dam's spillway channel.

Phosphorus reduction was not evaluated during this study, as biological phosphorus removal is more difficult to achieve on-the-fly, without having dedicated treatment facilities for same.

This report summarizes the findings during the evaluation.

Recommendations:

During their observation and data collection, DEP staff made several recommendations to the operators regarding operation and maintenance of this facility in order to enhance total nitrogen reduction as designed during its BNR upgrade. These recommendations are divided into two categories, those that may immediately improve BNR treatment and those that may require evaluation and implementation by the agency's consulting engineers (long-term):

Things to do to improve BNR treatment:

1. Regularly inspect and clean pH, ORP, and dissolved oxygen probes to prevent build-up of biological slime that interferes with these sensors. As demonstrated during the evaluation, the probes were cleaned with a mild dish detergent solution at least once every two weeks. Probes located in anoxic mixing zones required more frequent cleaning at once per week, because these treatment zones lacked the scouring effect of the aeration system.
2. Reduce the number of probes and controllers in each location: The two aeration tanks require only Dissolved Oxygen and pH probes, sharing one SC200 controller each. The two anoxic zones require only one Oxidation / Reduction Probe in each tank, sharing one SC200 controller. ORP probes in the aeration tanks are not required for nitrification if DO probes are employed as intended[1]; however, they may provide additional information that is useful to indicate whether or not nitrification has been optimized. Likewise, DO and pH probes are not necessary for the anoxic zones. Adjusting the number and application of probes will reduce operation and maintenance costs for this equipment.

[1] That is, connected to the variable frequency drives for the aeration blowers so as to regulate aeration to provide for effective wastewater and ammonia treatment.

3. Contract with the probe vendor for annual service and calibration of the probes. In September 2017, the probes were serviced by Hach technicians who suggested then that all pH and ORP probes required scheduled change-out of the salt bridges with renewal of internal solutions; however, treatment plant operators reported that this was never done.
4. Replace immersion probes that cannot be rehabilitated. The manufacturer reported that the probe life in rough-service conditions is sixty months (five years,) after which the probes may not be reparable.
5. Repair the existing SC200 probe controllers. The display screens of at least four of the eight controllers have been damaged by exposure to direct sunlight. DEP staff consulted with Hach, the manufacturer, and received pricing for service and repair, listed in Attachment C. The controllers are salvageable, and Hach recommends that they be repaired instead of replaced.
6. When reinstalled, assure that the SC200 units employ sun shields or shades to prevent sun-bleaching of the liquid crystal displays. DEP staff, upon reinstalling the SC200 controllers, fabricated temporary sun shades for them; however, this was not meant to be a long-term solution.
7. Connect the DO probes via the SC200 controllers to the variable frequency drives (VFD) for the aeration blowers: These probes and the VFD are meant to maintain dissolved oxygen within a range of 1 to 3 mg/L needed for oxidation of organic carbon wastes and for nitrification of ammonia-nitrogen. Any DO in excess of 3 mg/L is wasted energy, and DO that frequently falls below 1 mg/L in the aeration tanks (as observed when the facility is operated in “storm mode”) is ineffective for waste treatment.
8. Use the ORP probes in the anoxic mixing zones to optimize for denitrification. With adequate nitrate recycle, incoming carbonaceous waste, and ORP within the 0 to -100 mV range, denitrification should be rapid and thorough.
9. Use the pH probes in the aeration tanks to maintain mixed liquor pH above 7.0 s.u. at all times. The probes and controllers may be used to regulate existing caustic soda addition for alkalinity control as a substitute for direct alkalinity testing. Maintain aeration alkalinity in a range of 100-to-200 mg/L and mixed liquor pH between 7.0 and 8.6 s.u. for optimal nitrification within the aeration tanks. Because nitrification produces acidity as a side effect, mixed liquor pH may drop below 6.3 s.u. and inhibit or shut down nitrification. Therefore, pH control is critical to destroying ammonia wastes.
10. Increase frequency of clarifier and disinfection tank cleaning to reduce the incidence of algae and saprophytic filaments that consume chlorine during disinfection.
11. Increase the frequency of laboratory bench analysis for process monitoring and control. The laboratory at Bald Eagle / Howard is well equipped for process monitoring but the tests are not performed frequently enough due to other obligations requiring the operators’ time and labor. DEP recommends that the operators be given up to four hours, two days per week in order to complete recommended process monitoring for activated sludge treatment and biological nitrogen removal. A list of the recommended tests is provided in Attachment E, following.
12. Monitor the production of mixed liquor solids during extended storm mode operation. DEP found that, when reaerated, the mixed liquor solids increased considerably because solids had been settled in the aeration tanks. Inadequately mixed biomass can be a host to unwanted microorganisms such as filamentous bacteria that degrade effluent quality. Excessive suspended solids cannot be adequately aerated and are inefficient at treating waste; therefore, excessive solids accumulation should be discouraged. This can only be done if laboratory surveillance is adequate.

Long-term Improvements:

1. Critical to the successful operation of this treatment facility is control of ongoing inflow/infiltration problems causing excessive hydraulic loading of the secondary activated sludge. The plant operators indicated that most of the hydraulic loading is coming from the collection system of Liberty Township and that this contributor has not cooperated with recent Municipal Wasteload Management (Chapter 94) reporting required by state regulators. This hydraulic overloading has often resulted in the facility's equalization tank remaining full, where its safety overflow simply allows wastewater surges to wash solids out of the secondary treatment system. In an attempt to mitigate these wash-outs, operators reduce aeration supplied for long periods of time, resulting in inefficient treatment of wastes and loss of nitrification capability. For much of the time that DEP staff worked on-site, the plant was operating in "storm mode" with insufficient aeration. No aeration means little or no nitrification, meaning that nitrite lock is more predictable. While it may be possible to add more equalization capacity through capital expenditures, without mitigation of the I/I problem, no amount of equalization capacity will ultimately solve the problem.
2. The facility is equipped for pH control using caustic soda, inserted at the effluent side of the equalization tank; however, this facility does not appear to have been recently used. pH and alkalinity control are critical to optimal nitrification. It may be necessary to upgrade the existing equipment to provide this, whether using magnesium hydroxide, lime, or carbonate/bicarbonate: dry powders should be wetted into a slurry and metered into the treatment process; or, rehabilitate and enlarge the sodium hydroxide addition;
3. Consider improving aeration of equalization tank to "freshen" raw wastewater that has become stagnant.
4. If instrumentation that is needed for adequate BNR operation is repaired and added, the presence of rags and detritus in the mixed liquor becomes a problem. Rags collect on downstream equipment and damage it, not only probes, but aerators, mixers, valves, pump impellers as well. Therefore, it would be prudent to evaluate the efficiency of the existing plant headworks, a bar rack and comminutor, against more modern technology that will effectively remove rags and detritus. BNR plants typically require a modern headworks screening system, such as rotary fine screen.
5. Further, it may be necessary to clean and inspect treatment units to remove rags and detritus in the treatment units during an annual inspection and maintenance down-time.
6. Consider replacing airlift pump gate valves with ball valves that have a measuring scale to allow for fine adjustments.
7. Provide a smaller air blower to operate air lift pumps and digester aeration, so that aeration tank blower can be controlled using DO.
8. Add automated pumping capacity to provide for sludge wasting on a daily (or more effectively, near-continuous) basis.
9. Install 24-hour composite samplers for Effluent and Raw Wastewater sampling and testing. Although the Permit lists 8-hour manual composite as the method, BNR treatment requires more accurate sampling and analysis of raw wastewater strength since denitrification requires additional carbon to convert nitrate ion to nitrogen gas. If the carbonaceous waste entering the facility is insufficient, supplemental carbon in the form of methanol or food wastes will be needed. Better composite sampling will also produce more accurate data necessary for planning purposes, such as Municipal Wasteload Management Reporting under Chapter 94.

10. Sludge treatment and disposal at this facility requires further evaluation to determine a more efficient disposal method. Presently, the facility is equipped with drying beds; however, these drying beds are not sufficient for the increased amounts of sludge being removed through routine operation of the facility. Sludge may be dried and stored on site for later disposal, or it is more expensively hauled away as dewatered liquid for treatment and disposal at another site. DEP recommends that facility's consulting engineer evaluate the cost-effectiveness of sludge treatment and disposal.
11. During the evaluation, the long-time operator retired, and the facility operation was handled by DCNR staff working several different sites. DEP recommends that the new operator-in-charge of the facility be afforded adequate time for training not only in operations and maintenance but also in process monitoring and control testing required to assure that BNR goals are met. BNR facilities require greater process control testing than a traditional activated sludge plant.

