WASTEWATER PLANT PERFORMANCE EVALUATION

May 19 – July 29, 2009

Municipal Authority of Middleboro

Water Pollution Control Facility

NPDES #PA0046418

Bureau of Water Standards & Facility Regulation
POTW Optimization Program

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

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1. Executive Summary

The Pennsylvania Department of Environmental Protection conducted a Wastewater Plant Performance Evaluation (WPPE) of the Municipal Authority of Middleboro's (Middleboro) treatment facility located in McKean Borough, Erie County, from April through June of 2009, at the invitation of Mr. Doug Burdick, following a site visit on January 21, 2009. A WPPE is an evaluation of existing operations and practices followed by small-scale operational changes meant to optimize effluent quality. The purpose for optimizing effluent quality is to reduce pathogens at drinking water intakes directly downstream of the subject facility, with an overall goal of improving surface water quality.

The WPPE was performed by Robert DiGilarmo and Marc Neville of PADEP's Operations Monitoring and Training Division, Bureau of Water Standards and Facility Regulation. The WPPE program is conducted under terms of a federal grant administered by the United States Environmental Protection Agency (USEPA).

The following items summarize some of the important findings identified during the WPPE:

- Plant operations appear be optimal with solids levels at approximately 2,000-2,500 mg/l during the summer months. As the temperatures drop, higher solids levels will be necessary to maintain nitrification.
- DO above 3.5 mg/L in the aeration tanks essentially represents wasted energy. It is optimal to maintain DO levels at least 1.5 mg/L during the aeration phase to ensure that nitrification is occurring in the aeration tanks and limit excursions above 3.5 mg/L.
- High Sludge Volume Index (SVI) and sludge age (AGE) have led to minimal biological activity present in the mixed liquor as evidenced by microscopy analysis. It may prove beneficial to supplement the biomass with commercially-prepared bacteria and infusoria or by the addition of seed sludge available from another facility, on a regular basis or as indicated by the results of regular microscopic exam.
- Installation of continuous Total Suspended Solids (TSS) and DO monitors at the plant may offset the limited manpower available for process monitoring. Also DO monitors can be linked to blower operation through automatic motor pacing in the motor control center.
- Solids control is very important to extended air processes. We recommend a sampling plan similar to one described in Attachment C which, while requiring manual collection, will assist the operator in making process control decisions in the absence of having in-line monitoring equipment
- Reducing solids levels in the aeration tanks will allow the operator to reduce electrical usage by a significant amount by reducing the number of blowers necessary to aerate the same volume of mixed liquor.
- Effluent nutrient levels, Ammonia Nitrogen and Total Phosphorus, were reduced over the project period despite two significant rain events that impacted some effluent quality and resulting data.
- By closely monitoring the waste treatment process, it is possible to reduce effluent nutrients discharged to a receiving stream that is used as a public water supply within a mile downstream.
- The north aeration unit is not capable of efficient air transfer of mixing in its current configuration. The Authority should consider having a structural engineer evaluate the possibility of removing additional sections of the baffles between the old contact stabilization compartments. Some additional structural support may be necessary to do this.

- At several times during the project flow and BOD loading warranted operation of just one of the treatment trains. While doing so would be more labor intensive, due to opening and closing valves and possibly changing chemical feed rates, there would most likely be a cost savings associated with operations due to less equipment usage. Also, taking 1 treatment train off line would allow for additional maintenance operations to occur.
- There were 5 significant rain events (about 1.0” or more) during the course of the WPPE which increased influent flows without affecting daily waste loads.

The following items have been identified as focus points to assist in optimization efforts. Operators should review the focus points and are encouraged to incorporate them into their daily operating procedures when feasible. While some of these items will require more of the operator’s time to perform the outcome is expected to be favorable by improving the plants discharge quality and thereby improving downstream water quality. Focus points are listed in order of importance.

- Record and trend data to troubleshoot periods of reduced performance.
- When monitoring for Dissolved Oxygen in the aeration tanks, take the handheld DO meter to the tank and insert the probe in the contents of the aeration tank. This provides the most accurate DO reading possible reducing external interferences.
- Oftentimes at similar sized wastewater plants, solids are wasted from the process on a daily or semi-daily basis. Performing sludge wasting on a regular basis will allow the operator to target and calculate sludge age more effectively. Also, doing so can prevent the accumulation of undesirable bacteria that inhibit nitrification and settling within the aeration tanks.
- Using solids-by-volume measurements (centrifuge) in addition to periodic total solids testing (confirmation) of the mixed liquor to identify solids percentage within the treatment process will help establish a healthy biomass that provides maximum nitrification efficiency. Please refer to Attachment C for suggested process control testing frequencies.
- Try and reduce the SVI levels in the north tank to a range between 50 -150 and maintain such levels in the south tank. Levels during the WPPE were in the 170 range in the north tank but were reduced to the 130 range in the south tank by the end of the evaluation.
- Dissolved oxygen swings in the aeration tanks are significant and may lead to deterioration of effluent quality due to floc-shearing, hindering flocculation and settling in the secondary clarifiers. By installing in-line process monitoring equipment the operator can monitor the treatment process more effectively and by tying the DO sensors to blower motors one could provide only the amount of air necessary to achieve effective treatment of the wastewater. Over-aeration of the mixed liquor does not provide additional treatment; it does increase utility costs and can actually harm the nitrification process by encouraging the growth of undesired bacteria.
- Closely monitor solids and dissolved oxygen in the aeration tanks, especially in the Spring and Fall, so MLSS can be maintained at levels that will discourage and prevent development of filamentous bacteria that inhibit settleability of sludges.
- Permanently mounting the ultrasonic flow meter on a rigid mounting should assist in providing accurate flow data. The current configuration may prove troublesome to perform calibrations or yield unreliable data during times when the natural weather may cause the head of the unit to move or sway. Bracketing the head should easily solve this.
- Closely monitor power usage to correlate the amount of blower usage, plant nitrification efficiency, and electrical costs: This may prove beneficial in minimizing power consumption.

2. Background

The Municipal Authority of Middleboro's wastewater treatment plant is a 0.081 MGD conventional activated sludge, extended aeration treatment process employing aerobic digestion of waste solids. The service area includes McKean Borough, Erie County, and its waste stream is comprised of domestic sewage with no industrial users. Gas chlorination is used for disinfection of the treated wastewater before being discharged to Elk Creek. The Middleboro discharge is located approximately one mile upstream of the drinking water intake for Idyll Whyle Village (IWV). Due to the proximity of the discharge and intake this wastewater plant was selected to participate in a Wastewater Plant Performance Evaluation.

The Pennsylvania Department of Environmental Protection (PADEP) has undertaken a new project in its Bureau of Water Standards and Facility Regulation (BWSFR) to improve the quality of surface waters used for drinking water by optimizing sewage treatment plant operations to reduce pathogens and nutrients in the effluent from the wastewater treatment plant. BWSFR's optimization program is called the Wastewater Plant Performance Evaluation (WPPE) and is modeled on the successful program for drinking water filtration plants that has been operating for the past twenty plus years, the Filter Plant Performance Evaluation (FPPE) program. The WPPE program is fully explained in Attachment A.

Following a routine site visit on January 21, 2009, DEP contacted Mr. Doug Burdick of Middleboro with a request to deploy and operate the instrumentation at their wastewater treatment plant (WWTP) for a period of two months in order to assess current plant operations and provide the operator with process monitoring data for use in making process modifications that improve effluent quality and downstream surface water quality at the IWV drinking water intake.

DEP employed a trailer rented from Hach Company, containing several in-line probes installed within the secondary treatment processes. In addition, DEP brought instruments and test kits to the facility's laboratory for use during the evaluation and made available for the plant operator during the WPPE. This equipment supplements the in-line continuous monitoring and provides operators with the opportunity to utilize test equipment that is essential to making process control adjustments. The goal is to familiarize operators with process monitoring and control testing that is used to trend plant data and assists them in making decisions that optimize their treatment process.

We recommend that the Authority review our report and the plant operator continue to maintain and improve plant performance through the use of regular process monitoring and control. We believe that by doing so, the operator is capable of producing at this facility effluent water quality that exceeds current and planned future concentration and loading limits. In-line monitoring equipment for dissolved oxygen and total suspended solids could be used to optimize the wastewater treatment process at Middleboro. Reduced blower usage and associated electrical cost savings suggest that the equipment would pay for itself in less than 2 years at current utility costs, possibly even sooner as rate caps expire and the cost of electrical usage increases.

Attachment B lists the WPPE team and participating members of the Municipal Authority of Middleboro.

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3. Initial Observations

Plant Description

The Middleboro sewage treatment plant is located in McKean Borough west of State Route 99 and just east of Interstate 79 at the McKean Exit (West Road). It treats domestic sewage from its collection system servicing McKean Borough. The facility was originally constructed in 1978 as a contact stabilization treatment facility. Due to aging of the structure and the need to perform repairs to keep it structurally sound, a permit was issued in 2004 to expand by the wastewater plant. The expansion included construction of an additional treatment train consisting of an aeration tank, clarifier, and aerobic sludge digester, bringing the permitted treatment capacity to 0.81 MGD. Improvements were made to the facility's influent lift station, as well. Construction for the upgrade was completed in 2005.

According to the most recent Wasteload Management Report (Chp. 94), the collection system includes no industrial users, only domestic sewage customers. The facility is not required by USEPA to have an Industrial Pretreatment Program.

NPDES Permit No. PA0046418 establishes the operations and monitoring requirements for treated sewage at the Middleboro sewage treatment plant. The WWTP discharges treated effluent to Elk Creek, designated as a warm water fishery and known locally for steelhead trout. Elk Creek is in the 15EC- watershed- Lake Erie Tank. Discharge from the plant represents approximately 6.5% of the stream flow within this creek, considering Q7-10 stream flows of 1.8 cfs and plant flow of 0.081MGD. Stream flow data was gathered from the DEP Water Quality protection report.

A process description and treatment schematic are depicted in Attachment D.

This site was chosen for the WPPE because of its proximity to the IWV drinking water intake which is located approximately 1.0 mile directly downstream of the Middleboro outfall on Elk Creek. Middleboro's overall operating efficiency appears to be good with few violations of its operating permit within the past two years. Following deployment of the WPPE equipment, the instrumentation was used to collect data that supplemented existing operations by providing the operator with additional process data used when making decisions on modifying treatment plant control with the ultimate goal of improving effluent quality.

Background samples were collected on January 21 and May 20 and a summary of the results for all sampling is listed in Attachment E.

Figure 1, below plots the Middleboro WWTP and outfall to Elk Creek along with the IWV drinking water intake.

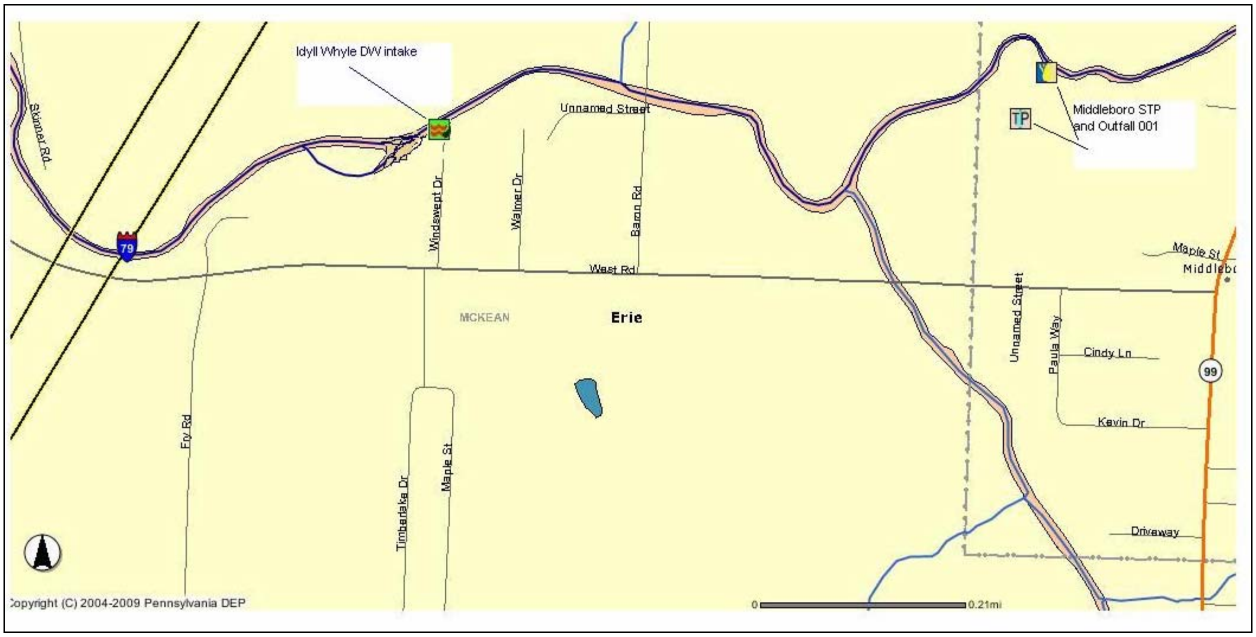

Figure 1: Middleboro WWTP and Idyll Whyle Drinking water intake: Approximately 1 mile separates the two locations.

Past Performance

A review of plant records showed that there have been 2 permit violations from this facility in recent years. Middleboro's operator is to be commended for the consistently high effluent quality produced from this facility and for correcting permit excursions quickly.

During file review, we reviewed the facility's NPDES Permit, its Part II Permit, Water Quality Protection Report, monthly Discharge Monitoring Reports (DMR), Chapter 94 Report, as-built drawings, and available daily process monitoring records.

DMRs for all of 2008 through April 2009 were reviewed in order to develop an understanding of the facility's daily operating ranges. For 2008, the annual average flow was 0.063 MGD and the peak monthly average flow of 0.096 MGD in December 2008. These records indicate that the collection system is occasionally impacted by inflow/infiltration during wet weather events, the operator identified snow melt as a possible source. However, the operator reports the elevated flows do not negatively impact the treatment process. There are no combined sewers in the collection system. We did not investigate the possibility of wildcat connections or roof downspouts and basement sump pumps discharging into the sewer system.

The Middleboro WWTP appears to consistently produce effluent of a high quality and the results of this project along with the review of DMRs for calendar year 2008 supported this conclusion, see Table 1 below.

Middleboro WWTP 2008 DMR Data													
Date	Flow Avg. Mon	pH min	pH max	DO min	TRC avg	Fecal Avg Mon	TSS Avg Mon	TSS Max Daily	BOD-load Avg Mon	CBOD-5 Avg Mon	CBOD-5 Max Daily	Effluent NH3-N Avg Mon	Effluent Phos Avg Mon
Jan	0.044	7.1	7.5	5.9	0.3	16.3	8.6	15	43	13.4	20.58	1	0.61
Feb	0.046	7.1	7.5	4.6	0.3	99.3	4.3	8	36	12.5	15.34	1	0.62
Mar	0.088	7	7.6	4.9	0.26	69	13.8	31	60	10.2	12.21	1	0.74
Apr	0.062	7	7.4	5.4	0.32	14.8	8.3	14	52	10.6	15.6	1	0.69
May	0.059	7	7.4	5.4	0.35	10.7	10.8	17	54	8.3	12.75	1.4	0.85
Jun	0.059	7	7.5	4.36	0.44	10	9.5	17	26	6.5	9.2	1.9	0.68
Jul	0.058	7	7.4	4.36	0.44	10.9	7.2	14	30	8.2	14.88	1.7	0.34
Aug	0.056	7	7.4	4.45	0.43	13	8.8	18	42	3.5	5.72	1	0.63
Sep	0.051	7	7.5	4.45	0.43	10.2	7	10	22	6	10.4	1	0.78
Oct	0.061	7	7.5	4.89	0.43	13	12.3	18	58	7.1	12.68	1	0.6
Nov	0.079	7	7.5	4.89	0.43	14.7	6.3	8	59	7.8	10.47	1	0.61
Dec	0.096	7	7.5	4.89	0.43	21.5	16.8	27	78	10.8	14.6	1	0.64

Table 1: Middleboro WWTP 2008 DMR data summary

Current Performance

During the period of the evaluation, we observed that the facility was experiencing low dissolved oxygen (DO) and high mixed liquor suspended solids (MLSS) from the onset of the project. Upon reviewing the data provided through this project the operator increased the volume of air delivered to the aeration tanks and reduced the levels of solids within said tanks. Throughout the project there were fluctuations in effluent quality; however, permit conditions were never exceeded.

Flow into the treatment facility averaged 0.046 MGD and BOD concentrations averaged 189 mg/L over the course of the WPPE. This equates to an average BOD loading of 72.5 lbs/day. The flows were approximately 56% of the design flow and approximately 65% of the permitted organic loadings that the plant is designed to treat. Several oxygen uptake rate tests were low indicating low biological activity. The low biological activity was verified through microscopic analysis of the biomass.