Wastewater Treatment Evaluation:

Pennsylvania Department of Conservation and Natural Resources owns and operates a wastewater treatment facility located near the face of Sayers Dam in Liberty Township, Centre County. The facility serves sources within the Bald Eagle State Park and from the surrounding townships of Howard and Liberty, including the village of Howard. It discharges treated water to a tributary of the West Branch, Susquehanna River in the Chesapeake Bay Drainage Basin, making it eligible for nutrient limits on nitrogen and phosphorus. The facility presently is required to "monitor and report" on its monthly discharge monitoring reports (DMR.)

Photo 1: Each of four treatment units has 3 probes and 2 controllers.

The treatment plant was originally built as an extended aeration, activated sludge secondary treatment facility, but it was upgraded to establish separate aerobic and anoxic treatment zones for biological nitrogen removal. The two parallel aeration tanks were partitioned using heavy curtains, and diffusers were upgraded to Sanitaire ceramic discs, with floating mixers placed in the anoxic mixing zones to improve denitrification. An original gas chlorine disinfection system was replaced with 12.5% sodium hypochlorite (bleach) solution. Original centrifugal blowers had been replaced with rotary lobe (PD) blowers with variable frequency drives (VFD) for the drive motors. Instrumentation was added for dissolved oxygen, pH, and oxidation/reduction potential monitoring, but this system was never connected to a supervisory control and data acquisition (SCADA) system or to any process controllers such as the VFDs.

A schematic of the treatment process is provided in Attachment B.

Other processes include a comminutor headworks for trash removal, a 0.3 MGD equalization tank, a small aerobic digester with conventional sludge drying beds, and chemical feed system for sodium hypochlorite solution used as disinfectant. Facilities exist beside the equalization tank to provide pH and alkalinity control using sodium hydroxide (caustic soda) solution, although the practice of such as not be recently implemented. There are surface aerators in the equalization tank. Photos of these are provided in Attachment D.

The control building houses two new rotary lobe blowers and an older centrifugal blower, a workshop, office/lab, and changing room. The basement of this building contains pumps and valves. Electrical service is standard 480-volt, three phase system with four wires. There are two variable-speed controllers for the PD blowers, although these are not connected for automatic control and have no controller feedback connection to the aerobic treatment zones.

Bald Eagle STP's service area consists of gravity sewer and force main, and it is served by two pumping stations.

The facility's Municipal Wasteload Management "Chapter 94" Report for 2017 noted that average annual daily flow was steady at 450,000 gallons per day (0.45 MGD) with an average daily organic load of 1,000 lb./day. Neither hydraulic overloads nor organic overloads were reported; however, one of two townships did not file its required supplement, and the operators have noted that inflow and infiltration (I/I) is a significant factor in plant performance during wet weather.

Nutrient Reduction Goals:

The facility's permit has "monitor and report" requirements for nutrients. These are usually precursors to numerical limits in future permits, although there is no date certain. When imposed, nutrient limits may be based on concentration limits of 6 mg/L for total nitrogen and 0.8 mg/L for total phosphorus.

Since this facility is not designed for biological phosphorus removal, phosphorus control would be done using metal salts and precipitation of metal ortho-phosphate. This was not evaluated.

NPDES Permit Excursions

Of interest to the regulatory community, the treatment facility at Bald Eagle State Park experienced eleven permit excursions for fecal coliforms since 2009 where seven occurred since 2015. Although the record lists most of the causes as "unknown" or simply blank, observations of the facility by DEP staff suggest that nitrite lock had been the cause of most of these. Nitrite lock occurs when products of incomplete nitrification bind with disinfectant chlorine, rendering it inert or unavailable for disinfectant purposes. This constituted 61% of all recent effluent violations (35% of all effluent and administrative violations since 2009.)

A table of permit excursions is included as Attachment C.

Existing Process Controls:

During the BNR upgrade, separation between aerobic and anoxic zones was achieved using semi-rigid baffle curtains. The anoxic zones employ surface mixers. The aerobic zones have diffused aeration grid supplied by retrofitted positive displacement (PD) blowers controlled using variable frequency drives (VFD); however, there is no automatic control of the VFDs, and operators must employ the manual override to control the blowers during times of high Inflow/Infiltration (I/I,) operating the facility in a "storm mode" similar to that employed at sequencing batch reactor (SBR) facilities.

Both sets of aerobic and anoxic zones are equipped with luminescent dissolved oxygen (LDO), oxidation/reduction potential, and pH probes, four sets in all, connected to eight Hach SC200 controllers. These controllers may be used for data monitoring, data collection, and for automated process control, but they are not connected to any control system at this facility: they do not control blower output, anoxic mixing rates, nor pH/alkalinity. Half of the SC200 controllers have sun-damaged liquid crystal displays (LCD) and are, for practical purposes, inoperative but can be repaired for about $750 each[2].

DEP staff found that the twelve digital probes for process monitoring and control had not been cleaned or serviced since September 2017. The probes sustained heavy growth of biological film and were out of calibration. The four LDO probes had no elevation setting programmed for calibration in air, and the plant operator reported that service technicians had informed them in September 2017 that some of the pH and ORP probes could not be recalibrated and should be

[2] Versus a replacement cost of $1,925 each.

replaced, although at the time of the DEP visit, the specific probes to be replaced were not known. All the pH and ORP probes were issuing corrective action messages for annual salt-bridge replacement, but this date function is preprogrammed by the service technician to coincide with an annual service call, whether the probe really needs it. In this case, it appeared that the probes should all be overhauled.

Even with overhauls, the pH and ORP probes may last for only five years when used in wastewater treatment conditions that are considered “rough” service.

Additional Equipment Deployment:

In late April 2018, DEP staff deployed additional process monitoring instrumentation on site. The eight SC200 were temporarily removed and replace with two Hach SC1000 controllers and a Hach Universal Graphing Display Module. This network was connected to a digital converter inside the lab/office area and attached to a DEP-provided notebook computer for continuous data logging. DEP utilized the existing monitoring probes along with a probe to measure Mixed Liquor Suspended Solids (MLSS) installed into Aerobic zone of Treatment Train 2. In addition, DEP staff deployed its portable process monitoring laboratory for monitoring nutrients and for checking and recalibrating DCNR’s probes.

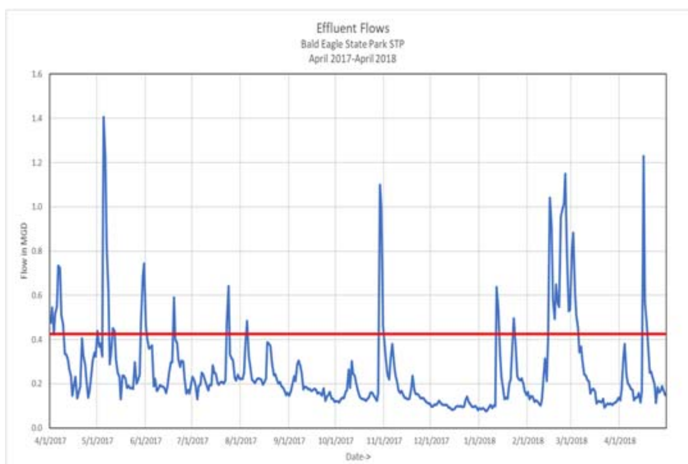
Staffing Needs:

At the time of the evaluation, the facility’s operator retired following a long career with DER/DCNR. He has been temporarily replaced chiefly by a licensed operator who works among several state park treatment systems. Notwithstanding his other job duties for DCNR, the operator who worked with DEP staff during the evaluation commented had very limited time to spend at the plant, approximately two hours per day. This would generally be insufficient for this type of BNR facility.

Operations:

During the evaluation, wet weather continued to affect the operators’ process control strategy. For many days, the facility was operated in a “storm mode” whereby operators reduce the aeration mixing in an effort to prevent hydraulic washout of biomass solids. The VFD for the single blower running was set for about 40% power on manual override. This VFD was never connected to the aeration tank dissolved oxygen probes for dissolved oxygen control.

The chart to the right shows the recorded effluent flow with many days shown in excess of the rated annual average daily flow (AADF.) It is reasonable to assume that several successive days of high flows will prevent the facility’s recovery from individual events of excessive hydraulic loading.



Graph 1: Hydraulic surges seen in effluent monitoring.

Interestingly, though, based on the Municipal Wasteload Management Report for 2017, this facility operates on average at only 61% of its rated hydraulic capacity.[3] Using five-year

[3] Likewise, according to the 2017 Chapter 94 report, in 2016 the facility’s organic loading was only 20% of its 1,000 lb./day rating. If nothing else, this proves the inadequacy of 8-hour manual composite sampling!

hydraulic and precipitation data from the facility's most recent Chapter 94 report and creating linear trend lines for both, data analysis shows that the linear progression for monthly average flows and precipitation track very closely. This proves the operators' assertion that precipitation directly affects hydraulic loading on the facility. The graph showing this is provided in Attachment E.

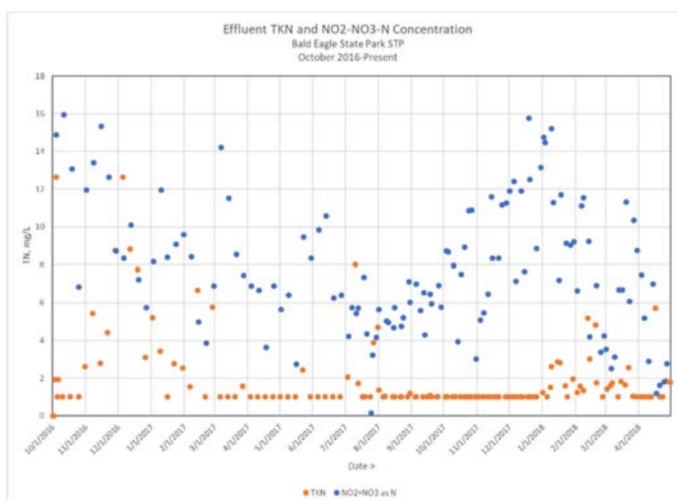
DEP found monitoring probes befouled with biomass, grease, and bits of rags or other detritus. DEP staff cleaned and recalibrated the probes, although some would not take new calibration. The dissolved oxygen probes were in similar state and appeared to have never been initially calibrated, as there was no entry for elevation that is used in the probe program to calibrate to atmospheric oxygen.

Photo 2: Immersion probe insufficiently maintained

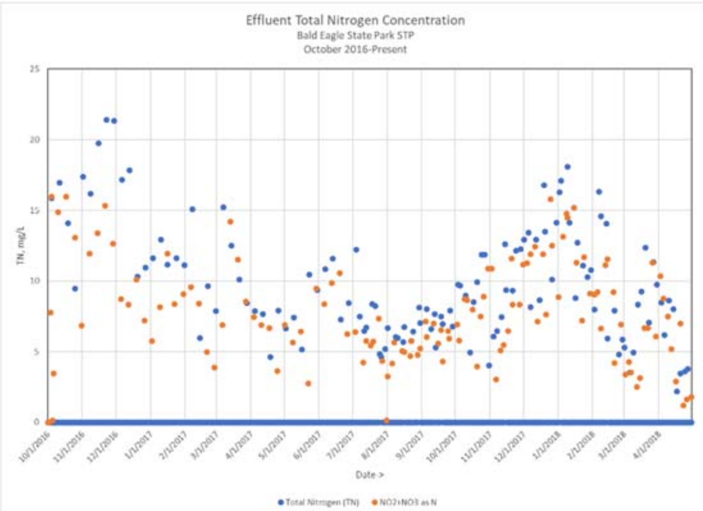
Photo 3: Clean probes regularly on a schedule

Because of the inadequate aeration, DEP staff could not initially determine biomass suspended solids or calculate sludge volume index or wasting rates. Although laboratory bench testing for ammonium in the effluent did not determine high amounts, the lack of aeration for extended periods would favor the nitrite formation that had resulted in nitrite-lock and high fecal coliform counts. The facility's nitrate formation usually appeared adequate.

The chart below shows a comparison of reported lab results for effluent total Kjeldahl nitrogen (TKN) and for effluent nitrite-nitrate. This chart shows that oxidized nitrogen (blue) tends to be lower during warm weather while reduced nitrogen is relatively uncontrolled during cold weather months. During the winter, nitrate is low not because of denitrification but because ammonium and TKN are not being oxidized through biological nitrification.



Graph 2: Effluent TKN & Nitrite-Nitrate Concentrations



Graph 3: Effluent Total Nitrogen vs Nitrite-Nitrate Concentrations

Similarly, and overall, the related chart showing effluent total Nitrogen (blue) and effluent nitrite-nitrate shows that, year-round, nitrite-nitrate predominates as the chief constituent of total nitrogen during the summer months (in the middle of the chart.) The interpretation of this chart suggests that, as operated, the Bald Eagle facility often has inadequate nitrification, most likely the result of prolonged operation in “storm mode” at the expense of nitrification.

Ideally, the Total Nitrogen concentration should no greater than 6 mg/L as an annual average; otherwise, nitrogen credits must be paid for in order to make up the surplus dicharge

Headworks and Flow Equalization:

Because of the wet weather, significant I/I usually resulted in the equalization tank operating at maximum level, where an emergency overflow allows water in excess of the tank freeboard to flow unimpeded through the downstream treatment processes. In addition, the surface aerators located here were usually either minimally running or not operating, allowing the contents of the tank to stagnate. A pH-regulating caustic soda chemical feed system at the equalization tank did not appear to be in use.

Photo 4: Comminutor & Bar Rack

The headworks consist of an antiquated comminutor with bar-rack backup channel. This allows rags and detritus, albeit comminuted, to accumulate downstream on the anoxic mixers, the aeration grid, instrumentation, and pump cables. Both the headworks and the equalization tank are not routinely performing well.

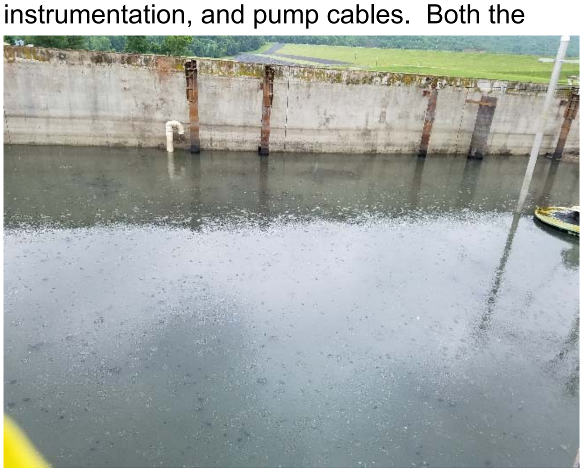


Photo 5: Off-gassing of waste in Equalization Tank

BNR treatment facilities employ equipment that may be damaged by rags and detritus that pass through inefficient screening. Comminutors produce strands of rags and debris that accumulate downstream on aerators, anoxic mixers, and immersion probes. This material may also clog pump impellers and some valves. During the evaluation, DEP staff cleared several pounds of rag debris from the clarifier scupper outlets, and the operator reported that he routinely reverses the anoxic surface aerators to throw off rags and debris that he then fishes out of the tanks.

Secondary Treatment

A problem with secondary treatment is that hydraulic overloading requires the operators to reduce aeration with deleterious effect, resulting in failure of nitrification and concurrent accumulation of suspended solids in the tank bottoms where it is not accounted for nor maintained in a healthy state. Typically, the facility is operated using only one of the two provided positive displacement (PD) blowers. Connection of the DO probes to the VFD of the blower would allow operators to set a proper DO range for maintaining the aeration tanks; however, this does not remedy the hydraulic loading. The reduced aeration results in incomplete treatment.

Photo 6: Secondary Treatment Train

The secondary clarifiers are hopper-style tanks with no moving parts. Settled sludge is returned to the anoxic treatment zone by way of air-lift pumps. Operators have previously lowered the return sludge discharges below the surface of the anoxic zone to reduce splashing that introduces unwanted oxygen into the anoxic zone, but the air lift pumps are difficult to control using the existing gate valves. Substitution with ball valves may provide a finer level of control. Unfortunately, though, if the aeration blower is connected for DO control, flow may be reduced through the air-lift pumps, interfering with clarifier performance. Options include replacing these pumps with electromechanical ones or to providing a small jockey blower to provide the air to drive these pumps as determined by its engineer.

Photo 7: Algae in Secondary Clarifiers

The clarifiers themselves generally perform well, with Secci disk clarity to 4/5 of the depth of the water column. Maintenance can be an issue, though, with the rapid formation of algae during warmer weather to interfere with the weirs and surface scuppers. More frequent maintenance may be necessary to keep the clarifiers and downstream disinfection tanks clear of algal blooms. Such algae will interfere with the efficacy of disinfection.