At the start of the WPPE we collected the following data:

Parameter	North Tank	South Tank	Anticipated Values
F/M ratio	0.02	0.01	0.05-0.1
Hydraulic Retention Time	49.6 hours	60 hours	18-24 hrs
Sludge Age	32 days	41 days	15-30 days
Sludge Volume Index	186	169	50-150

Utilizing the North tank only at the onset of the project would have yielded measured values more in line with the expected ranges depicted above. As the operator has shown, while it is not impossible to operate both treatment trains, it is somewhat inefficient to operate more equipment than necessary and the weaker biomass could be susceptible to shock loads. The operator did make it clear that limited time available for process control operations would make operating just 1 treatment train almost impossible. There would be many steps involved in taking the plant down to just one treatment train, and restarting the second train in time to deal with increased flows from rain events would be exceedingly difficult without additional labor and testing.

Headworks

The facility headworks provide for removal of nondegradable solids through use of a manual bar screen. Our study did not include an assessment of the quantity or nature of solids removed at this point; however, other studies have shown that regular removal of grease and solids at this point can lower downstream plant loadings by up to a third of the current waste load. Improved headworks can also remove non-degradable material, trash, and grit that can damage pumping equipment downstream and prevent accumulation of solid, inert material within those treatment processes. Grinder pumps work, but physical screening is more beneficial, and the frequency of shutting down tanks for cleaning and removing inert solids is reduced.

According to the facility's most recent Municipal Wasteload Management report, the facility is not running near its hydraulic and organic operating capacity, and inflow-infiltration is considered minimal. There is not much redevelopment anticipated within the service area. Figure 2 depicts the 2008 flows including monthly average and design values. A summary of daily flow measurements for April through July 2009 is listed in Attachment F.

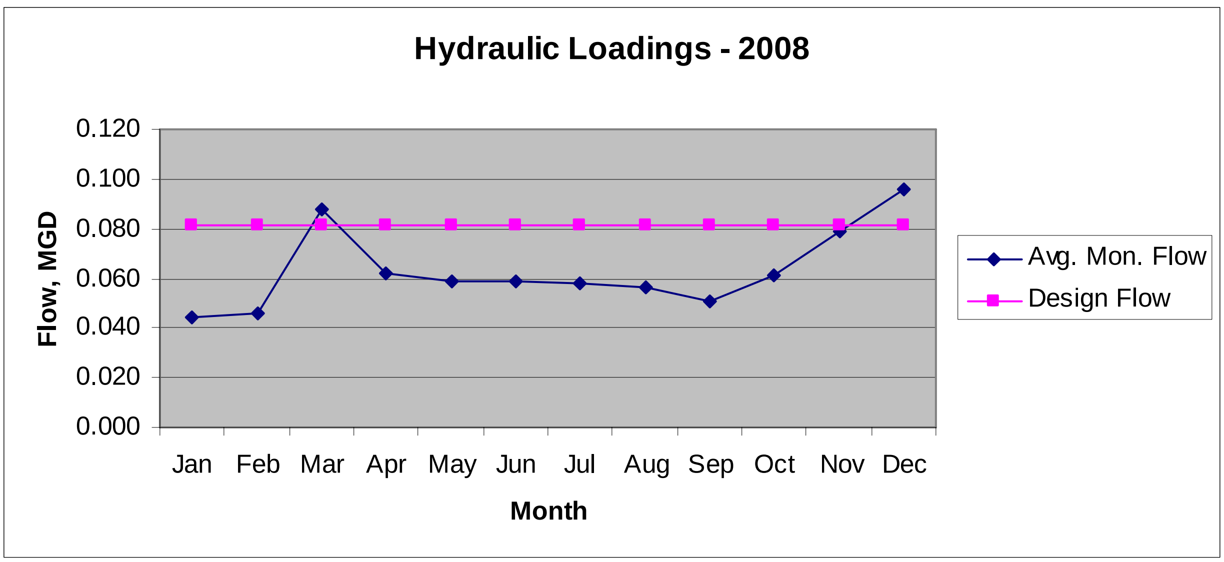

Figure 2: 2008 Hydraulic Loadings

Flow Equalization

Middleboro currently utilizes two aerated flow equalization tanks. We did not examine this process in detail during our site visits. Visual inspection of the flow equalization tanks showed that they appeared to be operating within normal design parameters.

Aeration

Two secondary aeration tanks having a total capacity of 112,000 gallons provide the bulk of treatment at the facility. These tanks are configured for extended aeration. Fine bubble diffusers are used for air distribution in both units. For the WPPE, we installed instruments in both the north and south aeration tanks. Flow is split at the influent distribution box into a 60:40 pattern before entering the aeration tanks. The larger flow is diverted to the north aeration tank, the larger of the two units with a 61,000 gal capacity. The south aeration tank was constructed of concrete during the 2005 upgrade and has a 50,000 gal capacity. The north aeration tank, constructed of steel, was part of the original treatment plant and was previously operated as a contact stabilization treatment unit. During the 2005 plant upgrade it was converted to extended aeration when sections of the dividing walls were removed to allow forward flow. Aeration within the north aeration tank is not consistent throughout the tank when compared to the newer south unit. This is explained further in the section on DO Profile. The WPPE confirmed that while the nitrification process is more efficient in the south aeration tank, nitrification does occur in the north tank, granted much less efficiently.

Secondary Settling

Each aeration tank discharges to an attached secondary settling tank, or clarifier. Here, activated sludge solids settle by gravity and are withdrawn using air lift return sludge pumps, for reintroduction to the aeration tanks or for wasting to the aerobic digester. The clarifier for the north aeration unit is the center most portion of that unit. The clarifier for the south unit is the second compartmentalized section after the aeration tank.

Disinfection

The Middleboro facility employs gas chlorination for disinfection of the treated wastewater, injecting it at the head of the chlorine contact tank. Following sufficient contact time, the effluent falls through a V-notch weir prior to discharge. The outfall at Elk Creek is approximately 50 yds from this final process.

Equipment Installation & Calibration

On May 19, 2009, Bob DiGilarmo and Marc Neville arrived at Middleboro to diagram the instrument layout and install the mechanical connections for the in-line probes.

That same day, representatives and technicians from Hach Company came to the facility to assist in setting the probes and connecting the communications lines between the probes and SC1000 control units.

The in-line monitoring equipment is described as having microprocessor technology built into each probe. Each probe has sufficient memory to retain several days' worth of readings. The SC1000 and SC100 base units are microprocessor-driven routing and transit units, working in conjunction with detachable display units. The display units are used to calibrate the attached instruments, in addition to relaying information to other microprocessors. The technology allows plant operators to observe and track operational trends that can be interpreted using readily available literature, reinforcing an operator's process control decisions and showing him/her, in real time, the results of process changes that affect plant performance. The entire system is capable of being combined with a Supervisory Control and Data Acquisition (SCADA) operations and monitoring system

The portable wastewater trailer utilized in this WPPE contains a portable notebook computer for displaying the continuous signals from the digital probes. This is an enhancement, as the SC1000 units installed on the trailer also support displays that provide graphical depiction of trends collated from the data recorded by the probes.

This WPPE utilized a sufficient number of probes to allow for monitoring equipment to be installed in both aeration tanks. At the onset of the project the DO probes were installed midway through the north aeration tank. After performing a DO profile of the unit it became obvious that the probe needed placed at the discharge end of the unit to achieve the most meaningful data.

The installations were:

- 2 Hach SC1000 base units, 4 SC100s mounted on the trailer
- 1 Amtax and Phosphax placed in the chlorine contact tank
- DO, ORP, pH, DO, Nitrate, and Ammonia and Total Suspended Solids sensors in each of the aeration tanks
- UVAS, UV organic monitor at the influent splitter box

Attachment G shows a diagram of where the continuous monitoring probes were installed.

Continuous Digital Monitoring

In this application remote monitoring capability was established following installation of the in-line monitoring equipment and establishing communications with the base units. The remote monitoring capability proved essential in this application to the location of the work site near Erie and the location of team members in Ebensburg and Harrisburg. After logging into a website set up for this particular facility, users were able to view current measurements of all probes, download data, and view trends. The equipment was set to log measurements at 15 minute intervals.

Laboratory Equipment

The continuous monitoring digital probes provide the plant operators with graphical output that allows them to see how the tested parameters fluctuate during a variety of conditions. However, we supplemented their use by making available less expensive portable laboratory equipment for obtaining “snapshots” of plant conditions using relatively simple test methods. This equipment was also utilized to verify the quality of data being collected with the digital probes.

In addition to the digital probes, we brought the following laboratory equipment:

- Microscope with digital recording camera and computer interface;
- Raven Products centrifuge, settleometers, and clarifier core-taker for sampling and testing according to sludge inventory methods developed by Al West and cited in <u>Activated Sludge Manual of Practice No. OM-9</u>
- Portable LDO and pH/temperature instruments;
- Portable spectrophotometer and packaged wastewater lab, for colorimetric analyses of water and wastewater;
- Chemical oxygen demand (COD) heater block and test kit.

The purpose of this equipment is to supplement the digital recording probes with a variety of lab tests that can be used by plant operators to track solids inventory, health and condition of the biomass, and relative strength of incoming wastewater. This equipment may be purchased through several vendors and can provide sufficient test data for an operator to make process control decisions, even in the absence of the digital, in-line continuous monitoring equipment.

The purpose of the additional testing is to provide an operator with data needed to develop Mean Cell Residence Time (MCRT), Food to Mass Ratio (F/M), or Sludge Age (AGE) methods of managing activated sludge treatment facilities.

Middleboro has limited laboratory glassware on hand and most process control testing is performed at the McKean WWTP nearby. The operator indicates he performs all the required testing for process control and effluent testing as required.

Our purpose in bringing the lab equipment was to make it available for the operators use and to perform our own process control testing to include monitoring: pH, DO, NO3, NH3, Phos, COD, clarifier sludge blanket depth, and OUR tests.

There were a significant number of process control tests performed during the WPPE, some representative spreadsheets of the output data are included at Attachment H.

Sampling & Tests Ordered

Initial background samples were collected on January 22, 2009:

Location	Sample Number	Analyses	Sampler
Upstream of Outfall 001 at Rt 99 bridge on Elk Creek	0907005	Method 1623	DiGilarmo
Chlorine contact tank discharge	0907004	Method 1623	DiGilarmo
Downstream of Outfall 001 at Idyll Whyle drinking water intake	0907006	Method 1623	DiGilarmo

Table 2: Initial sampling locations and analyses

A summary of all the test results is located in Attachment E.

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4. Process Monitoring

Beginning on May 20, and lasting until July 29, with some interruption, we continuously obtained digital data from the in-line probes installed at Middleboro. Some interruptions of data collection occurred because of power interruption and due to power surges during a thunder storm. To prevent future occurrences, Hach representatives installed an uninterrupted power supply on the laptop computer and modem hardware; this seemed to prevent further instances of signal loss and data collection.

Attachments I and J include graphs of monthly and daily data, respectively, collected by the digital probes. These graphs were developed in-house using MS Excel. The data collected during this project was available remotely though Hach software, WaterEye®. On at least 2 particular occasions during this project, DEP staff identified conditions at the wastewater plant which indicated a treatment plant upset, loss of nitrification, was beginning. After contacting the operator via cell phone and relaying the real time data he was able to make adjustments to the treatment process which averted any plant upset that would have impacted the IWV intake.

During the project, the operator explained that during the last several years there would be a plant upset which occurred in late spring early summer. This was the first year since he'd been there that this upset had not occurred. One can deduce that through closely monitoring the treatment process, conducting additional process control testing, and communicating often with the operator, this WPPE project assisted in preventing treatment plant upsets and, according to the data, had some benefit in reducing nutrient loading to the receiving stream lessening the impact on the downstream water intake.

It is vital for plant operators to perform regular process monitoring tests to assay the condition of their facility and to look for trends that both support process control decision-making as well as predict future plant performance under changing conditions. The manufacturer of the centrifuge equipment, sludge settleometers, and core-taker suggests that their equipment be employed on a daily basis in order to monitor the health of the facility. Likewise, use of the digital spectrophotometer and accompanying portable wastewater lab chemical test kits will allow an operator to assay any number of chemical parameters for process monitoring and control purposes. Even those operators who employ an independent contractor for compliance reporting lab tests do need to regularly conduct process monitoring tests of their facility systems. Once this data is collected it should be trended to identify the optimal set points for various parameters including DO, MLSS, waste rates and pH to name a few. If future situations arise then an operator can refer to the trending data to identify the conditions during a previous similar situation and see what remedial actions were taken to rectify the issue. Without having trending data, an operator is starting at square one for each occasion where the plant experiences an abnormal condition. Trending is also very important when more than one operator runs a treatment plant or even more importantly when a secondary operator only occasionally operates the plant.

Interpretation of Data

Loadings to the plant over the course of the WPPE were calculated using samples drawn about weekly and sent to DEP's Bureau of Laboratories for testing. The concentration results were then multiplied by the flow in MGD and by 8.34 lb/gal. The graphical results for loadings are shown in Figure 3, below:

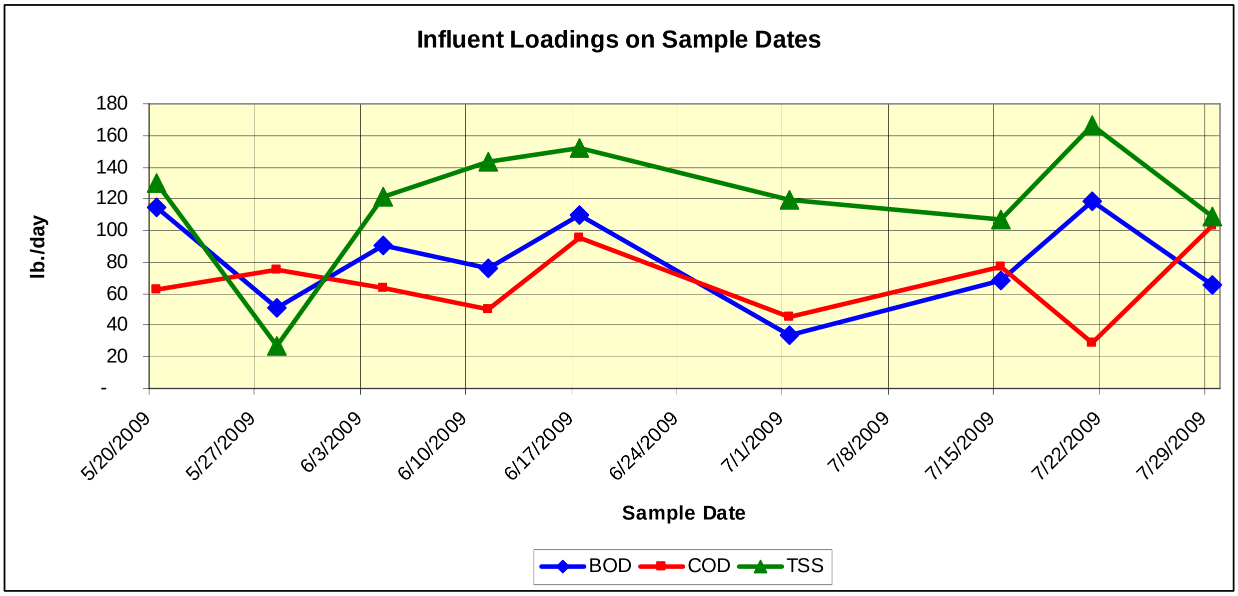

Figure 3: Influent Loadings in lb./day for Dates Sampled

A table showing plant loadings follows in Attachment E.