Solids Treatment and Disposal:

Wasted biomass is aerobically digested in integral holding tanks and then dewatered and hauled as liquid or spread onto drying beds and left to dewater naturally. The operators reported that this latter method is slow and often inefficient resulting in increased operation attention and less time for other tasks.

Photo 6: Solids Drying Facilities

ATTACHMENT A: EVALUATION TEAM

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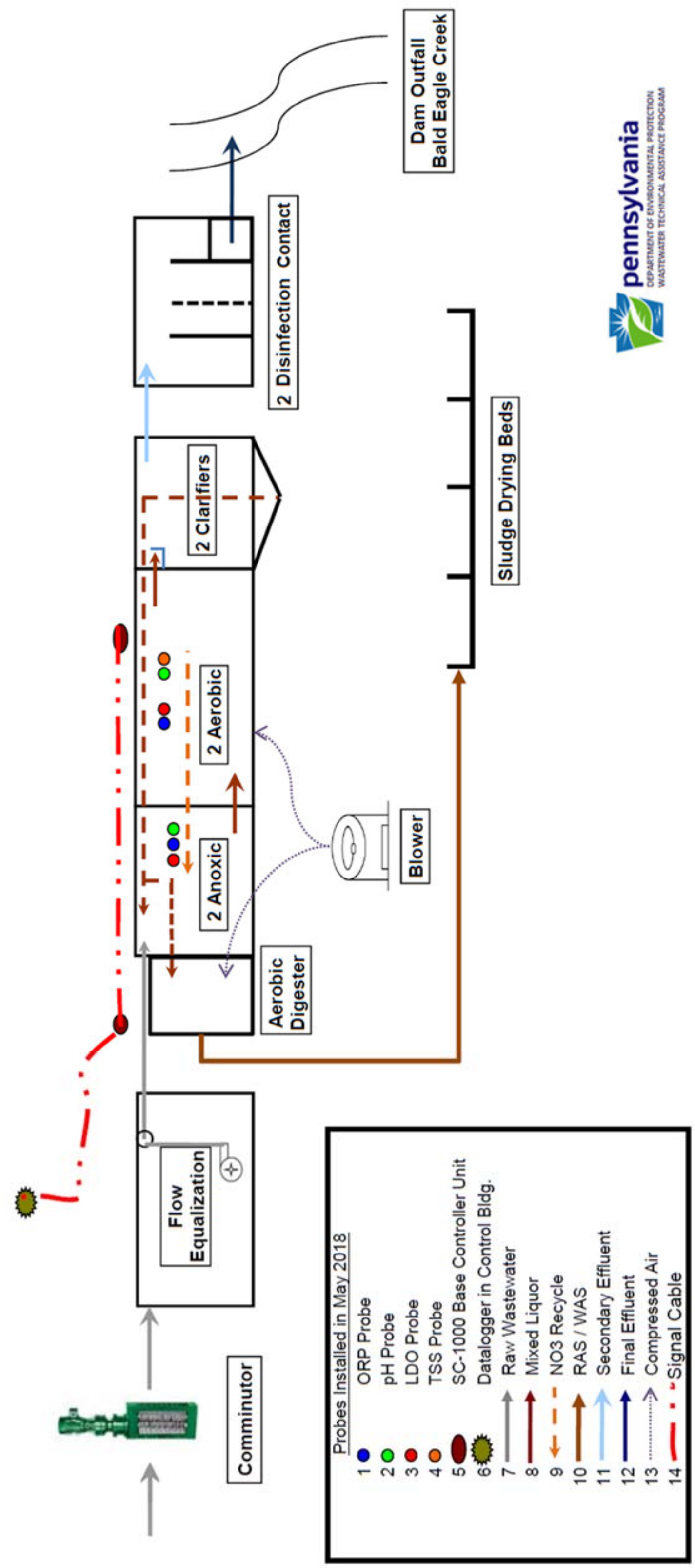
ATTACHMENT B: EQUIPMENT PLACEMENT SCHEMATIC



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ATTACHMENT C: NPDES PERMIT EXCURSIONS

Bald Eagle State Park STP
Liberty Township, Centre County
NPDES PA0032492

Reported Permit Violations:

Event Start Date	Event End Date	Parameter	Limit Type	Reported Value		Permit Limit	Unit	Sampling Point	Sample Type	Sampling Frequency
2/1/2018	2/28/2018	Fecal Coliform	Instantaneous Maximum	24,196	>	10,000	No./100 ml	Final Effluent (001)	Grab	1/week
1/1/2017	1/31/2017	Fecal Coliform	Instantaneous Maximum	24,196	>	10,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
6/1/2016	6/30/2016	Fecal Coliform	Instantaneous Maximum	3,921	>	1,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
2/1/2016	2/29/2016	Fecal Coliform	Instantaneous Maximum	12,098	>	10,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
1/1/2016	1/31/2016	Fecal Coliform	Instantaneous Maximum	12,033	>	10,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
6/1/2015	6/30/2015	Fecal Coliform	Instantaneous Maximum	1,892	>	1,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
4/1/2015	4/30/2015	Fecal Coliform	Instantaneous Maximum	12,098	>	10,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
9/1/2012	9/30/2012	Fecal Coliform	Instantaneous Maximum	4,820	>	1,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
5/1/2012	5/31/2012	Fecal Coliform	Instantaneous Maximum	3,980	>	1,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
9/1/2011	9/30/2011	Fecal Coliform	Instantaneous Maximum	1,160	>	1,000	CFU/100 ml	Final Effluent (001)	Grab	1/week
7/1/2009	7/31/2009	Fecal Coliform	Geometric Mean	311	>	200	CFU/100 ml	Final Effluent (001)	Grab	1/week
5/1/2011	5/31/2011	Total Suspended Solids	Weekly Average	205	>	169	lbs/day	Final Effluent (001)	8-Hr Composite	1/week
11/1/2010	11/30/2010	Total Suspended Solids	Weekly Average	85	>	45	mg/L	Final Effluent (001)	8-Hr Composite	1/week
9/1/2010	9/30/2010	Total Suspended Solids	Weekly Average	104	>	45	mg/L	Final Effluent (001)	8-Hr Composite	1/week
9/1/2010	9/30/2010	Total Suspended Solids	Average Monthly	31	>	30	mg/L	Final Effluent (001)	8-Hr Composite	1/week
10/1/2014	9/30/2015	Total Nitrogen (Total Load, lbs)	Total Annual	8,954	>	8,219	lbs	Effluent Net (001)	Calculation	1/year
10/1/2013	9/30/2014	Total Nitrogen (Total Load, lbs)	Total Annual	12,902	>	8,219	lbs	Effluent Net (001)	Calculation	1/year
10/1/2013	9/30/2014	Total Phosphorus (Total Load, lbs)	Total Annual	1,365	>	1,096	lbs	Effluent Net (001)	Calculation	1/year

Monitoring Begin Date	Monitoring End Date	Non-Compliance Type	Version Number	Sampling Point	Parameter	Excursions
2/1/2017	2/28/2017	Sample collection less frequent than required	1	Final Effluent (001)	Flow	0
12/1/2016	12/31/2016	Late DMR Submission	1			
11/1/2016	11/30/2016	Late DMR Submission	1			
10/1/2016	10/31/2016	Late DMR Submission	1			
9/1/2016	9/30/2016	Late DMR Submission	1			
4/1/2016	4/30/2016	Sample type not in accordance with permit	1	Final Effluent (001)	Fecal Coliform	0
3/1/2016	3/31/2016	Sample type not in accordance with permit	1	Final Effluent (001)	Fecal Coliform	0
2/1/2016	2/29/2016	Sample type not in accordance with permit	1	Final Effluent (001)	Fecal Coliform	0
1/1/2016	1/31/2016	Sample type not in accordance with permit	1	Final Effluent (001)	Fecal Coliform	0
12/1/2015	12/31/2015	Sample type not in accordance with permit	1	Final Effluent (001)	Fecal Coliform	0
11/1/2015	11/30/2015	Sample type not in accordance with permit	1	Final Effluent (001)	Fecal Coliform	0
11/1/2015	11/30/2015	Sample type not in accordance with permit	1	Effluent Net (001)	Total Nitrogen (Total Load, lbs)	0
2/1/2016	2/29/2016	Sample type not in accordance with permit	1	Final Effluent (001)	Total Phosphorus	0

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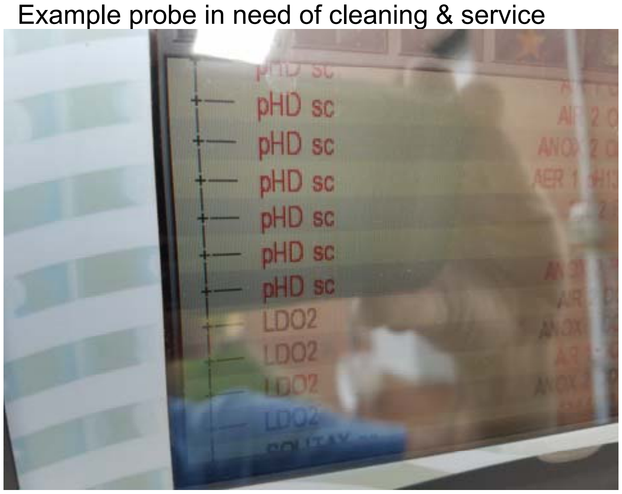
ATTACHMENT D: RECORD PHOTOGRAPHS

Existing Probe and Controller Installations

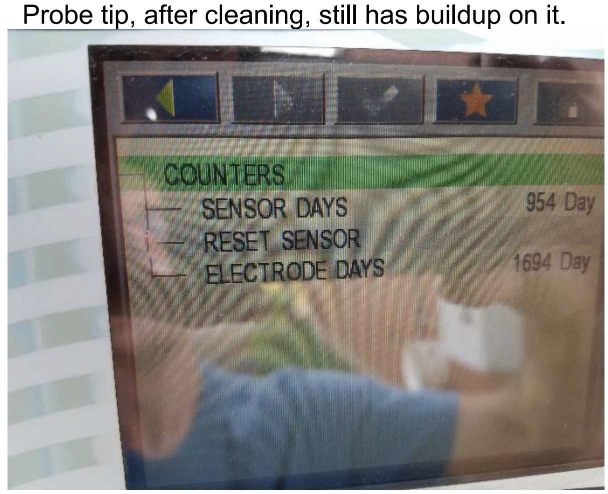
Controller notes probe recalibration is due

Example probe in need of cleaning & service

Probe tip, after cleaning, still has buildup on it.



“Red” indicates probes are out of calibration

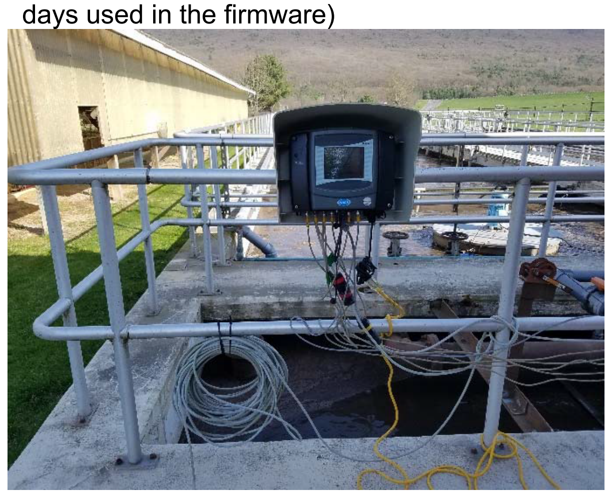


Sensor days: 2.6 years; Electrode, 4.6 years

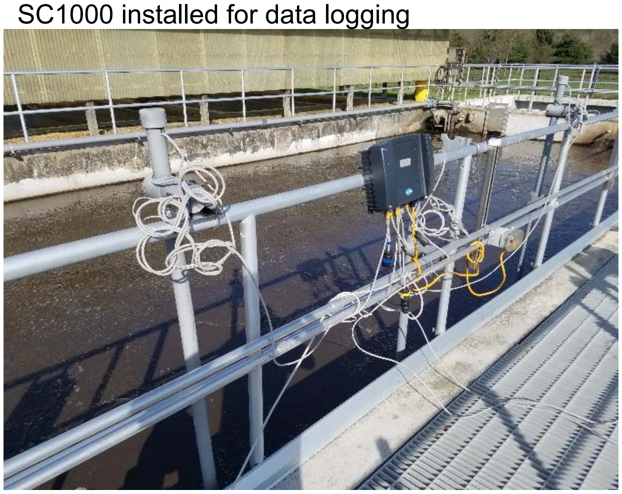
Sensor days left: 1.33 years (5-year total)

Sensor Life: 178 years or 7.45 years (if hrs not days used in the firmware)

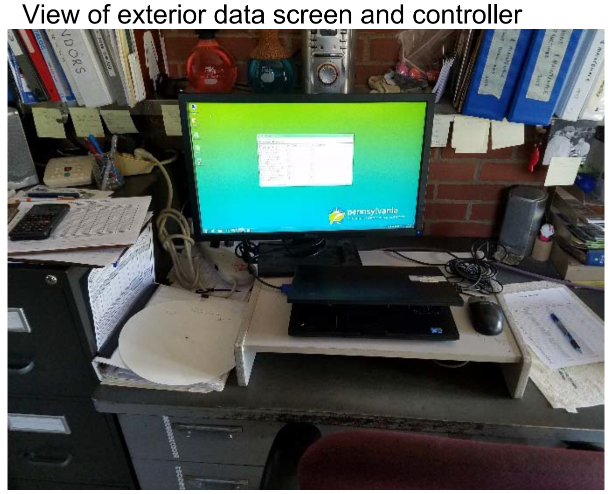
SC1000 installed for data logging



View of exterior data screen and controller



Second controller for aeration tanks



Data-logging monitor in control building

Algae growth in clarifier

Woody growth in anoxic tank

Operators cited need for more capacity

SC200 reconnected following on-site activities.