Shown below in Figure 4 is a graphical representation of Dissolved oxygen versus time for both treatment trains, in this graph the last half of June 2009. This example shows the wide fluctuation in DO levels in the aeration tanks. On the 22nd into the 23rd, while the north aeration tank was going on 12 hours of 0 DO, a phone call was made to the operator alerting him of the condition. In response, the operator was able to get to the plant and increase the air supplied to

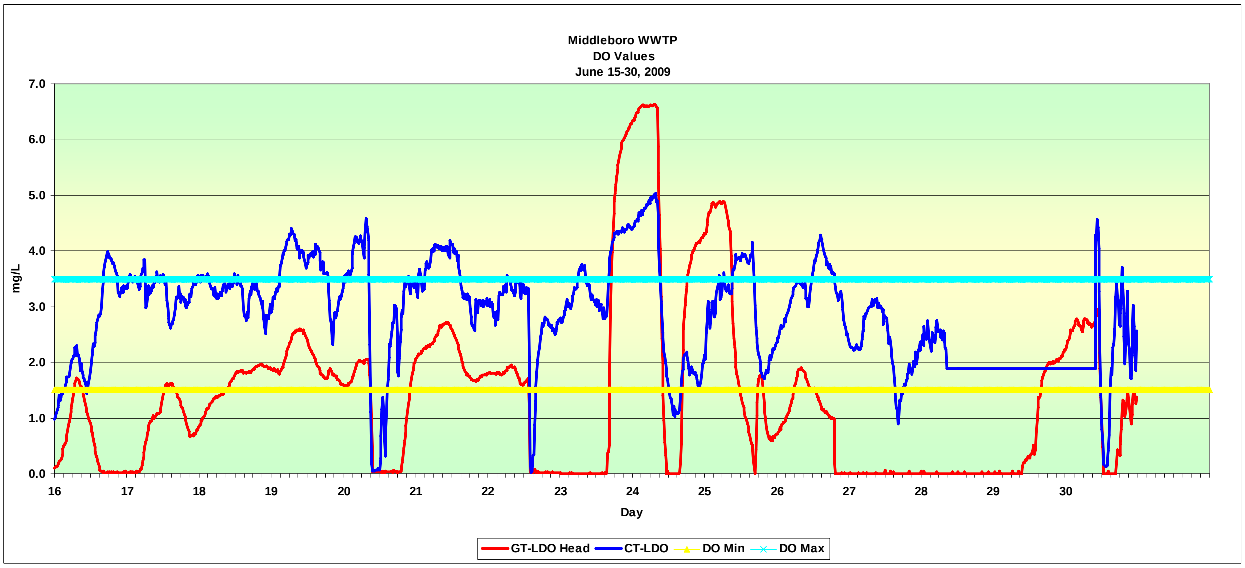

Figure 4: DO versus time

the aeration tanks and DO levels shot up drastically. At Middleboro there were several occasions, based on loadings and flows that the DO levels in the aeration tanks dropped to dangerously low levels. While this type of uncontrolled DO level fluctuation is not the most advantageous; there are treatment methods, such as “on/off aeration” which purposely incorporate these DO swings into the process. When initiating new treatment methods such as on/off aeration an operator needs sufficient data on the treatment process relating to current operating conditions.

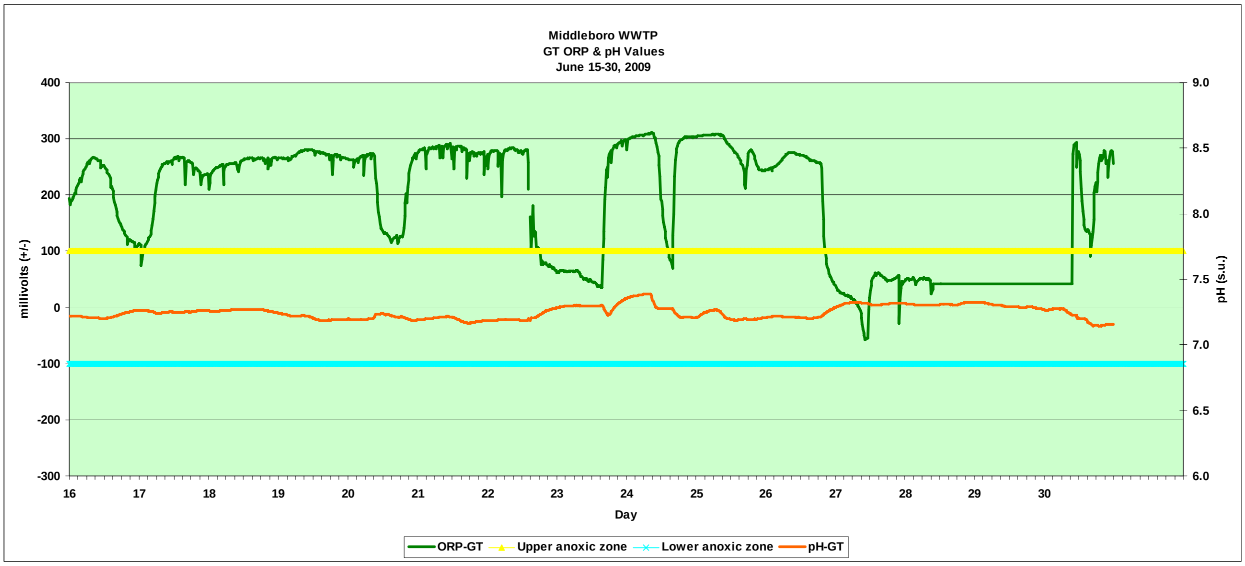

Figure 5. ORP vs. time

Figure 5 shows ORP levels during this same period support the DO measurements the tank was in an anoxic phase during the 22nd to 23rd and at times from the 27th through the 30th. While providing periods of anoxic activity can be advantageous for nitrate reduction, reducing costs, and improved settling; extended periods can lead to a complete loss of nitrification and the need to reseed the wastewater plant. In this instance an effluent sample collected on July 1 for nutrients yielded a Total Nitrogen result of 12.5 mg/l, the lowest measured value of the entire project. With the previous periods of anoxic activity, the sample appears to substantiate that periods of on/off aeration do lead to reduced nitrate values which in turn lead to reduced Total Nitrogen values. An operator must have the time available to invest in the increased monitoring necessary to nitrify and more importantly denitrify wastewater. While the DO levels were at or near 0 mg/l in the north tank during this period, the ORP levels remained, for the most part, above 0 mV which indicated that there was sufficient oxygen available between the air being delivered to the tank and that from the nitrate in the wastewater to prevent the contents of the aeration tank from going into an anaerobic phase.

The varying levels of ORP at the Middleboro plant most likely contributed to reducing levels of nitrate in the wastewater. At times when DO could not be maintained due to excessive solids and ORP dropped, some denitrification occurred. It’s important to note that this would not be an effective way to operate the plant to denitrify the wastewater; that is, operating with high MLSS levels which reduce DO levels and also affect the MCRT which in turn is impacts nitrification. Without nitrification occurring, you can’t have any denitrification. It is important to choose a method of plant operations, F/M or MCRT, and stick with that method of operation.

Equally important, it should be noted that appearance alone cannot be a method of operating a wastewater treatment plant. Throughout the project, the aeration tanks maintained a medium brown color indicative of a healthy biomass regardless of the swings in DO and ORP levels.

Oftentimes during the late spring when water temperature rises, the concentration of MLSS needs be lowered from the levels that sustained the plant through cold weather. Treatment efficiency rises as a function of temperature, and fewer MLSS are needed to accomplish the same amount of waste treatment as may be necessary during winter months. Regular sludge wasting is a vital part of maintaining a healthy biomass. The operator at Middleboro explained that wasting was based on MLSS tests results and visual observations collected at the wastewater plant. These methods are effective in assisting to maintain optimal levels of biomass but the wasting operations are limited by capacity of the sludge drying beds. At Middleboro there are 2 sludge drying beds that receive waste sludge from the holding tanks. A layer of 2-4 inches can be applied at one time; layer depth is limited by weather since the more solids applied to the bed increases drying time. The drying beds at this facility are not covered so weather is an even more important factor in solids removal. Any rain will re-wet the drying solids and the drying time automatically increases. Covering the drying beds isn't the best option either as sunlight is necessary to dry the solids. Future upgrades at the facility could include reed beds for sludge disposal, centrifuge, or belt filter press. Other disposal methods are also available.

In order to maintain a healthy biomass and an optimally performing treatment system, sludge wasting is usually a daily or semi daily operating event. If solids are wasted from the process less frequently and in large volume then large amounts of nitrifying bacteria will be removed from the process all at once. Through the use of gravimetric MLSS tests, centrifuge testing, and other laboratory test an operator can adjust the solids levels in the aeration tanks to anticipate the changes in operating conditions as the weather changes from warmer to colder and vice versa. Instead of wasting solids over a few days to transition the operation from winter to spring conditions, an operator would be better to withdraw waste solids to establish a desired MCRT, gradually reaching a solids concentration where biomass growth rate is nearing the peak of log growth, where treatment efficiency is optimal, and the potential for negative indicators such as filamentous organisms are reduced.

It is generally best to maintain a consistent solids management plan that includes wasting solids based on process control testing that includes monitoring the food to mass ratios (F/M), mean cell residence time (MCRT), sludge volume index (SVI), and mixed liquor suspended solids (MLSS). Generally, choosing a method such as a targeted F/M or MCRT and sticking with it produces the most consistent wastewater quality.

Figure 6, below, depicts the mixed liquor suspended solids levels in the aeration tanks during the last half of July. As requested the operator had reduced solids in the south aeration tank to a level of approximately 2500 mg/l. While the north tank solids levels were much higher, the operator intended to next target this unit for solids reduction. It is suspected that not only will the lower MLSS levels in the tanks provide a healthier biomass but it will also allow for reduced blower usage to provide an adequate amount of oxygen transfer keeping DO levels in the desired range. Ideally, the DO probe could be used to interface with dedicated, soft-start, variable speed blower motors to maintain the aeration DO in the optimal range of 1.5 mg/L to 3.5 mg/L.

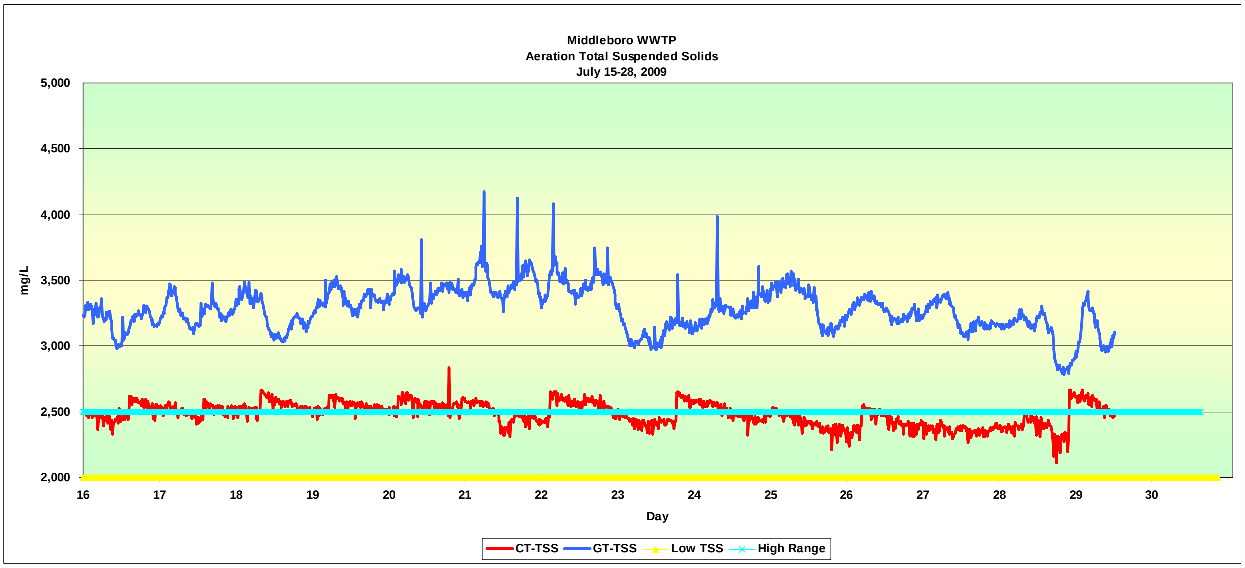

Figure 6. Mixed liquor suspended solids

At the Middleboro plant, we observed that DO levels in the north unit were consistently lower than those of the south unit. This is attributed mostly to the modification of the unit from contact stabilization to extended aeration. It is suspected that more cross sectional area is needed between the old contact and stabilization zones to allow for a better forward flow.

At the start of the project the solids levels in the aeration tanks were over 5000 mg/L. While these levels may have been acceptable during the colder months in keeping the nitrification process on track, the warmer months necessitated the reduction in solids levels. The in-line TSS probes were essential in tracking the solids levels both on-site and remotely. Reductions in solids levels impacted the biological activity in the aeration tanks, increased DO levels without increasing the number of blowers in use, and improved settleability in the clarifiers.

Figure 7, below, shows how nitrate levels are reduced with corresponding reductions in DO. DO is necessary for nitrification to occur and ammonia increases during periods of low DO residual. On June 27, as the DO levels reached a 0 mg/L level, the ammonia increased dramatically, from its normal range of less than 1 mg/L. A corresponding decrease in nitrate values is due to the partial loss of nitrification.

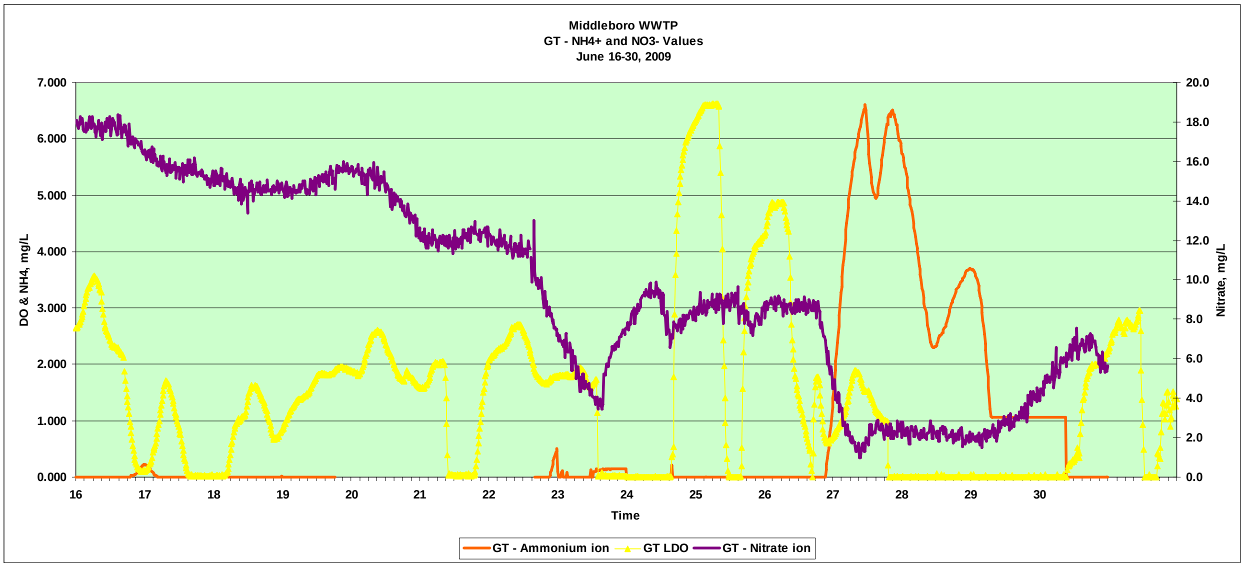

Figure 7. Nitrate Levels

Figure 8, below, is a graphical representation of how ammonia concentration in the mixed liquor is an inverse function of DO residual. This is a single-day in the data set. A decrease in DO does not allow the biological process to occur since oxygen is essential in converting influent ammonia to nitrite and finally to nitrate. As DO levels rebound, ammonia levels decrease due to the conversion of ammonia to nitrite and then nitrate.

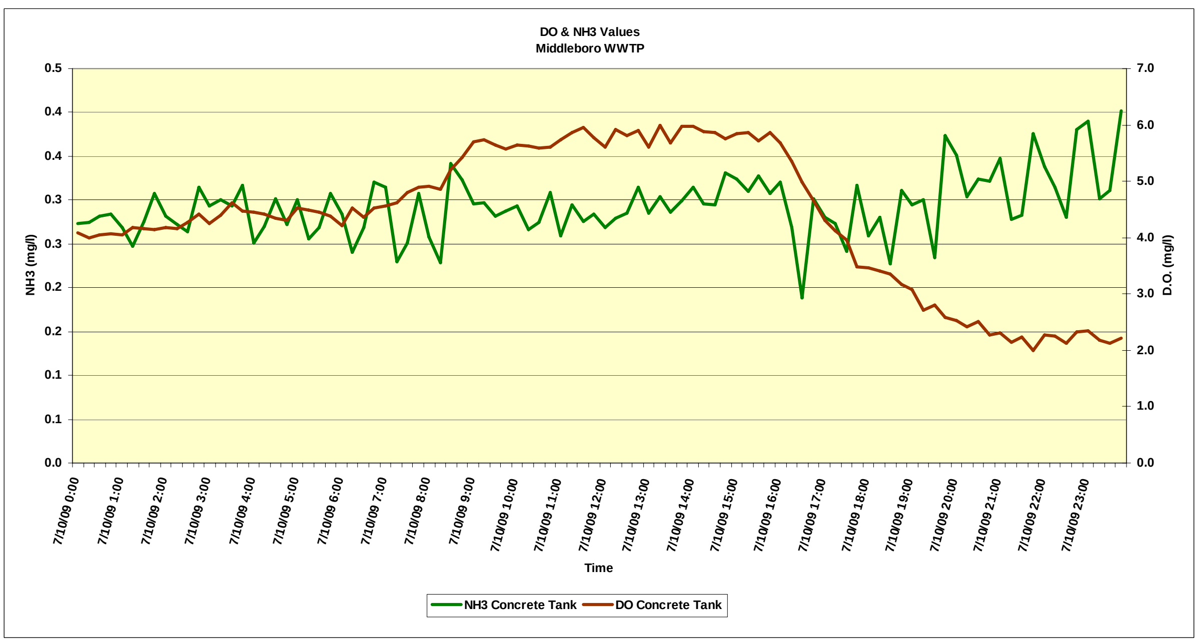

Figure 8: Ammonia concentration inverse of DO

Reductions in effluent ammonia and phosphorus levels are graphically depicted on Figure 9, below. While there were some spikes in the effluent data the effluent trend lines show how the overall values were reduced over the term of the Middleboro WPPE. Through the use of the in-line equipment, bench testing, and adjusting solids levels the operator was able to adjust the treatment process in an effective manner that reduced overall nutrient levels without any capital expenditures.