Full Equalization Tank on a Sunny Day

Gas Production in Equalization Tank on a Sunny Day

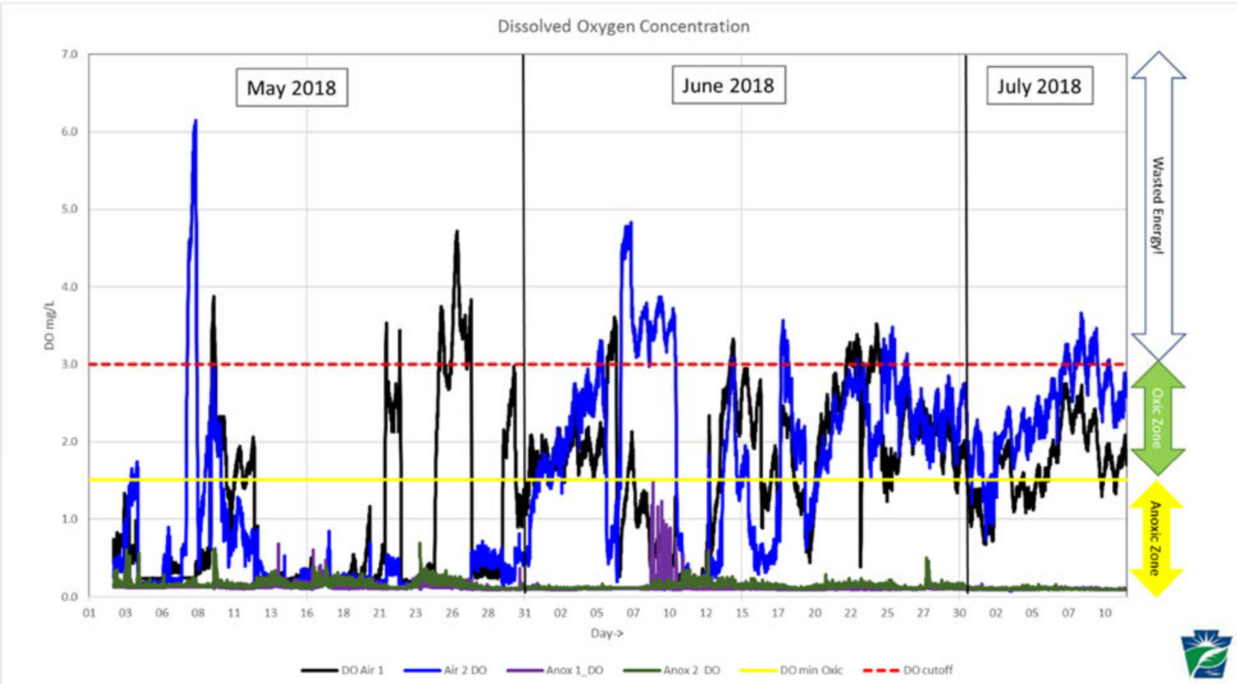
Old Comminutor at Headworks

Cover for LCD screen protection

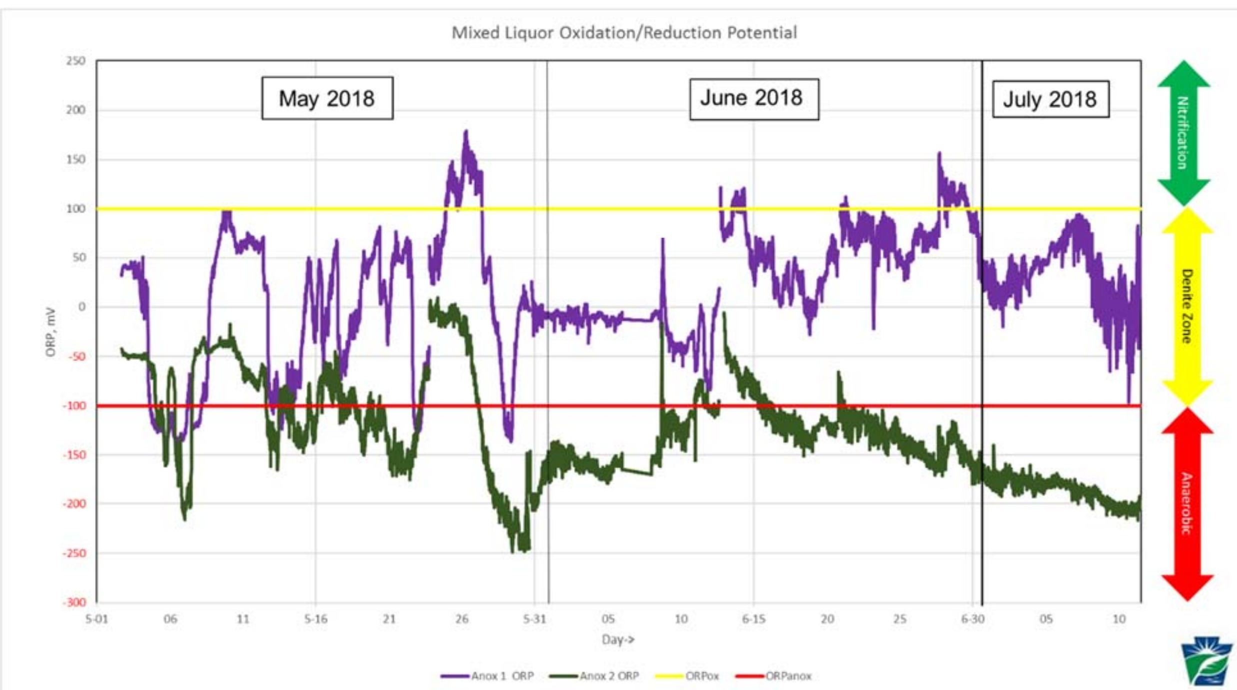
Sun shades on SC200 LCD displays

Completed sun shade

ATTACHMENT E: EXAMPLE TRENDS CHARTS

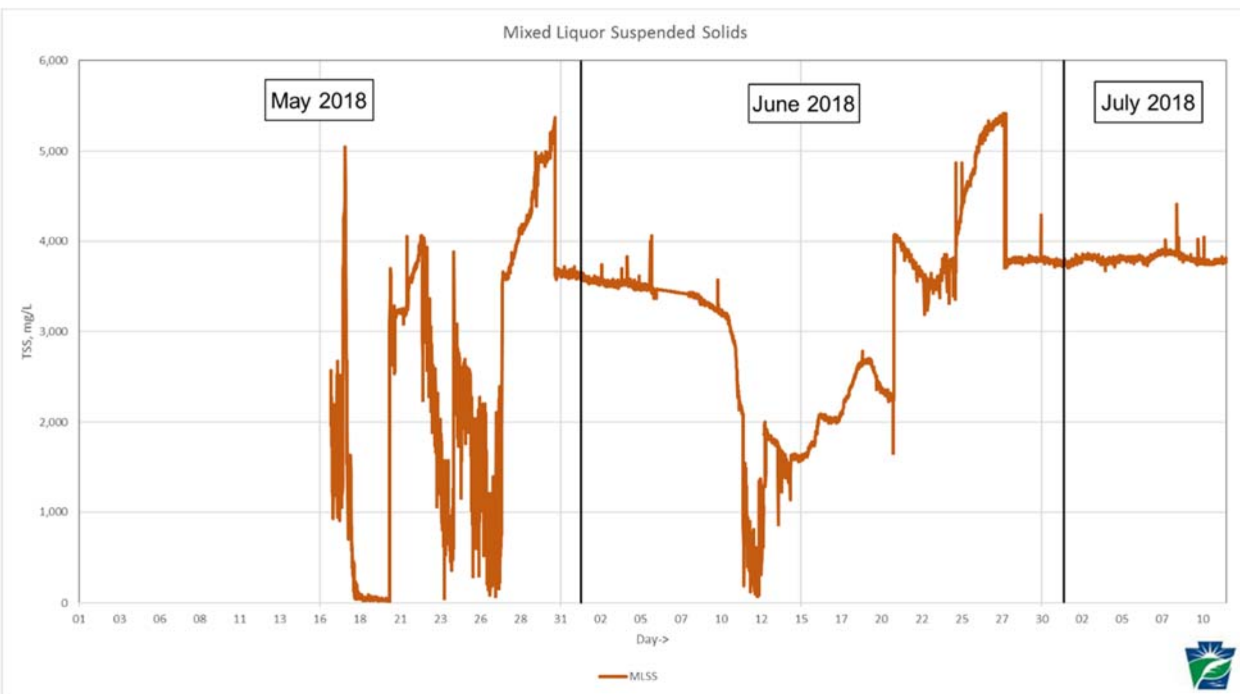


DO graph shows that it is not well-regulated. In May, there were many days when the aeration was minimal to prevent solids washouts. This “storm flow” operation persisted in June, to the detriment of overall operations.

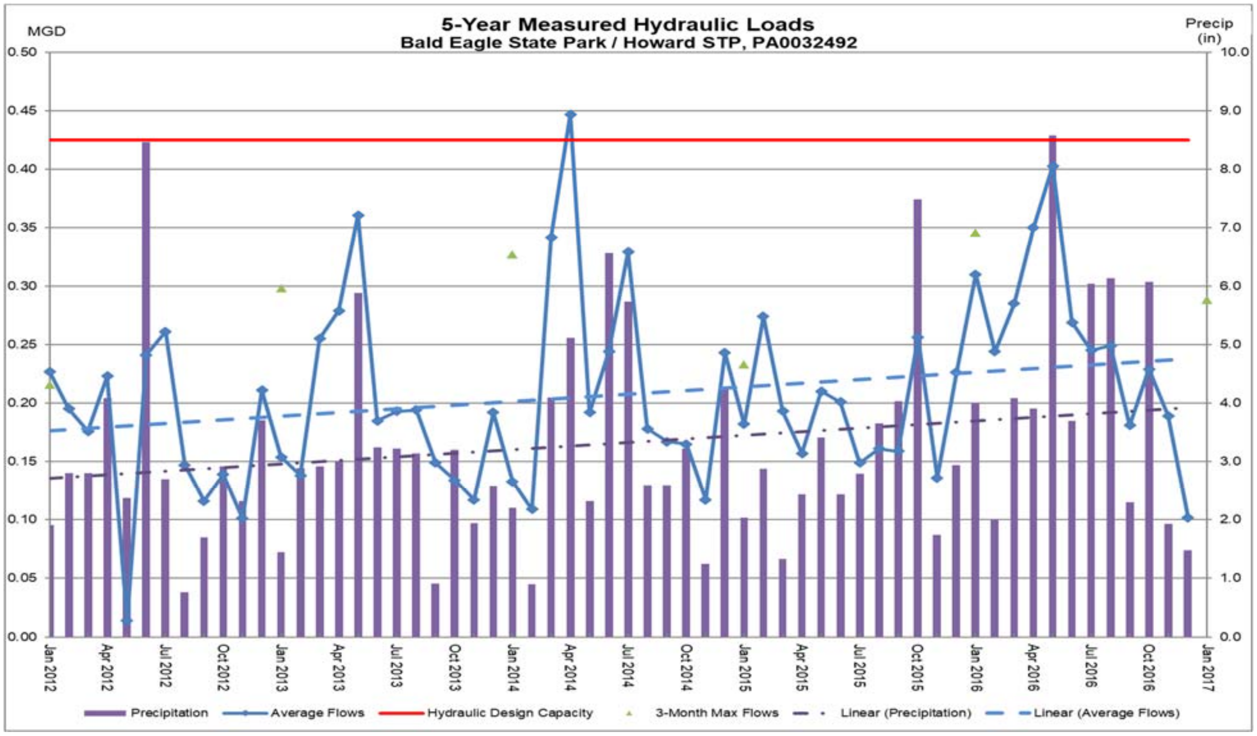


ORP probes in the Anoxic Zones proved suspect. After recalibration, the one in Anoxic 1 appeared to be working, while the salt bridge in the other one was failing. Both probes should have had salt bridges replaced. (Aeration probe data is not displayed because the probes could not be calibrated.)