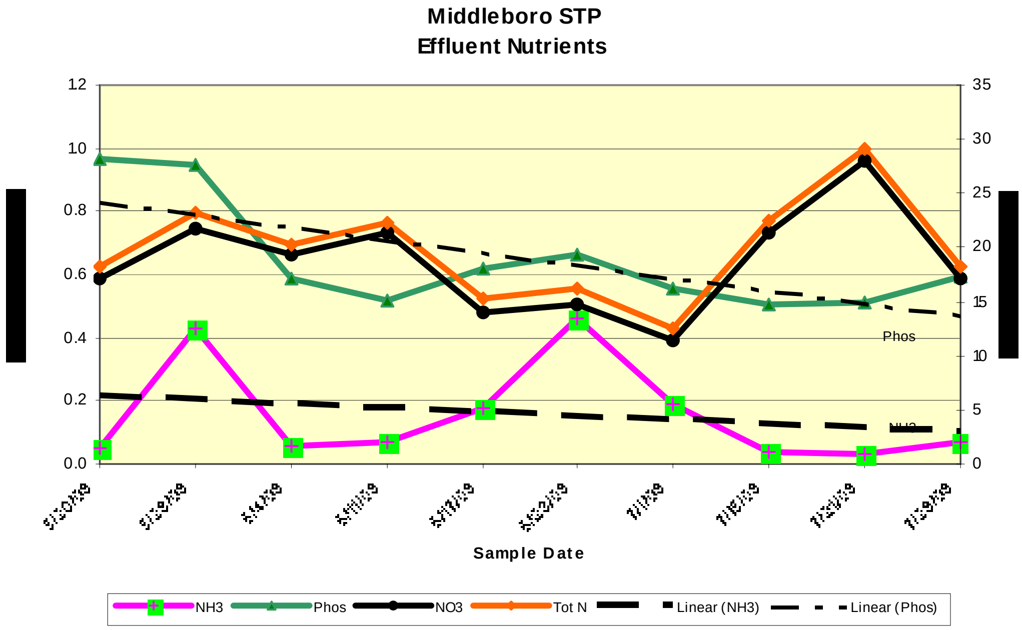

Figure 9: Effluent nutrient reduction over the course of the WPPE

Figure 10, below, shows the *Cryptosporidium* oocyst levels in nine samples taken during three events over five weeks. Effluent concentrations remained constant through the period, although downstream concentrations, taken at the Idyll Whyle water plant intake, showed a reduction during the period.

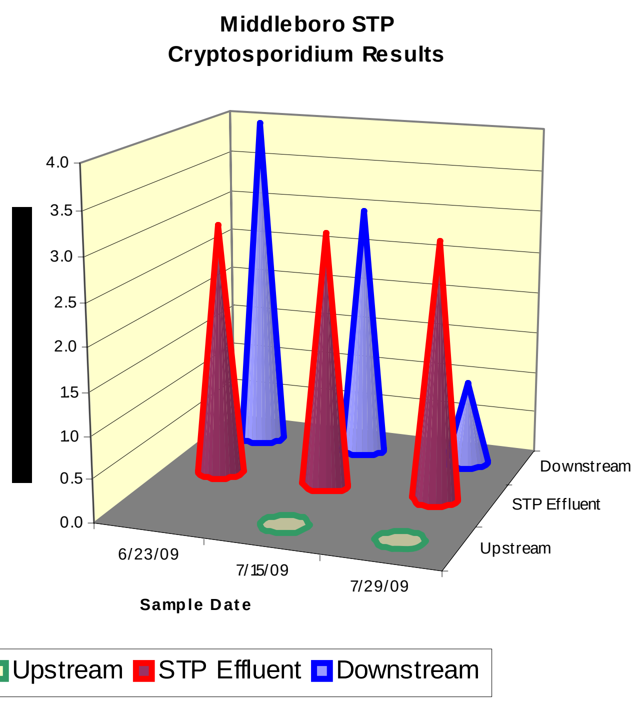

Figure 10: Cryptospordium oocyst levels

In figure 11, the level of *Giardia lamblia* cysts found in 10L samples is shown. In this illustration, the treatment plant produced a much higher quantity of *Giardia* cyst than was present in the upstream samples, where concentration averaged 3 cysts per 10 liters. *Giardia* was found in lower quantities at the downstream, drinking water plant intake, where the average level was 1 cyst per 10 liters. The treatment plant levels of 37 cysts per 10 liters on both dates in July may represent contamination washing into the collection system through surface water run-off (Horton flow,) or it could be due to the presence of rodents within the collection system, where their contaminated feces are flushed downstream during rain events. The high number of *Giardia* does not indicate that the disease causing organism is endemic in the population of the service area; neither does the test indicate whether or not the organisms have been inactivated by disinfection methods.

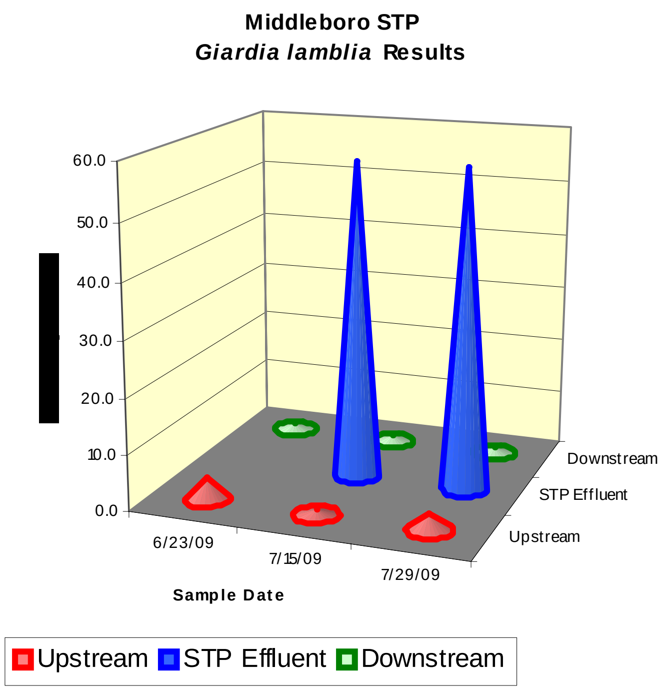

Figure 11: *Giardia lamblia* cysts per 10 L sample, taken over 37 days.

Downstream pathogen sampling also yielded some reductions in *Cryptosporidium* oocysts as shown in Figure 12, below. An earlier background sample downstream, taken during January 2009, resulted in no detectable pathogens at that time. The presence of pathogens during the summer months is more a function of increased zoological and biological activities concurrent with the time of year, so no statistical conclusion may be drawn from the difference in that sample.

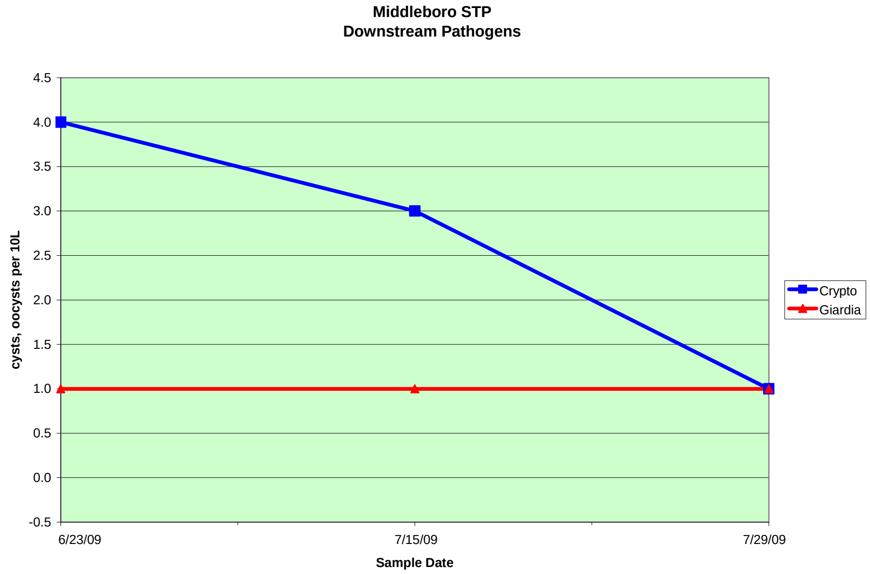

Figure 12: Pathogen reduction downstream at Idyll Whyle intake

There has been a reduction of pathogens from treatment plant effluent. However, the reductions shown may be statistically insignificant. Pathogenic, parasitic organisms such as these tend to accumulate in suspended solids. If the treatment plant is working properly, without excessive ashing of solids in the effluent, one can infer that the incidence of pathogenic organisms will be low or null. We noted that during the evaluation, we did not observe solids carry-over into the disinfection tank or the effluent line. Reduction of *Cryptosporidium* may be due to solids control.

In order to more effectively assess the level of pathogens, and the effect of annual weather patterns on them, an effective statistical population would necessarily include many samples per location, taken over the course of the entire year. The study would have to account for temperature and weather variability, seasonal activity of host wildlife in the area, changes in stream flow and chemistry, and other factors.

Microscopy with Digital Photography

A microscope is a beneficial addition to any wastewater laboratory. DEP provides temporary use of a microscope during the WPPE so that operators become familiar with the organisms of the activated sludge process, including indicator organisms that may be used to predict the relative health of the biomass and the operating condition of the facility. Following are some example photographs of the Middleboro activated sludge samples taken during early June.

Figures 13 through 15, below, shows stalked ciliates and nematodes in a mixed liquor sample of the south aeration tank. Stalked ciliates can be indicators of a good settling sludge when present with free swimming ciliates and rotifers. The samples collected at Middleboro contained minimal stalked ciliates, some nematodes, and various inert matter. The microscopic analysis further supported the other indications suggesting that the plant had a very old sludge with not much active bacteria within the biomass.

Figure 13: Stalked Ciliates in the south aeration tank

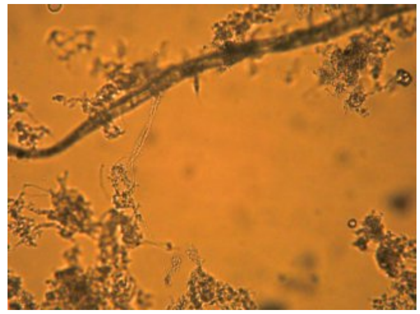

Figure 14: Nematode in the south aeration tank

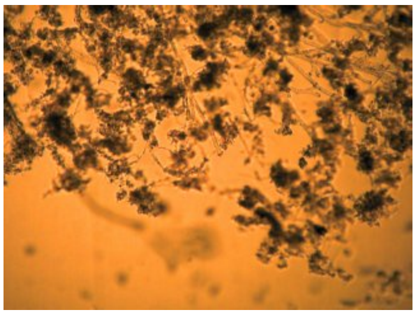

Figure 15: Filaments in the north aeration tank

The north aeration unit showing biomass with some filaments and minimal biological indicators. Between the north and south units, the north unit had the least biological activity. As the project went on and solids levels in the aeration tanks were reduced the biological activity made some improvement.

Some of the filaments present in the biomass were most likely due to the periods of low DO, limited influent loadings to the tanks and high sludge age.

Sampling for Tests done elsewhere

On several occasions, grab samples were collected for Method 1623 pathogens (*Cryptosporidium* and *Giardia lamblia*) from the treated plant effluent at the chlorine contact tank discharge, upstream near the bridge on Rte. 99 over Elk Creek, and downstream at the drinking water intake for IWV.

At various times during the WPPE, we sampled the contents of the wastewater plant and receiving stream; these samples were submitted to the Department's Bureau of Laboratories for analysis. We sampled the mixed liquor for suspended solids, volatile solids, and alkalinity. The influent, effluent, upstream, and downstream samples were checked for conventional sewage pollutants and chlorides. The effluent, upstream, and downstream were also sampled for *Cryptosporidium* and *Giardia lamblia*.

A summary of these test results is fully listed in Attachment E.

5. Process Control

Permit Modifications

Any modifications to the permitted treatment process may require an amendment to the Water Management Permit. If you are unsure whether a permit modification is necessary then you should contact the DEP regional office that supports your wastewater facility prior to making and modifications.

General

The objective of Process Monitoring and Testing is to develop regular monitoring procedures for the individual treatment facility. Typically, an operator chooses to maintain a facility according to mean cell residence time (MCRT) or food-to-mass (F/M) ratio. The objective of these broad parameters is to find a level where plant performance is optimal for the current conditions (including season, amount of precipitation, loading variations, industrial or commercial contributors) and then adjust the treatment processes in order to maintain a steady-state. For example, if an operator runs a facility according to constant Food to Mass ratio of 0.35, if the plant loading (the “food” value) is either naturally constant (based on collection system) or can be sufficiently buffered (using flow equalization tanks), then their objective in maintaining constant F/M is to assure that the biomass (the “mass” value, or the amount of MLSS in the system) can be adjusted through wasting in order to keep the ratio at or near a constant 0.35.

Mean Cell Residence Time is a method by which the operator adjusts solids retention to achieve a steady sludge age. MCRT incorporates a regularly tested solids inventory with adjustments to the wasting rates and an accounting for the expected growth rate due to plant loading. The end result of such operation is an MCRT of x-number days.

Guidance manuals generally suggest that an operator choose a parameter and then operate the facility accordingly. Operators have found that doing so maintains conditions in an optimized state whereby the chance of plant upsets is mitigated or controlled.

Solids Tracking

At present, the Middleboro facility tracks sludge solids in the two aeration tanks by performing gravimetric tests for mixed liquor suspended solids (MLSS) as deemed necessary by the operator. Solids were slightly on the high side in the north aeration tank during the WPPE and neared an average level near the end of the project in the south tank. A core taker was present on site in the composite sampler building. The core sampler can be used to monitor solids blanket depth in the clarifier and to identify conditions occurring in the chlorine contact tank. When solids have accumulated in the chlorine contact tank they hamper the effects of the chlorine, since the solids are essentially a clump of bacteria, and required increased chlorine dosage.

To develop and maintain a complete solids inventory, the clarifier solids needs be regularly assayed in a consistent method. During a WPPE, DEP provides, on loan, a clarifier core-taker sampler that is used to determine the level of the sludge blanket and which can be used to sample the entire clarifier for a percent solids number that, with measurements of the return and waste sludge values, may be used to determine an operational MCRT. This method only involves the core taker and a centrifuge to spin the solids samples. A clarifier spin cycle that runs six samples, or three with duplicates, takes approximately 15 minutes to complete.

The MCRT method is described in earlier versions of WPCF's Activated Sludge Manual of Practice No. OM-9 and in other sources. Calculation of a sludge inventory using undefined sludge units allows an operator to derive an MCRT value for his facility, and this can be done on a daily, semi-weekly, or weekly basis.

We employed a Hach Solitax suspended solids sensor to track changes in the mixed liquor suspended solids. By itself, use of this instrument can provide the operator with intelligence on the volume of solids under aeration. Correctly used, a solids monitoring probe can be used predictively to warn of increases in solids levels they may lead to decreased performance and/or poor solids settling in the clarifiers. This device is calibrated by comparing to gravimetric solids test results.

Solids monitoring is very important in a wastewater treatment plant. If the MLSS concentrations are to low then there won't be enough nitrifying bacteria present for nitrification to occur and MLSS concentrations too high can cause problems with clarifier operations and suspended solids levels in the effluent. MLSS levels are usually adjusted seasonally as the temperature plays an important part in nitrification. (Winter MLSS levels are higher than those of summer in order to treat the same amount of waste load, due to temperature effects on biological activity.)

Dissolved Oxygen (DO) Concentration

The DO readings at this facility follow a typical diurnal pattern with peaks occurring in the morning hours prior to the facility receiving an increase in flows due to residents starting their day. The flows then decrease over the daytime hours and begin to creep up in the evening until repeating the cycle the next day. Optimal DO range for activated sludge plants is usually between 1.5 mg/L and 3.5 mg/L. Any DO over 3.5 mg/L usually represents wasted energy, because the biomass functions adequately within this prescribed range. At Middleboro, we believe the facility could benefit from continuous monitoring of DO, insofar as the operator may interconnect a DO probe with their blower system in order to achieve demand-based aeration which is a much more cost effective operation when considering utility costs.

Oxidation/Reduction Potential (ORP)

ORP can be used by the operators to control periods of anoxic or aerobic treatment conditions, as described earlier, for the removal of nitrates. The following table depicts ORP values at which denitrification occurs; the operators may wish to pursue the use of timed intervals as a method to optimize nitrate removal, even in the absence of dedicated treatment units where denitrification would occur.

General values for ORP used to determine which biological condition exists within a particular treatment unit:

ORP (mV)	Process	Electron Acceptors	Condition
+300	1	O2	Aerobic
+200	1	O2	Aerobic
+100	1	O2	Aerobic
0	2	NO3	Anoxic
-100	2	NO3	Anoxic
-200	3	SO4	Anaerobic
-300	3	SO4	Anaerobic
-400	3	SO4	Anaerobic

1= Nitrification

2= De-Nitrification

3= Methane Formation

Table 3: ORP Chart showing optimal ranges for electron receptors during cellular respiration

ORP readings are typically used in conjunction with the DO readings to identify the effectiveness of a given biological treatment process and the condition of each zone. At times during the evaluation the DO levels reached 0 mg/L. Had we not been monitoring with the ORP, we would not have known what stage of the biological process was in, i.e. nitrification, denitrification, anoxic, or anaerobic.

DO Profile

A dissolved oxygen (DO) profile was developed in May to characterize mixing in the two aeration tanks. For this, a Hach 40d digital meter and LDO portable probe were used. DO was recorded at several locations in the aeration tanks, at varying depths. Recordings were made approximately 2 ft from the edge of the tank at three depths: 1 ft, 6ft, and 12ft along the length of the tanks.

The complete DO profiles are reproduced in Figures 16 and 17, below. Results of this analysis show that, for the most part, mixing within the south tank is complete and DO remains fairly consistent throughout the process. However, the DO within the North aeration unit is dramatically different as the wastewater flows from the influent end to the effluent end of the tank. The DO near the influent end was near 0 mg/l and increased quite dramatically nearing the discharge end of the tank allowing nitrification to occur. Also the DO dropped significantly with the depth indicating dead zones within the tank. Lower DO was found near the bottom of the tank, where there may be eddy currents or dead zones formed by the diffuser configuration and flow patterns formed by the wall partitions.

Operators at similar facilities have found that performing a DO profile on a regular basis helps to characterize weak spots in the aeration grid and identify dead zones that may be caused by occluded diffuser outlets or by faulty baffling. Performing a DO profile every two months at this facility should be sufficient. Studying the DO profile over time also allows the operator to see the effects of plug-flow loading on the tanks, and data may be used to support arguments in favor of aeration balancing, adding holes through the baffle walls, or the need to add more diffuser capacity to the tanks. A structural engineer should be able to evaluate the possibility of removing additional sections of baffle walls to promote more even aeration throughout the tank.

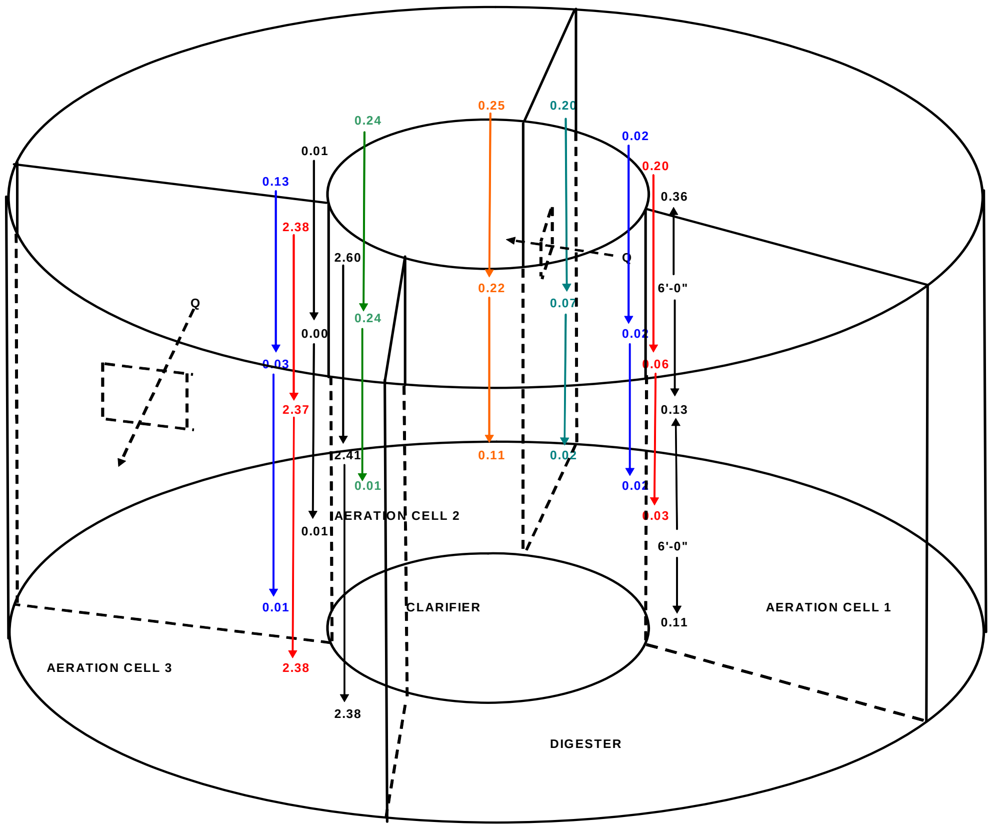

Figure 16: DO Profile of the Middleboro North aeration unit

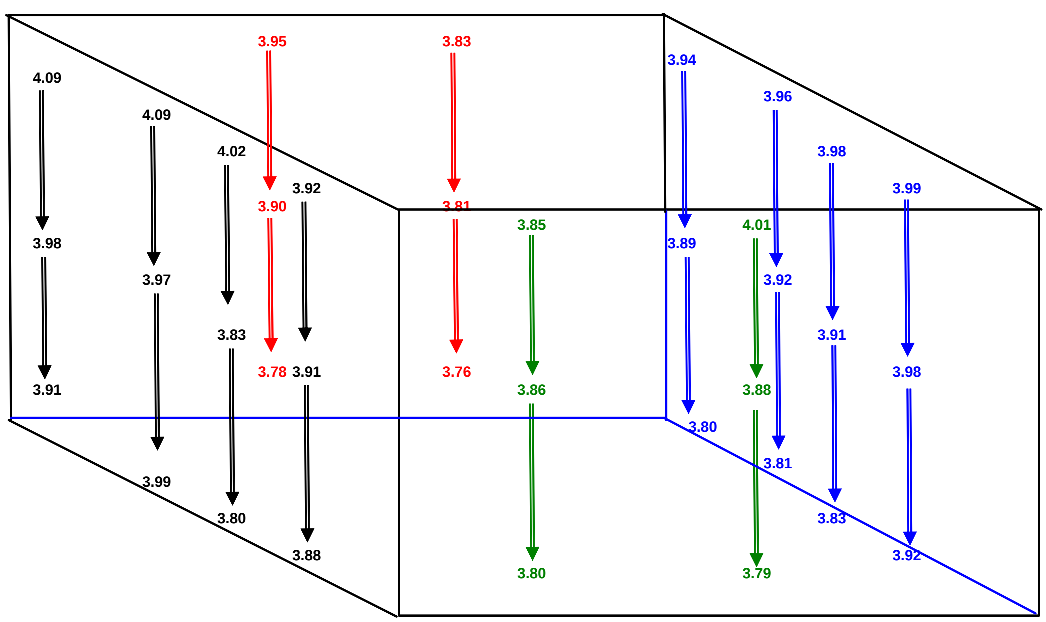

Figure 17: DO Profile of the Middleboro South aeration unit

DO Grab Testing

During the course of the study, DO grab samples were collected at various locations in the aeration tanks for process control purposes and to validate in-line monitoring equipment. These samples were also used to perform OUR and SOUR testing on both tanks to analyze biomass health and food supply.

After the in-line monitoring equipment has been removed the DO within the aeration tanks can be tracked and trended using this same method to ensure sufficient oxygen is available for nitrification to occur. This project suggests that the north aeration tank will need more attention due to its uneven oxygen distribution throughout the unit.

While anoxic conditions prove to beneficial for reducing nutrients and improving settling characteristics, attempting to utilize this same process control strategy without tools to accurately monitor the process will most likely prove fruitless and could cause severe problems with effluent quality.

Chemical Oxygen Demand (COD)

Facilities that contract their compliance testing to independent laboratories typically do not test the strength of the raw wastewater on a frequent basis, although doing so provides a sure method of determining the loading to the facility. Textbooks on the subject typically recommend that at least one 24-hr composite sampling of the raw wastewater be tested for its load value at least three times per week, with daily testing being the optimum.

Because the standard test for loading, the Biochemical Oxygen Demand (BOD) test, takes five days to complete and is comprised of a number of difficult preparation steps and incubation under constant heat, some operators have found that the Chemical Oxygen Demand (COD) test provides a quicker, timelier indication of wastewater loading. The COD test takes about 150 minutes from start to end, and its results may be calibrated against the less-frequent BOD test in order for the operator to know his facility’s wastewater loading on any given day.

At this location, several grab samples were collected of influent wastewater and analyzed for COD and compared to BOD samples submitted to the Department’s laboratory. Over the course of the WPPE, the BOD averaged 95% of COD. Composite samples would be most representative for establishing a long term relationship between the two parameters.

The operator can use the following equation to estimate BOD loading utilizing COD values:
Load, lb/day = Q, MGD x (COD, mg/L / 0.95) x 8.34 lb/gal; hence,

At a flow of 0.057 MGD and a COD of 201.4 mg/L, an equivalent BOD loading would be:
Load, lb/day = 0.057 MGD x (201.4 mg/L / 0.95) x 8.34 lb/gal = 101 lb/day

The BOD/COD ratio should be regularly updated by split sampling and testing for both BOD and COD. The laboratory values for the 5-day BOD test may be incorporated into a rolling average in order to refine and update the ratio coefficient in the above equations, so that the operator may rely on substituting the COD test and performing it on those days when BOD testing is unavailable. The food loading value is then useful for operating the facility based on Food to Mass Ratio, discussed elsewhere in this report.

Nitrate and Ammonia Nitrogen

Use of the nitrate and ammonium ion probes at the Middleboro plant showed that relatively high nitrate concentration within the south aeration unit with lower values in the north unit. While the south values were initially higher due to issue with the nitrate probe, adjustments were made and the values were reduced while still being elevated in comparison to the north unit.

The low ammonia nitrogen values and high nitrate values throughout the project indicate that a level of nitrification was maintained throughout the entire time.

At the onset of the project, the high nitrate level and low ammonia level, along with very flat OUR test results suggested that the south aeration tank was acting somewhat like a digester in endogenous respiration, consuming itself, due to the high solids concentrations and low loadings.

With extended aeration processes, ammonia-nitrogen tends to be quickly converted to nitrite and nitrate. Nitrate is a pollutant-of-concern in wastewater effluent because nitrate acts as a fertilizer, increasing algal growth that leads to eutrophication of streams and lakes and, ultimately, the mortality of higher life forms. Nitrates have also been indicated as damaging to human health, having both immediate and long-term effects.

Our study has shown that Middleboro may benefit from adopting flow and aeration configurations that favor denitrification, without excessive capital expense. Use of "on/off aeration" for several one to two hour periods per day, or establishment of "anoxic zones" in the aerators, could significantly reduce the nitrate concentrations in the plant's effluent. Additional cost savings benefits are also possible. Attachment K shows a comparison of running 1 blower to that of needing 2 blowers. The potential cost savings of lower blower motor run times due to reduced solids values and reduced overall run time due to utilizing on/off aeration methods could lead to savings of over $500 per month.

pH, Temperature

Our study showed that the plant's operating pH and temperatures were normal for the times and conditions observed. Generally, the optimum pH for nitrification is in the 7.5 to 8.5 s.u. range. In Middleboro's case, pH values of 6.8 to 7.0 are typical. There is no chemical addition for pH adjustment. The alkalinity in the effluent is usually less than 100 mg/l. The nitrification process consumes approximately 7.2 lbs of alkalinity for each pound of ammonia converted to nitrate. While the north treatment unit had the most inconsistent DO values, it had the highest alkalinity values, approximately twice the levels of the south aeration tank. This could be related to the unit not providing as efficient nitrification and thereby consuming less alkalinity than the south unit. There may be times when the Middleboro plant would benefit from adding soda ash or lime to replenish alkalinity in the south aeration tank.

Regular testing of the pH of the raw wastewater, at the head of the plant or at the equalization tank, can predict the quality of the wastewater entering the aeration tanks. The pH of the raw wastewater was in the 7.0 – 7.5 s.u. range during the WPPE and the effluent wastewater had a pH in the 7.7 – 8.1 s.u. The NPDES permit typically limits effluent pH to a range from 6.0 to 9.0 s.u.

Clarifier Blanket Level & Core Sampling

The clarifier blankets were measured utilizing a core-taker sampler. Clarifier sludge blanket should be regularly measured to determine at what plant conditions the best effluent is produced by the clarifiers. Typically, an operator should check the sludge blanket once or twice per shift. Rising sludge blanket can indicate trouble a day or two out; falling sludge blanket could indicate over wasting or short-circuiting.

Using the core taker we identified occasions when the blanket levels fluctuated to some extent but they did not rise to a point of discharging over the weirs. We also used the core-taker to obtain samples of the clarifier solids for the centrifuge test, which provides a sludge concentration-by-volume measurement that may be used for trending operations and in developing MCRT or AGE.

Flow Measurement

The Middleboro totalizer readings were utilized for flow readings during the WPPE.

Laboratory Tests

A significant part of the WPPE includes sampling on-site using a centrifuge, pH and DO meters, COD heater block, and a spectrophotometer. Also, the clarifier sludge blankets are monitored to define the blanket depth and clarity.

A centrifuge is utilized to perform percent solids analysis on the mixed liquor, return activated sludge, clarifier contents, and waste activated sludge. When these parameters are monitored over a period of time, one can draw a correlation between the suspended solids levels and percent solids test results. Once this correlation is established you can utilize the centrifuge to identify the solids levels in the aeration tanks within 15 minutes, the duration of the test.

We employed the Raven Process Control products centrifuge for developing quick information on solids inventory and biomass condition. This equipment includes settleometers, which mimic clarifier performance, and a core-taker that is used to determine both clarifier sludge blanket level and percent solids of a representative sample, used in determining total plant solids inventory. According to supplemental information provided by Raven, it is possible to determine a sludge age, similar to use of MCRT, for tracking overall plant performance. Doing so includes maintaining a running sludge solids inventory of all processes and tanks, including aeration, clarifiers, return- and waste-sludge volumes, and inflow and effluent solids. It is also recommended that the sludge solids by percent volume be calibrated to sludge solids by gravimetric analysis.

We also provided a hand-held dissolved oxygen probe and pH probe for use in field testing of the aeration tank mixed liquor. The preferred method of determining process DO is to immerse the DO probe into the aeration tank or effluent stream and to read the DO after the meter stabilizes.

To verify the accuracy of the digital probes, we provided a field spectrophotometer kit that included test materials for several water quality parameters. During the WPPE, we used this kit to determine nitrate, phosphate, COD, and ammonia nitrogen.

Attachment H contains examples of the Process Control Testing worksheets prepared during the WPPE.

The digital-reading microscope is an excellent tool for observing the biomass for indicator organisms. Doing so helps plant operators to determine the relative sludge age and health of the system. Generally, the observance of only free-swimming amoeboids and ciliates indicates a very young sludge, while observance of rotifers and nematodes indicates an old sludge. Ideally, one would observe a dominance of free and stalked ciliates, indicator organisms that show sludge with optimal settling characteristics.

Method 1623 Pathogen Test Results:

Date	Sample Location	Weather	Sample Number	*Giardia* cysts/~10 L	Crypto oocyst/~10 L
1/22/09	Upstream near Rte. 99 bridge	Clear, Cold	0907005	0	0
1/22/09	Effluent	Clear, Cold	0907004	72	1
1/22/09	Downstream at Idyll Whyle DW intake	Clear, Cold	0907006	0	0
6/23/09	N. clarifier discharge	Clear, Dry	0907030	36	0
6/23/09	S. Clarifier discharge	Clear, Dry	0907031	59	1
6/23/09	Upstream near Rte. 99 bridge	Clear, Dry	0907033	4	3
6/23/09	Downstream at Idyll Whyle DW intake	Clear, Dry	0907034	1	4
7/15/09	Upstream near Rte. 99 bridge	Clear, Dry	0907035	1	3
7/15/09	Effluent	Clear, Dry	0907037	57	0
7/15/09	Downstream at Idyll Whyle DW intake	Clear, Dry	0907036	1	3
7/29/09	Upstream near Rte. 99 bridge	Rain 1.13"	0907047	3	3
7/29/09	Effluent	Rain 1.13"	0907049	57	0
7/29/09	Downstream at Idyll Whyle DW intake	Rain 1.13"	0907048	1	1

Table 4: Method 1623 test results

The table above shows the pathogen test results for *Giardia* and *Cryptosporidium*. The effluent samples from the plant consistently indicate the presence of *Giardia lamblia* cysts and *Cryptosporidium* oocysts in the effluent. Most present disinfection methods used in wastewater treatment do not eliminate these pathogens from the system, although some do inactivate the cysts. UltraViolet light may be used to disrupt the reproductive cycle by breaking and/or polymerizing DNA and RNA within the cell nuclei, but the Method 1623 test does not determine if a cyst has been inactivated. Chlorination, though, is of insufficient dose to impact these cysts. It has been recommended by some sources that employing multiple disinfection methods, such as halogenation followed by UV disinfection, or UV disinfection and membrane filtration, will effectively remove these pathogens.