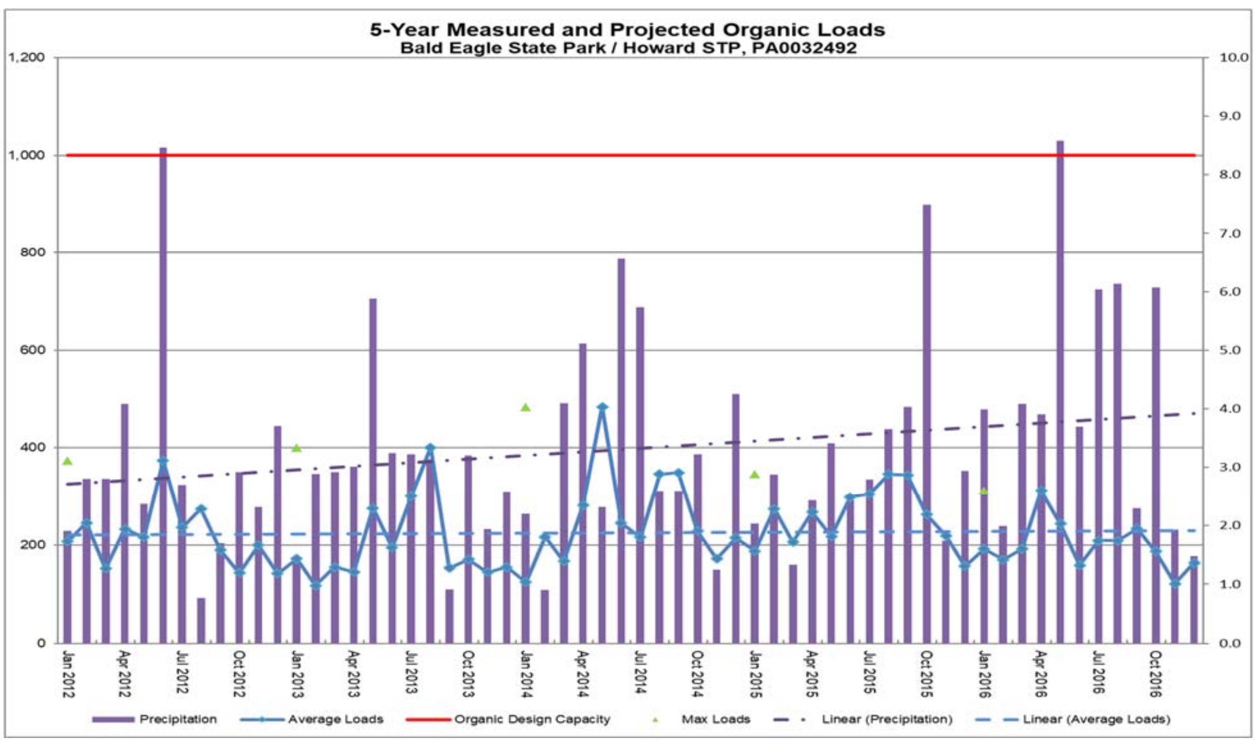
pH Probe readings displayed a lot of drift, but the general trend was that pH became lower as nitrification was working better in June and July, due to formation of nitrous and nitric acids. What is notable here is that in May, probe performance improved after a thorough cleaning and recalibration, although the salt bridges in all these probes were no longer very effective.



Total Suspended Solids concentration in aeration tank 2 were difficult to measure, because the aeration rate was often reduced to minimal mixing to prevent solids loss during high (storm) flows. The chart shows when solids were often mostly settled in the tank. When full, useful aeration was restored, the solids often shot upward due to inclusion of those that had settled out of range of the probe.



This hydraulic loading chart based on the 2017 Chapter 94 report data was adjusted to show linear trend charting of both average flows and precipitation. The two linear trends mirror one another very closely, indicating that inflow/infiltration is a serious problem at this treatment facility.



Note that for the same period, the organic loading remains constant while precipitation increases: This is to be expected when I/I influences hydraulic loading, as seen in the preceding chart.

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ATTACHMENT E: PROBE REPAIR / REPLACEMENT COST ESTIMATES

At the request of the facility operators, DEP staff contacted Hach Inc., the probe and controller manufacturer, for suggestions on repair and replacement costs for damaged or expired equipment. The following table summarizes these costs that should be budgeted as part of the facility's maintenance costs.

Minimal Probe Repair/Replacement Pricing:			
Hach.com	List price	Qty	Cost:
pHDsc	$ 1,049	2	$ 2,098
pH/ORP	$ 1,119	2	$ 2,238
Replace Caps for LDO Probes	$ 215	2	$ 430
Salt Bridge for pH&ORP	$ 81	4	$ 322
Std.Cell Solution for Salt Bridge	$ 72	1	$ 72
200mV ORP Sol'n. 500 ml.	$ 63	2	$ 127
		Total:	$ 5,287

Repair/Replacement Recommendations:

1. Hach staff did not recommend replacing the SC200 with an SC1000 that the operators preferred. The reason for this is that the SC200 has all the same functionality as the SC1000, except that SC200 has only a pair of inputs, while the SC1000 has up to eight. The cost for an SC1000 base unit with full capability is $2,586 but it also requires a universal display module for another $2,520. Total SC1000 cost would be: $5,106.
2. The SC200 can be repaired for $750 each. Price new is $1,965. Cost to repair four SC200 is only $3,000. QED: Repair the SC200 and daisy-chain them if you want to have data recording on an existing computer. Repair sub-total: $750.
3. ORP and pH probes: As illustrated in the photographs in Attachment D, the average age of the probes at the time of the evaluation was 4.6 years. The recommended life of the probes was given by Hach as 5 years, so these probes should be replaced. As recommended in this evaluation, only half of the pH and ORP probes are truly needed for BNR operation; therefore, the sub-total cost for 2 pH and 2 ORP probes is $4,336.
4. The cost for sensor end caps for the LDO probes is $215 each. These must be replaced annually and should be budgeted as recurring expense. Sub-total cost: $430.

Automation Improvements:

1. Cost of probes to automate the final effluent compliance testing, as recommended in the evaluation, includes the following:

1 pHDsc immersion probe:	$1,049
1 Chlorine analyzer & accessories:	$5,300
Rededicate spare LDO2 probe with new cap	$ 215
Sub-total:	$6,564

   This would require repairing additional two of the damaged SC200 controllers, for $1,500. Costs do not include installation and electrical work.
2. The operators desired to have digital recording of probe output on the computer used in their control building, which would require connecting all SC200 to one another and a digital converter for the lab computer, with software. The digital converter is about $140, but the software may cost up to $1,200. This would provide continuous data recording and display, and data could be graphed and displayed as done by DEP's evaluator.

Nutrient Probes:

BNR treatment facilities generally require a higher standard of process monitoring, including monitoring of ammonium and nitrate nitrogen in addition to process alkalinity and nitrite-nitrate, nitrite nitrogen, total Kjeldahl (organic nitrogen + ammonium,) and orthophosphate. While considered "luxury" items in smaller treatment facilities, pricing information for ammonium and nitrate probes are here provided for possible consideration in budget planning:

1. Cost of probes to automate monitoring of ammonium and nitrate, exclusive of a probe controller (the facility may employ one of eight repaired SC200 with these):

1 Ammonium + Nitrate ISE Probe	$10,114
1 Rail Mount Kit	453
1 Air-blast Cleaning Harness	301
1 Air-blast 120vac Compressor	2,003
2 Probe heads per year	2,056
1 Nitrate Standard solution for calibration	$ 61
Total these items:	$14,988
-or-	
1 Ammonium ISE Probe	$ 7,428
1 Rail Mount Kit	453
1 Air-blast Cleaning Harness	301
1 Air-blast 120vac Compressor	2,003
2 Probe heads per year	2,056
1 Nitratax Plus SC Probe, 2mm:	18,251
1 Wall-mount Kit	522
1 Replacement wipers for Nitratax	314
1 Nitrate Standard solution for calibration	61
Total these items:	$31,389

2. Like all immersion probes, these probes require regularly scheduled maintenance, and the ISE probe requires replacement of the sensor head every six months. Parts and bench calibration should be budgeted as recurring costs.