The in-stream waste concentration (IWC) is based on plant design flow and the Q7-10 flow of Elk Creek. The Q7-10 flow is the lowest average, consecutive 7-day flow that would occur with a frequency or recurrence interval of one in ten years (from SRBC website). The Q7-10 flow and IWC are used in the Department's NPDES permitting process. The IWC for Middleboro is 6.5%, indicating that during relatively dry conditions the Middleboro discharge flow would represent 6.5% of the stream flow. The stream flow of Elk Creek was not measured during the WPPE. There have been positive markers for both parameters in upstream samples collected over the duration of the WPPE.

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6. Idyll Whyle Village Water Treatment Facility

The Municipal Authority of Middleboro treatment plant was chosen for this project because of its proximity to the Idyll Whyle Village (IWV) water treatment facility (PWSID 6250058), a small, private provider of potable water to the 300 residents and renters of the Idyll Whyle mobile home community. The intake for this water plant is located along Elk Creek, approximately one mile downstream of Middleboro's outfall. Idyll Whyle Village withdraws approximately 14,000 to 20,000 gallons of water each day from Elk Creek and is permitted withdrawals up to 50,000 gallons. Before the water is distributed to customers, it is disinfected with chlorine and treated by coagulation/flocculation, sedimentation, and filtration at the water treatment facility located in the Village's Maintenance and Office building.

The system used a conventional two-phase pressurized treatment system by Culligan. IWV was evaluated in a Filter Plant Performance Evaluation (FPPE) in May of 2004 by representatives of the PA DEP and Erie County Health. Routine testing for *cryptosporidia* and *Giardia* was performed on 5/6/2004 and found that the source water contained 4.26 giardia cysts per 100 liters, but no *cryptospidium* oocysts. Samples of finished water from pressure filter #2 did not contain any of either organism.

IDV has had numerous permit violations over the years and has upgraded equipment in order to meet current regulations. Their reported violations caught the attention of the New York Times in December 2009, which reported SDWIS data from US EPA, indicating some 136 violations in the period from 1997 to June 2009. Three of these violations, most recently one in 2009, were for health-based reasons. The remainder are for monitoring/reporting or for contaminants above threshold limits.

In December 2007, IWV was issued a construction permit to a second filtration train in series behind the original Culligan system; this is a second two-tank pressure filtration system by Kinetico. The owners' consulting engineers, Hill Engineers of Erie, had run a pilot project using this second treatment system, and the pilot showed that it helped them get into compliance, but they needed to modify it. The Culligan system acts as a roughing filter, and the Kinetico serves as a finishing filter. IWV has applied for an operating permit, but they do not have it yet. Subsequent testing by Erie DOH and by PA-DEP found the upgraded system out of compliance, most notably because it has been operating without a permit, resulting in a Consent Order Agreement (COA).

Although the City of Erie is extending its water distribution system southward into this part of the county, and laying of pipe was occurring as this WPPE advanced, we were told by the Middleboro STP Operator that the Idyll Whyle community was not presently being connected to the Erie system. However, as a result of continuing problems with water quality and an ongoing-boil water advisory (BWA), IWV is now under a consent order to either correct its problems and get permitted or else cease operations and join the City of Erie's expanded distribution system.

Lisa Boughman of the DEP Northwest Regional Office told us that the owners of IWV recently indicated they may soon hook up to Erie, with a firm decision date by May 2010. The COA requires resolution by August 1, 2010.

Significant Recent Actions by IWV

1/24/1998	Permit WA 25-1002 issued	Water allocation application to withdraw 50,000gpd from Elk Creek for treatment & distribution to mobile home park consisting of 91 units and up to 300 population
12/28/2007	Permit 2507501 issued	Permit to Construct Modifications to existing water treatment facility issued December 28, 2007
8/3/2009	NOV issued	Health-based violation; included facility operating without permit, June 2009
5/1/2010	COA reply required	IWV must notify PA-DEP of decision to either obtain operating permit or join Erie City's water system
8/1/2010	COA resolution date	Drop dead date for IWV to resolve its COA

Table 5: Significant Recent Actions at Idyll Whyle Village MHP filtration plant

Our own pathogen testing included sampling Elk Creek at the intake for the IWV treatment facility. Although the facility is reported to employ an infiltration chamber, due to low stream levels, a small portable sump pump inside a plastic milk bottle crate was being used to transfer surface water from the creek to the infiltration chamber for IWV's filtration plant.

To reiterate sample data found elsewhere in this report, our pathogen tests at the intake reported results of:

Date	Sample no.	*Cryptosporidium* Count	*Giardia* Count	Sample Volume	Weather	Creek flow
1/21/09	0907006	0	0	11	Fair, Cold	Moderate
6/23/09	0907029	4	1	10	Clear, Dry	Low
7/15/09	0907036	3	1	10	Clear, Dry	Low
7/29/09	0907048	1	1	10	Rain: 1.13"	Moderate

Table 6: Method 1623 Results for Idyll Whyle raw water at intake

These data suggest that there are many more variables affecting pathogens in Elk Creek than sewage treatment plant effluent immediately upstream. Although pathogens are more likely to persist in cold water, seasonally during winter, there were no pathogens detected in the grab sample taken on January 21, 2009. We would have expected to see persistent *Giardia* under winter conditions but did not. In addition, the *Cryptosporidia* counts decreased during the course of the WPPE: While we would like to attribute this to an effective optimization, we cannot scientifically conclude this with certainty. It appears that other factors, such as mammalian activity upstream, weather, stream flow, and temperature affect the concentration levels, and in any case, the sample pool and concentration spread shown in Table 6 demonstrate that the observed variability in test results is statistically insignificant.

As shown in Figure 18, below, the concentration of Nitrate-nitrogen in the raw water from Elk Creek, sampled at the intake for IWV, was progressively reduced over the course of the WPPE. A trendline added to the graph shows that the trend projected a reduction. Theoretical loadings were calculated based on raw water withdrawals of an average 20,000 gpd and a maximum 50,000 gpd: The nitrate total loadings for the first sampling event on 6/4/09 were estimated at 0.06 lb./day and 0.15 lb./day, respectively. For the final sampling event on 7/29/09, the estimated loadings were 0.03 lb./day and 0.08 lb./day, respectively. The average concentration for the entire period was 0.48 mg/L, with theoretical loadings of 0.08 lb./day for 20,000 gal./day and 0.20 lb./day for 50,000 gal./day.

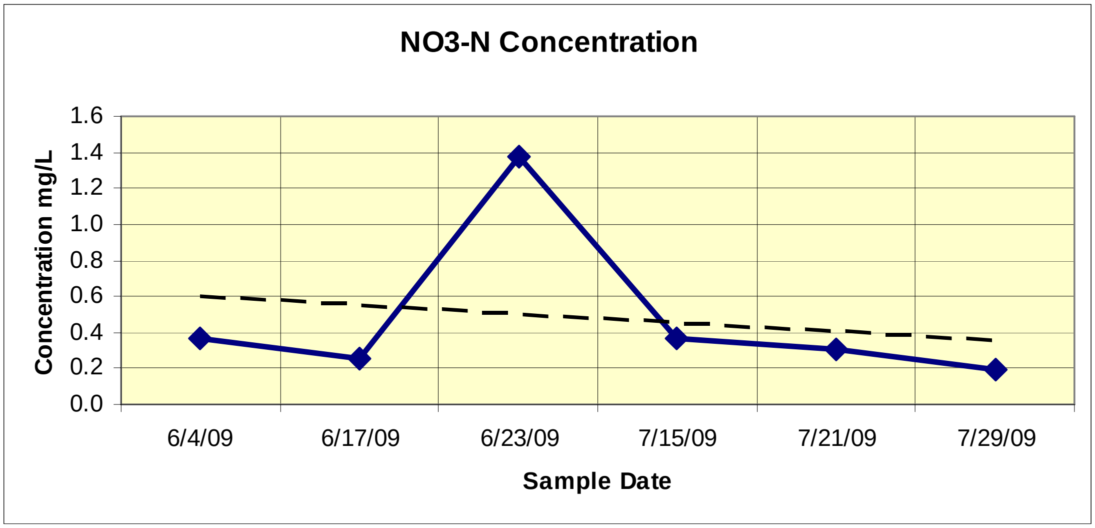

Figure 18: Nitrate concentration over course of downstream sampling, at IWV water intake

Theoretical loadings are depicted in Figure 19, below:

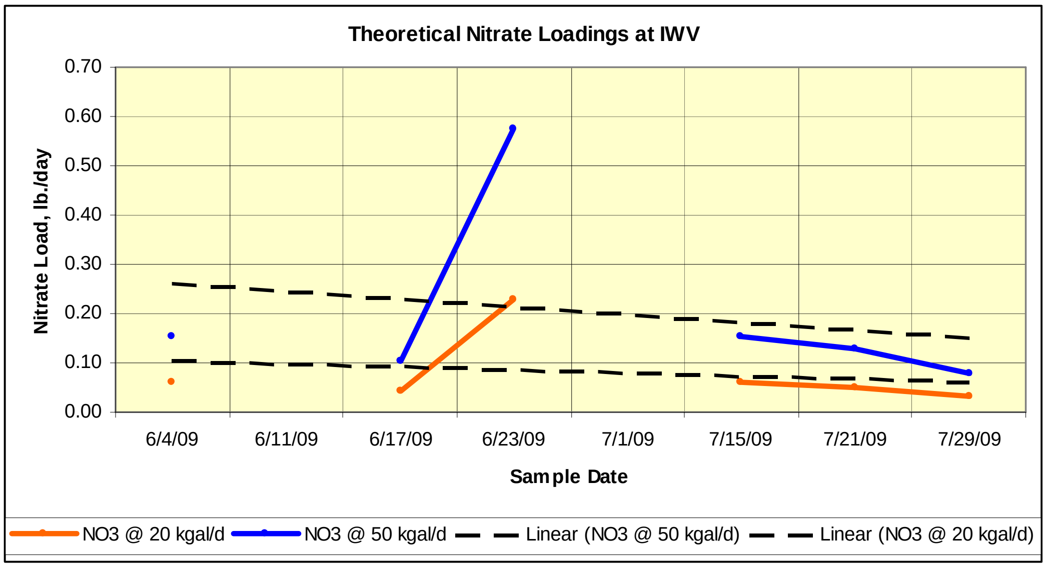

Figure 19: Theoretical nitrate loading over course of downstream sampling, at IWV water intake

Replicating the same theoretical analyses for Phosphorus and using sample series for which data was available, we find that phosphorus concentrations were almost the same throughout the WPPE; however, when running a linear regression trendline, there was a hint that the concentration toward the end of the optimization project tended to be lower, shown in Figures 20, 21, and 22. This effect was more pronounced if the sample result for July 1 were eliminated by means of a Q test.

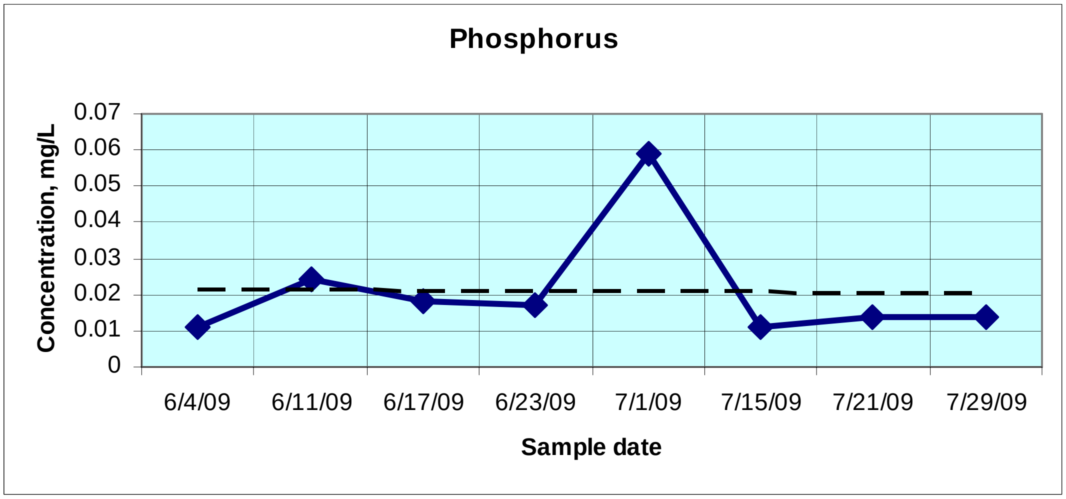

Figure 20: Phosphorus concentration in downstream surface water samples, taken at IWV intake

Again using withdrawal rates of 20,000 gpd average and 50,000 gpd maximum, theoretical average raw water loadings were calculated at 0.035 lb/day and 0.0088 lb./day, respectively. The average concentration over the first three sample events, from 6/4/09 to 6/23/09, was 0.0175 mg/L, resulting in theoretical loadings of 0.003 lb./day for an average withdrawal of 20,000 gpd and of 0.007 lb./day for a maximum withdrawal of 50,000 gpd. Replicating this for the three sampling events from 7/15/09 through 7/29/09, where the average concentration was 0.0130 mg/L, the theoretical loadings were 0.002 lb./day for an average withdrawal of 20,000 gpd and of 0.005 lb./day for a maximum withdrawal of 50,000 gpd. Theoretical phosphorus loadings and accompanying linear regressions are depicted in Figure 23 on the following page.

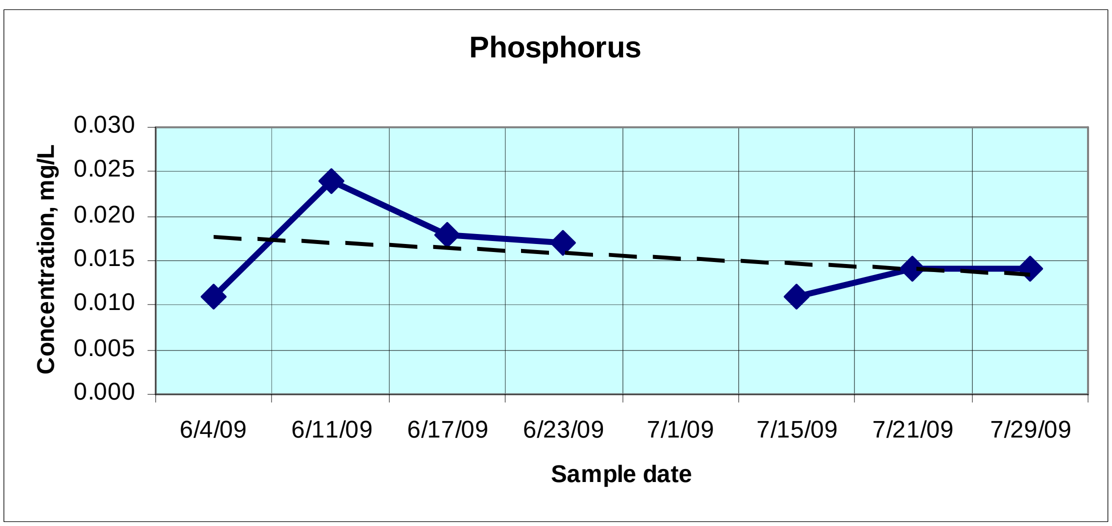

Figure 21: Phosphorus concentration in downstream surface water samples, taken at IWV intake, Q-tested

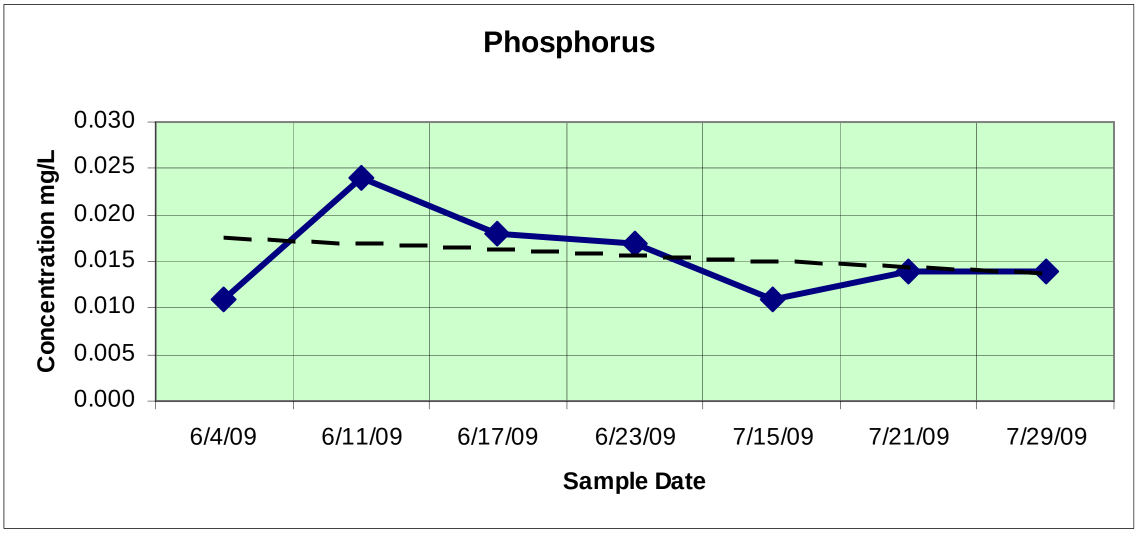

Figure 22: Phosphorus concentration in downstream surface water samples, after Q test