2 AN-ISE or AISE probe heads	$ 2,056 w/o annual svc.
AN-ISE or AISE annual bench service includes 2 new probe heads per year	$ 3,050 w/ annual svc.
Nitratax Plus SC annual bench service	$ 870

3. These probes are usually installed post-secondary treatment, usually in the effluent stream or following secondary clarifiers.

Suspended Solids Probe:

DEP employed a suspended solids probe in the aeration tank to monitor the concentration of mixed liquor suspended solids (MLSS.) While laboratory process monitoring tests are adequate for this facility, the solids probe has been eminently useful for reducing laboratory time, provided it is regularly calibrated with laboratory test results. The pricing is provided here for planning purposes.

Solitax sc Probe	$4,539
Rail Mount Kit	519
Annual bench service	450
Total these items:	$5,508

ATTACHMENT G: RECOMMENDED MONITORING TESTS & FREQUENCIES

PROCESS CONTROL TESTS FOR DOMESTIC WASTEWATER TREATMENT FACILITIES

Activated Sludge Facility: Conventional, Complete Mix, Step Feed, or Extended Air
Less than and including 1.0 MGD (Page1 of 1)

SAMPLE PARAMETER	SAMPLE LOCATION	SAMPLE TYPE	3/WEEK	1/WEEK	2/MONTH
Raw Influent*					
BOD_5 and/or COD	Influent	Grab			X
TSS/VSS, NH_3-N, and pH	Influent	Grab			X
* Frequency of sampling may need to be increased or decreased depending on plant size or conditions.					
Aeration Basin					
MLSS/MLVSS (or centrifuge, with correlated data from periodic MLVSS values)	RAS line and effluent	Grab			X
Dissolved oxygen	Effluent	In situ		X	
Settleability (SV30)	Effluent	Grab	X		
pH	Effluent	Grab		X	
Microscopic examination	Effluent	Grab			X
Computation of SVI, F/M ratio, sludge age, and/or MCRT, as desired	Effluent	—	As data collected		
Secondary Clarifier					
Sludge blanket depth	As appropriate	In situ		X	
Final Effluent					
Parameters, sample types, and frequencies as required by permits.					

The table reproduced above lists suggested sampling frequencies for facilities of capacity up to 1.0 MGD. This represents the minimum monitoring requirements; however, experience suggests that process monitoring tests be performed more frequently when a facility is experiencing any changes. These changes include any process changes made by the operators and any changes due to unavoidable circumstances, such as slug loading, hydraulic overloads (“storm mode”,) or equipment service interruptions. Generally, the higher the level of treatment, the more process control testing is necessary. For example, denitrification operations require additional process monitoring when compared to nitrification operations.

The facility employs the gravimetric solids test, which is the gold standard for solids testing. The DEP portable laboratory included a solids-by-volume centrifuge test that was unnecessary at Mapleton; however, the centrifuge test does in 15 minute what otherwise takes up to four hours. If used, centrifuge solids tests are done daily and are backed up with gravimetric solids tests at least twice per week to maintain centrifuge calibration (Weight-to-Concentration Ratio, or WCR.) Microscopy, Settleability, and water chemistry should be done on the mixed liquor at least twice per week until the operators have reasonable understanding of a 4-season set of reference data to which they may refer in future years. Whenever process or treatment methods change, the test data set would need to be reproduced. Also, whenever the facility experiences plant upset conditions more frequent process-monitoring and control testing should be performed by the operators, until conditions stabilize.

Process Monitoring testing is often not the same as those performed by contract laboratories in that approved test methods are not utilized. Compliance testing refers to those analyses used by certified laboratories for reporting parameters required by the NPDES permit and the daily required effluent testing for dissolved oxygen (DO,) pH, and total residual chlorine (TRC.) Over the years, many small treatment facilities began to contract compliance testing to certified environmental laboratories. This eased the burden on operators, and it saved the facility owner the cost of maintaining certification of its own laboratory. However, over time, many facilities ceased to perform regular process monitoring tests, as well. It is important for operators to know the condition of their facilities, the sludge solids inventory, and the qualities of the treatment solids (i.e., quantity and quality of "bugs") to effectively optimize operations.

DEP's WWTAP has adopted the process monitoring tests recommended by US-EPA and the professional trade organization, Water Environment Federation (WEF.) These tests include the following:

- Centrifuge solids test: percent volume/volume measurement of activated sludge solids for activated sludge-type plants: Calculations stemming from this data include solids inventory (expressed as "sludge units" (SLU).)
- Clarifier blanket level: a core-sampling of the clarifier contents provides a proportional quantity of mixed liquor and supernatant that can be analyzed for percent suspended solids (TSS) using the centrifuge. Test results are used for developing awareness of how much mixed liquor is detained in the effluent clarifier, representing part of the overall sludge inventory.
- Settleometry test: 30- and 60- minute activated sludge settling rates in wide half-gallon or 1-liter, calibrated vessels: Settled sludge volume (SSV) is expressed in standard 30-minute intervals and used to calculate Settled Sludge Concentration (SSC) which is a qualitative measure of how well the activated sludge settles in the clarifier, mimicking clarifier performance in terms of supernatant quality as well. Using WCR, it is also possible to calculate and track Sludge Volume Index (SVI).
- Oxygen Uptake Rate (a.k.a. Soluble Oxygen Uptake Rate): By measuring the rate of dissolved oxygen depletion in a sample of mixed liquor, one may demonstrate the relative effect of BOD loading on the biomass, how quickly this material will be metabolized by the activated sludge organisms. Expressed in "milligrams Oxygen per hour," when mixed liquor volatile suspended solids concentration is known or can be extrapolated, then one may determine the actual Respiration Rate, in mg. Oxygen per hour per gram of activated sludge. OUR and RR are also useful for comparing the relative health of the biomass under toxic conditions, should there be undesirable contaminants in the raw wastewater, or anoxic conditions, should the aeration be insufficient to treat the incoming waste load using the available amount of oxygen.
- Raw Wastewater and Effluent Chemical Oxygen Demand (COD): an analog of the 5-day Biochemical Oxygen Demand test, COD can be determined in about three hours and give operators a quick assessment of relative strength of wastewater and/or the amount of material remaining in treated effluent, thereby providing an analog of treatment efficiency.
- Nutrient Tests: A portable wastewater laboratory provided during the WTE consists of materials for conducting various colorimetric analyses for nutrients such as ammonia-nitrogen, nitrite, nitrate, organic nitrogen, phosphorus, etc. to determine whether the facility is removing or treating nutrients. For process monitoring purposes, nutrient test strips provide ample, low-cost, low-trouble test results. They are available in most supplier catalogs (USA Blue Book, Hach, Grainger, et al.)

- Various other tests included in the portable wastewater laboratory include alkalinity testing (the buffering capacity of the mixed liquor or the clarified supernatant to resist changes in pH,) chlorides, sulfides, halogens such as Total Residual Chlorine and Free Chlorine, and metals including aluminum and iron, known contaminants to downstream aquatic life.

The objective of all this testing is to develop a unique profile for the facility useful in creating visual graphs of operational trends, showing conditions that become predictive of how the facility responds to various beneficial or adverse conditions that could affect effluent quality and treatment efficiency. Once sufficient data exists, operators should have a cogent understanding of how the facility responds to process adjustments and what they must do to maintain it in good condition.

Typically, operators of activated sludge treatment facilities should determine an overall treatment strategy for their facility, using standard industry calculations for constant:

- Food to Mass Ratio (F/M)
- Mean Cell Residence Time (MCRT)
- Sludge Age or Dynamic Sludge Age

These values can be determined using the equipment described above. These calculations provide set-points unique to the facility that can be adjusted either through changes in sludge wasting rates or aeration capacity, assuming that the concentration of waste in the wastewater is a variable that operators cannot control.

Since operators have the most control over sludge wasting rates, adjusting any of these process control strategies can be done successfully by adjusting the concentration (or load) of suspended solids (biomass) under aeration.

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pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WASTEWATER TECHNICAL ASSISTANCE PROGRAM