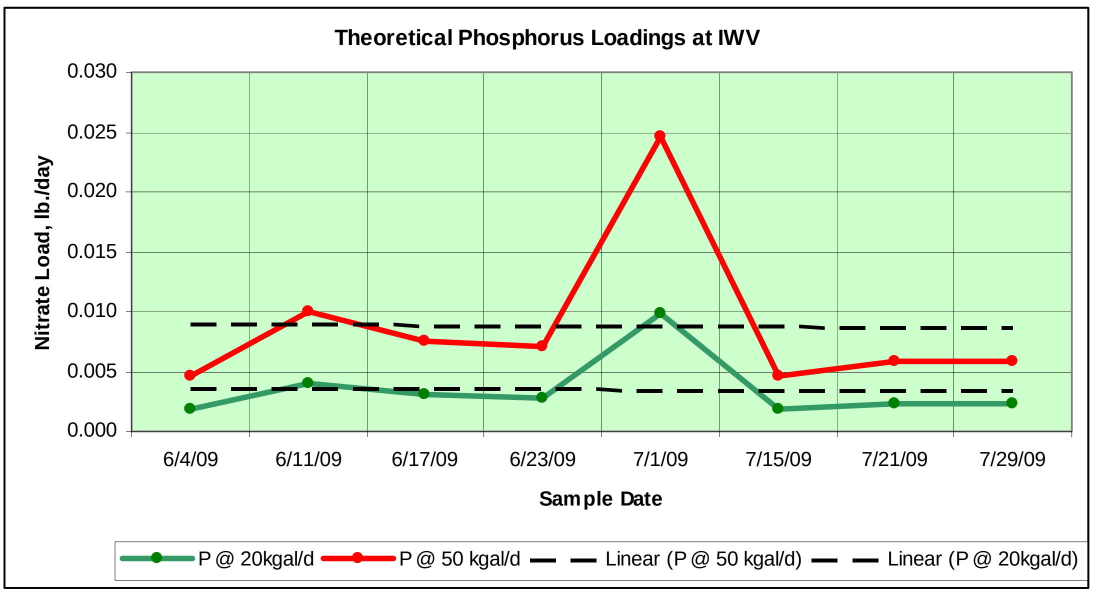

Figure 23: Theoretical nutrient loadings at IWV filtration plant

From these data, it is possible to conclude that the optimization project, with its resulting improvement in effluent quality at the sewage treatment plant, resulted in improved surface water at the intake for Idyll Whyle Village MHP water filtration plant downstream.

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7. Conclusions

Considerations for Operational Modifications

The following are possible modifications that could be made at the WWTP and are based on the data collected during this study and current operating practices commonly utilized at other WWTP's across the Commonwealth. These modifications are presented for the operators benefit but should only be instituted while cautiously observing the effects on the overall treatment efficiency. Since the WWTP process is a biological process, changes made on a particular day may not be visible until at least 24-48 hours later, or more. The responsibility for instituting changes and their outcomes remains with the Operator in Responsible Charge at the WWTP where the changes are made.

DO control

Currently, the plant lacks the ability to modify DO levels in the aeration tank without manually starting and stopping blower motors and/or opening and closing valves on other tanks, i.e. air lift pumps and digestor aeration. Air supply to the north aeration tanks is inconsistent which results in uncontrolled DO levels. A more consistent air delivery system could save a considerable amount of money. Middleboro should consult with their engineer to determine whether it is feasible to remove additional areas of baffle wall between the aeration units in the north aeration tank.

Future modifications to the plant could include utilizing modern, energy efficient motors with soft-start and variable-speed drive capability. By creating a feedback loop between the motor starters and in-line DO probes, the operator could efficiently regulate aeration capacity to support nitrification and denitrification, saving thousands of dollars over the long term on electric energy costs. Middleboro's engineer could develop a depreciation and payback term for such equipment changes.

Meanwhile, trying on-off aeration can trigger the denitrification process. This could reduce the need for adding lime to the mixed liquor, since the denitrification process devours nitrate and creates alkalinity as a byproduct.

Optimum Levels for Nitrification

Nitrifying bacteria (autotrophic aerobes) convert NH3 to NO3 consuming inorganic carbon, DO, and alkalinity.

Optimal conditions for nitrification are:

MCRT:	10 to 13 days
Wastewater Temperature:	60 - 95°F
MLSS:	2,000 to 3,500 mg/L (colder temperatures may require increased MLSS levels)
DO level:	> 1.5 mg/L (4.6 lbs per lb of NH_3 converted to NO_3^-)
pH:	7.5 to 8.5 s.u.
Alkalinity	Sufficient to provide 7.2 lbs per lb. of NH_3 converted to NO_3^-

Unfortunately, all plants have their individual characteristics based on influent flow, waste characteristics, plant design, and operating procedures. While these levels are generally used in the nitrification process, individual plants may find necessary to deviate from these general values.

Power Consumption

Electrical usage is commonly the highest expense when operating a wastewater treatment facility. As described in the DO control section above, we believe significant cost savings could be realized through the use of in-line process monitoring equipment. The equipment is utilized to assist the operator in identifying the current conditions of the plant and make timely process control changes to the motor run times based on the DO readings so as to not operate equipment when unneeded.

Electricity deregulation is a concern for everyone across the state and it is anticipated that all homes and businesses will see increases in utility bills. The utilization of automated equipment to operator blower motors and assist the operator in maintaining solids levels in the aeration tanks should effectively reduce electrical consumption of the motors by requiring a shorter run time.

Assuming an average electricity demand charge of $4.99/kw and an average electricity charge of 5.4 center/kWh and utilizing 2 blower motors and 1 motor for the EQ tank, we estimate the electrical usage at $14,541 per year. On several occasions during the WPPE, the operator was able to reduce the number of blower motors used in the aeration tanks to 1. This was done by controlling solids levels and utilizing the motors only when needed to control DO in the desired range. Using the same electricity charges, the savings using just 1 blower motor instead of 2 in the aeration tanks is estimated at $7,995 per year. Assuming these rates above are correct, the install of in-line monitoring equipment is anticipated to pay for itself within two years time. Attachment K shows the power usage calculation.

Another note of importance is that when repairing or replacing damaged or failed motors, it may be useful to buy energy efficient motors or even variable-frequency drive, "soft-start" replacements. A very useful tool for motor replacement guide is the US-EPA's free computer program "Motor Master+ 4.0" which allows plant supervisors to assess motor efficiency and determine costs of replacements. This program is available from EPA's website, at http://www1.eere.energy.gov/industry/bestpractices/software.html

Typically, with motor rewinds, we note the following:

- Traditional fast cheap motor rewinds have an average loss of 20% efficiency each time the coil is repaired.
- Even with reliable repair shops, using OEM or OEM-equivalent materials, the efficiency loss is 1% or 2% each instance.
- We recommend that motors be replaced if:
  - Motor of any age has a rating less than 40 hp;
  - The cost of the rewind exceeds 65% of the price of a new energy efficient motor;
  - The motor was rewound before 1980.

During the WPPE, we did not evaluate the facility's emergency power generator, although we did note that the unit was temporarily out of service for maintenance. Most facilities of similar size and treatment technology will exercise the emergency power generator once per week for a duration of sixty minutes. This is usually sufficient time to maintain internal lubrication of the engine as well as keep a good charge on the engine battery.

Pathogen control

Disinfection for fecal coliform reduction is currently performed with the addition of gas chlorine. No solids were noted in the chlorine contact tank during the WPPE.

Middleboro originally used a hypochlorite disinfection system, but it may have proved ineffective. Generally, for small treatment systems, the recent trend has been to eliminate gas chlorine disinfection in favor of ultraviolet light systems. Doing so eliminates the hazards associated with using gas chlorine, and this may be advantageous, especially because the plant is in such close proximity to an elementary school. Chlorine disinfection sometimes generates halogenated byproducts in treated wastewater, such as chloramines and organohalides, which may be deleterious to human health when consumed in drinking water.

We make no recommendation regarding the current disinfection process; however, when funding and conditions exist (such as equipment replacement, plant upgrades, etc.), alternative methods for disinfection should be evaluated.

Laboratory methods

Mixed liquor suspended solids tests are usually conducted once weekly. Generally this practice would be acceptable for monitoring the biomass. During spring and fall times of year, when the temperatures are changing, it may be beneficial to monitor the MLSS more frequently, at least twice weekly. Also, once the MLSS test is complete, volatilizing any solids remaining in the muffle furnace will provide data on ML volatile suspended solids, which allows for the calculation of the mean cell residence time (MCRT). Generally, MCRTs in the 10 - 13 day range allow for optimum nitrification of the wastewater.

Use of the centrifuge, settleometers, and core-taker would allow the operators to develop a sludge inventory based on sludge units (SLU), which is a product of both solids-by-volume percent and process volume or total flow. Developing such a sludge inventory also allows the operators to determine a sludge age (AGE) for the process, which on a daily basis is used similar to the MCRT as an operational guideline.

In either case, whether using AGE or MCRT, it is beneficial to plant operators to find an ideal operational setpoint and then adjust the process to maintain the plant at or near that setpoint. It is somewhat like flying by instruments instead of using visual flight rules. Intuition and experience with the appearance of the facility does help, but it only goes so far.

Inflow/Infiltration

As are many POTWs in the Commonwealth, the collection system is impacted by inflow and infiltration. A maximum daily flow of 0.094 MGD indicates that some I/I does exist and could adversely affect operations. Continued maintenance on the collection system is needed to reduce these impacts. MA should maintain an aggressive policy to find and disconnect wildcat connections, storm drains and downspout connections, and root infiltration in its collection system. If manhole cap inserts are not in use, they should be installed to reduce inflow.

Solids Management and Inventory Control

The solids management and inventory control program is based primarily on mixed liquor suspended solids analysis and operator interpretation of the current operating conditions.

The current practices include wasting solids after they are allowed to accumulate in the system for some time. It appears that this practice may lead to significant DO demands within the aeration system. If a centrifuge were available for testing at the Middleboro and comparison charts were set up between MLSS levels and % solids then a quick 15 minute centrifuge test could give a good indication of solids levels and help with deciding when to waste solids.

It has been shown that activated sludge systems should be wasted on a daily basis in order to spur growth of the biomass and maintain the system in a steady-state near the top of the growth curve. Extended aeration plants, as a rule, host microorganisms that are slightly endogenous, with higher MCRT, low F/M, and generally low respiration rates, as observed. However, it is beneficial when operating in this manner to also augment the existing biomass with seed sludge or commercially prepared bacteria preparations. This bioaugmentation can help with digesting fats, oils, and greases, as well as aid settleability in the clarifiers.

Flow Monitoring

The flow meter may provide more accurate data if installed with a permanent mounting bracket. An "L" shape piece of aluminum or stainless steel would be a good option for permanently fixing the ultrasonic flow meter head to the composite sampler building. The current configuration may prove to be unsteady and cause inconsistent readings during high-wind events. It would most likely prove to be very complicated to obtain and maintain calibration. The original equipment manufacturer (OEM) manual will provide useful information on a secure, permanent mount.

If contemplating installation of digital electronics such as the instrumentation employed during this study, it would be helpful to connect the existing flow meter to the system. Doing so would ensure that recording of daily flow occurs at the same time each day. This will also allow the software to automatically calculate loadings and treatment efficiencies.

Attachment A— Program Description

POTW Optimization Program

Description and goals

As part of an EPA-sponsored grant, the DEP has created a Wastewater Optimization Program to enhance surface water quality by improving sewage treatment plant performance beyond that expected by existing limits of the plants' National Pollutant Discharge Elimination System (NPDES) Permits.

The goal of this program is to reduce pathogen, nutrient, and emerging contaminant loadings to downstream drinking water facility intakes. The initial focus will be to work with wastewater treatment facilities within five miles upstream of these filter plant intakes. DEP will conduct Wastewater Plant Performance Evaluations (WPPEs) to assist municipal wastewater systems in optimizing their wastewater treatment plant processes as part of the Wastewater Optimization Program. Each evaluation is expected to last up to 2 months.

This new program is modeled after DEP's Filter Plant Performance Evaluations (FPPEs) conducted at Drinking Water facilities.

This program is not part of the Field Operations, Monitoring and Compliance Section. Sample collection methods utilized during this evaluation generally do not conform with 40 CFR Part 136, therefore the data collected will not be used, and in some cases is not permitted to be used for determining compliance with a facility's effluent limits established in its NPDES permit.

Wastewater plant performance evaluation

- Department staff will consult with the plant operators to explain the program, the goals, the equipment used, and the expectations for participation.
- Upon arrival at the wastewater plant, Department staff will set up equipment, including meters capable of continuous, in-line monitoring for pH, Oxidation-Reduction Potential, Ammonia, Nitrates, Dissolved Oxygen, and other parameters.
- The Department will utilize the equipment to gather data on system performance, show the operator how to gather similar data, and explain the value of gathering the data. We'll also explain how operators could choose to modify their treatment processes based on interpretation of the data collected.
- Although the Department may show operators how to achieve effective process control by using these process monitoring tools, the operators will continue to make all process control decisions, in conformance to their licensing requirements, and retain responsibility for those changes.
- The Department will also lend the facility additional laboratory equipment which will remain on site during the WPPE to assist in data collection and interpretation.
- During this time, the operator may need to spend more time performing routine testing at the treatment plant than was done previously; this will allow correlations to be made between process modifications and the process response.

- One major goal of the program is to provide the operator with the process monitoring knowledge and experience necessary to gather useful data and utilize it to make beneficial changes in the treatment process and the receiving stream long after the Department and its equipment have been removed.
- There is no charge for the Department's review of the treatment process, setup of all equipment, the process control monitoring that will take place, lending meters to the plant during the WPPE, data collection and explanation of potential effects that process modifications can have on the treatment process.
- The municipality will be responsible for providing laboratory bench space and 120 VAC power for the instrumentation. Any costs associated with process modifications (such as equipment upgrades, chemical purchases, etc.) that the municipality deems appropriate and beneficial as a result of the WPPE remain the responsibility of the municipality. The municipality reserves the right to cease participation in the WPPE at any time.
- Following the equipment set-up, the Department will observe the facilities and review operational practices, treatment processes, chemical treatment, operational data currently collected, and overall system performance.
- During the evaluation, the Department will review monitoring records, laboratory sheets, operations log sheets, and any drawings and specifications for the treatment facility. Also of interest is data currently collected and how it is utilized for daily process modifications. This information is usually available from existing reports.

Program evaluation team will consist of 1 to 2 people: Wastewater Optimization Program Specialists, PA licensed as a wastewater plant operators with operations and compliance assistance experience.

Potential Benefits

- Use of online process control monitoring equipment during the WPPE, use of hand held meters and portable lab equipment during the WPPE, and furthering the operators' knowledge of process control strategies and monitoring techniques,
- Producing a cleaner effluent discharge which minimizes impacts to the environment and downstream water users, and possible identification of process modifications that could result in real cost savings.
- Where the optimization goals may be more stringent than current requirements of your NPDES permit, they are completely voluntary. The WPPE objective is to optimize wastewater treatment plant performance in order to enhance surface water quality, minimizing the effects of pathogen and nutrient loading to downstream drinking water plant intakes.
- Furthermore, pursuit of a good rating in the WPPE program may place the wastewater system in a better position to meet more stringent regulatory requirements in the future, should they occur. For example, regulatory changes over the last ten years have reduced the final effluent Total Chlorine Residual limits requiring dechlorination or optimization of treatment processes to reduce the levels of chlorine added to the process for disinfection. Facilities who have voluntarily maintained lower residuals than listed in their permit have found it easier to comply with the updated regulations.

Attachment B— WPPE Team

Municipal Authority of Middleboro-Wastewater Treatment Plant

Evaluation Information

WPPE Team
Robert DiGilarmo, Water Program Specialist DEP – Ebensburg Office 286 Industrial Park Rd Ebensubrg, PA 15931 814.472.1819 rdigilarmo@state.pa.us Marc Neville, Water Program Specialist DEP- RCSOB 400 Market St Harrisburg, PA 17105 717.772.4019 mneville@state.pa.us

Persons Accompanying Evaluators
Doug Burdick, Chief Operator Municipal Authority of Middleboro P.O. Box 335 McKean, PA 16426 814-474-4644

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Attachment C— Suggested Sampling Frequencies

Operator Sample collection guidelines Plant Flow: Less than 1.0 MGD

Sample Parameter	Sample Location	Sample Type	3/Week	1/Week	2/Month
Raw Influent *					
BOD5 and TSS	Influent	Grab			x
Alkalinity	Influent	Grab			x
COD	Influent	Grab			x
NH3-N	Influent	Grab			x
pH	Influent	Grab		x	
Flow	Influent	Totalizer	Daily		
* Frequency of sampling may need to be increased or decreased depending on plant size or conditions					
Aeration Basin					
MLSS / MLVSS (or centrifuge, with coorelated data from periodic MLVSS values	Aeration Tank	Grab			x
Dissolved Oxygen	Aeration Tank	In Situ		x	
Settleability (SV30)	Aeration Tank	Grab	x		
pH	Aeration Tank	Grab		x	
Microscopic Evaluation	Aeration Tank	Grab			x
Return Activated Sludge, SS	RAS line	Grab			x
Computation of SVI, F/M, sludge age, and/or MCRT	-	-	As data collected		
Secondary Clarifier					
Sludge blanket depth	As appropriate	In situ		x	
Waste Activated Sludge, SS and VSS	Waste Line	Grab			X
Final Effluent					
Alkalinity	Effluent	Grab			x
Parameters, sample types, and frequencies required by permit					

Table 7: Suggested sampling frequencies

These parameters and frequencies are the minimum for facilities with flows rated less than 1.0 MGD. Operators are encouraged to sample more frequently as necessary to gather enough data to effectively make informed process control decisions. Depending on the chemical makeup of the wastewater, additional analyses may need to be performed to provide adequate treatment.

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Attachment D—Treatment Schematic

Process Description:

Middleboro's treatment train is depicted in Figure 24, below, showing a conventional activated sludge, extended aeration treatment process employing aerobic digestion of waste solids. Plant headworks include a manual bar screen and flow equalization. Two aeration tanks provide for 112,000 gallons of capacity. Secondary settling is provided in two clarifiers. The south unit clarifier has a 200 sq ft surface area and 14 ft depth for a 21,000 gallon capacity. The north clarifier has a 15'-0" of headwall depth. The disinfection processes utilizes one tank with gas chlorination to destroy pathogens prior to discharge to the receiving stream. Middleboro's final outfall into Elk Creek employs a standard, shoreline point discharge and headwall.

Aluminum Sulfate is added for phosphorus control, automatically, at the flow equalization tank using a parabolic pump and 55 gallon containers of chemical.

Waste sludge is transferred to sludge drying beds, allowed adequate time to dry in the sun, and manually removed and stored in a roll-off container on-site. Upon filling the roll-off container, the biosolids ultimately are disposed of in a municipal waste landfill.

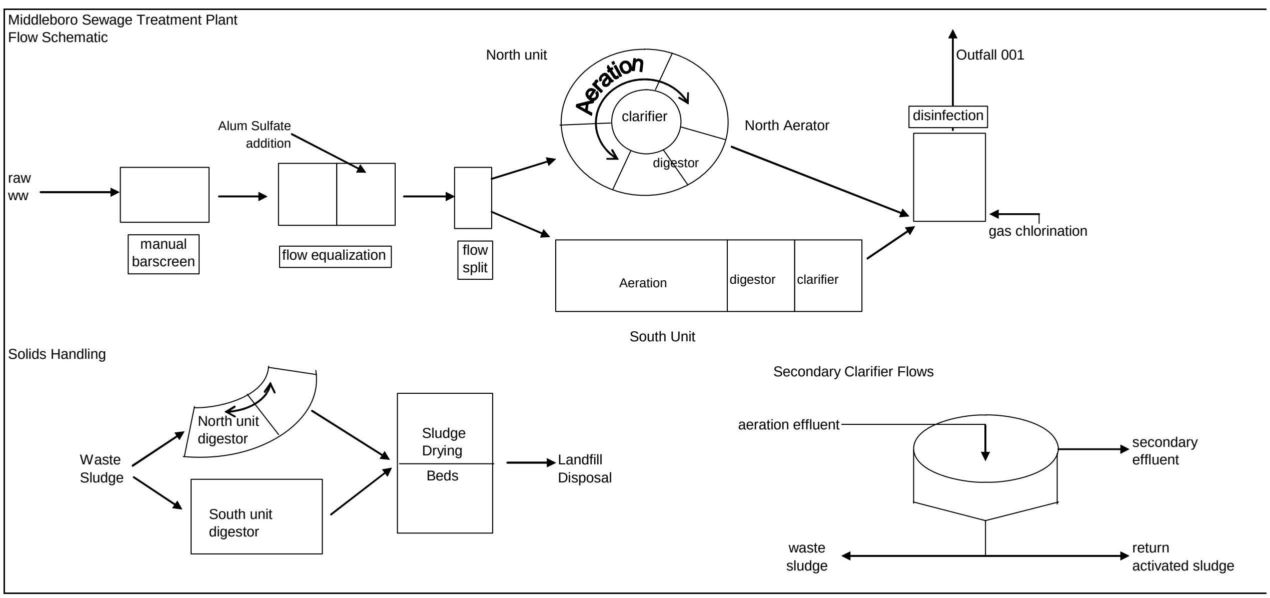

Figure 24: Middleboro sewage treatment plant process flow schematic

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Attachment E— Laboratory Sampling Results

Municipal Authority of Middleboro Laboratory Sample Results

Upstream, Downstream, Effluent, Mixed Liquor Suspended Solids

The following pages represent the samples collected by Department personnel over the project period. These samples are for informational use in identifying trends and effects of process modifications where applicable. These samples were not collected with the intentions of being used for compliance purposes.

Municipal Authority of Middleboro, DEP Laboratory sample results

Lab Resutls-Middleboro STP

	5/20/2009	5/27/2009	5/28/2009	6/4/2009	6/11/2009	6/17/2009	6/23/2009	7/1/2009	7/15/2009	7/21/2009	7/29/2009
Effluent-Sample #	0331806		0331812	0907017	0331818	0907022	0907032	0331825	0907037	0907043	0907049
CBOD	1.6		0.9	2	1.2	1.3	1.1	0.9	1.6	0.9	1
TSS	<5		5	<5	<5	<5	<5	<5	<5	<5	18
Alkalinity	113		89.2	102.4	97.2	124.4	110.4	103.4	95	76.4	115
NO2-N	0.01		0.03	0.01	0.01	0.06	0.11	0.02	0.02	0.02	0.05
NO3-N	17.05		21.7	19.33	21.3	13.98	14.69	11.49	21.39	28.06	17.13
NH3-N	0.05		0.43	0.06	0.07	0.18	0.46	0.19	0.04	0.03	0.07
TKN	1.17		1.49	<1	<1	1.29	1.44	<1.0	<1	<1	<1
Phos	0.967		0.945	0.588	0.516	0.62	0.663	0.556	0.503	0.514	0.592
TOT N(TKN+NO3+NO2)	18.23		23.22	20.34	22.31	15.33	16.24	12.51	22.41	29.08	18.18
Fecal	<20		<20		20						
Chloride	401		432.7	453.8	448.5	442.4	451.9	442.4	371.2	377.3	474.7
pH			7.8	7.7	7.9	7.8	8.1	8	8	7.9	8.1
Crypto							3		0		0
Giardia							4		57		57
Upstream-Sample #				0907018	0331822	0907020	0907033	0331828	0907035	0907041	0907047
CBOD				1.4		1.5					0.8
TSS				<5		<5					10
Alkalinity				107.8		131					107.6
NO2-N				0.01		<.01	0.01		<.01	<.01	<.01
NO3-N				0.31		0.11	1.68		0.34	0.2	0.25
NH3-N				<.02	<.02	<.02	<.02	<.02	<.02	<.02	0.03
TKN				<1	<1		<1	<1.0	<1	<1	<1
Phos				<.01	0.012	0.014	0.047	0.073	<.01	<.01	0.013
TOT N(TKN+NO3+NO2)				1.32		1.12	2.69	2.41	1.35	1.21	1.26
Fecal											
Chloride				18.7		23.2	15.3			19.7	12.9
pH				8.1		8					8.2
NO3+NO2-N								1.41			
Crypto									3		3
Giardia									1		3
Downstream-Sample #				0907016	0331823	0907021	0907034	0331829	0907036	0907042	0907048
CBOD				1.5		1					0.6
TSS				<5		<5					11
Alkalinity				111.6		137					105.8
NO2-N				0.01		0.01	0.01		<.01	<.01	<.01
NO3-N				0.37		0.25	1.38		0.37	0.31	0.19
NH3-N				<.02	<.02	0.03	<.02	<.02	<.02	<.02	<.02
TKN				<1	<1		<1	<1.0	<1.0	<1	<1
Phos				0.011	0.024	0.018	0.017	0.059	0.011	0.014	0.014
TOT N(TKN+NO3+NO2)				1.38		1.26	2.39	2.15	1.38	1.32	1.2
Fecal											
Chloride				24.1		33	19.5			28.4	15.6
pH				8.1		8.1					8
NO3+NO2-N								1.15			
Crypto									3		1
Giardia									1		1

Table 8: Middleboro sample data: Effluent, Upstream, and Downstream

Municipal Authority of Middleboro, DEP Laboratory sample results

Lab Resutls-Middleboro STP

	5/20/2009	5/27/2009	5/28/2009	6/4/2009	6/11/2009	6/17/2009	6/23/2009	7/1/2009	7/15/2009	7/21/2009	7/29/2009
MLSS- CT - Sample #	0331810		0331815		0331820	0907027		0331827	0331832	0907046	0907052
MLSS	5112		4916		5264	3926		4022	3312	2956	3040
MLVSS	4016		3700		3476	2598		2548	2036	1782	1834
MLSS/MLVSS ratio:	78.6%		75.3%		66.0%	66.2%		63.4%	61.5%	60.3%	60.3%
Alkalinity	297		178		118.4	109.8		144.8		124.8	173.6
MLSS- GT - Sample #	0331807		0331814		0331819	0907026		0331826	0907039	0907045	0907051
MLSS	4544		4634		4560	5216		5152	4576	4776	4572
MLVSS	3174		3192		3084	3528		3506	3028	3288	3010
MLSS/MLVSS ratio:	69.9%		68.9%		67.6%	67.6%		68.1%	66.2%	68.8%	65.8%
Alkalinity	243		266		254.6	308		220	231.8	258.4	281
RAS- CT - Sample #	0331809								0907040		0907054
MLSS	6024								3508		3054
MLVSS	4640								2160		1846
MLSS/MLVSS ratio:	77.0%								61.6%		60.4%
RAS- GT - Sample #	0331808								0331831		0907053
MLSS	5544								6836		5996
MLVSS	3830								4524		3934
MLSS/MLVSS ratio:	69.1%								66.2%		65.6%
Influent -Sample #	0331805	0331816	0331813	0907019	0331821	0907023		0331824	0907038	0907044	0907050
BOD	235		123	278	237	231		59.9	192	244	150
COD	128.9	133.7	179.3	194	155	201.4		79.5	215.3	60.1	237.6
BOD/COD ratio:	55%		146%	70%	65%	87%		133%	112%	25%	158%
TSS	266		64	374	446	320		210	300	344	250
Alkalinity	363		193.6	357	276.8	336.2		65.8	278.2	310.2	274.2
NO2-N	0.01		<.01	<.01	<.01	0.01		0.12	0.01	<.01	<.01
NO3-N	<.04		<.04	<.04	<.04	<.04		0.81	<.04	<.04	<.04
NH3-N	38.3		38.55	36.15	35.71	50.92		11.73	38.51	39.51	31.31
TKN	49.6			53.48	49.53	49.48		17.7	44.98	45.79	
Phos	6.3		1.939	7.624	6.421	6.626		2.636	6.434	5.185	4.615
TOT N	49.65			53.53	49.58	49.53		18.63	45.03	45.84	0.05
Chloride	450		281.6	448.3	310.1	541.6		174.4	421.7	1232.4	367.9
pH	7.5		7.1	7.3	7.3	7.5		7	7.4	7.4	7.5
Iron					1570 ug/l						
Manganese					139 ug/l						

Table 9: Middleboro sample data: MLSS, RAS, and Influent WW

Municipal Authority of Middleboro, DEP Laboratory sample results

Lab Resutls-Middleboro STP

	5/20/2009	5/27/2009	5/28/2009	6/4/2009	6/11/2009	6/17/2009	6/23/2009	7/1/2009	7/15/2009	7/21/2009	7/29/2009
Clarifier-GT -Sample #						0907024	0907030				
BOD						1.6					
COD											
TSS						<5					
Alkalinity						135					
NO2-N						0.02					
NO3-N						14.34					
NH3-N						0.16					
TKN											
Phos						0.45					
TOT N											
Chloride						470.6					
pH						7.7					
Iron											
Manganese											
Crypto							0				
Giardia							36				
Clarifier-CT -Sample #						0907025	0907031				
BOD						2.9					
COD											
TSS						11					
Alkalinity						23					
NO2-N						0.01					
NO3-N						52.68					
NH3-N						0.17					
TKN											
Phos						1.209					
TOT N											
Chloride						475.3					
pH						7					
Iron											
Manganese											
Crypto							1				
Giardia							59				

Table 10: Middleboro sample data: Clarifiers

	5/20/2009	5/28/2009	6/4/2009	6/11/2009	6/17/2009	7/1/2009	7/15/2009	7/21/2009	7/29/2009	Averages	Max
BOD	115	51.3	90.4	76.1	109.8	34.0	68.4	118.0	65.1	80.9	118.0
COD	63	74.8	63.1	49.8	95.7	45.1	76.7	29.1	103.0	66.7	103.0
TSS	130	26.7	121.6	143.2	152.1	119.1	106.9	166.4	108.4	119.4	166.4
Alkalinity	177	80.7	116.1	88.9	159.8	37.3	99.1	150.0	118.9	114.2	177.1
NO2-N	0	<0.0042	-	-	0.0048	0.0681	0.0036	-	-	0.0102	0.0681
NO3-N	<0.02	<0.0167	-	-	-	0.4594	-	-	-	0.0656	0.4594
NH3-N	19	16.1	11.8	11.5	24.2	6.7	13.7	19.1	13.6	15.0	24.2
TKN	24	-	17.4	15.9	23.5	10.0	16.0	22.1	15.2	16.1	24.2
Phos	3	0.8	2.5	2.1	3.1	1.5	2.3	2.5	2.0	2.2	3.1
TOT N	24	-	17.4	15.9	23.5	10.6	16.0	22.2	15.3	16.1	24.2
Chloride	220	117.4	145.8	99.6	257.5	98.9	150.2	596.1	159.6	205.0	596.1

Table 11: Middleboro Influent Loadings (lb./day) on Sample Dates

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Attachment F— 2009 Flow Data, April through July

Middleboro Flow Readings, recorded manually at McKean wastewater plant

April 2009

Day	Reading	delta	x1000 gal	MGD	Rainfall
1	49802	92.8	92800	0.093	0.33
2			92800	0.093	0
3			92800	0.093	0.63
4			92800	0.093	0
5			92800	0.093	t
6	50266	70.5	70500	0.071	0.1
7			70500	0.071	0.16
8	50407	94.3	94333	0.094	0.07
9			94333	0.094	0
10			94333	0.094	0
11	50690	74.1	74143	0.074	0
12			74143	0.074	0
13			74143	0.074	t
14			74143	0.074	0.1
15			74143	0.074	0.59
16			74143	0.074	0
17			74143	0.074	0
18	51209	66.4	66385	0.066	0
19			66385	0.066	0.01
20			66385	0.066	0.36
21			66385	0.066	0.08
22			66385	0.066	0.12
23			66385	0.066	0
24			66385	0.066	0.04
25			66385	0.066	0
26			66385	0.066	0
27			66385	0.066	0
28			66385	0.066	0.43
29			66385	0.066	0
30			66385	0.066	0.07
Average				**0.076**	**0.110**
Max				0.094	0.630
Min				0.066	0.000

Month: **May** **2009**

Day	Reading	delta	x1000 gal	MGD	Rainfall
1	52072	300	75,000	0.075	0.15
2			75,000	0.075	0
3			75,000	0.075	0
4			75,000	0.075	0
5	52372	240	60,000	0.060	0
6			60,000	0.060	0.41
7			60,000	0.060	0.16
8			60,000	0.060	0.11
9	52612	379	63,167	0.063	0.06
10			63,167	0.063	0
11			63,167	0.063	0
12			63,167	0.063	0
13			63,167	0.063	t
14			63,167	0.063	0.1
15	52991	203	50,750	0.051	0
16			50,750	0.051	0.05
17			50,750	0.051	0
18			50,750	0.051	0
19	53194	234	58,500	0.059	0
20			58,500	0.059	0
21			58,500	0.059	0
22			58,500	0.059	0
23	53428	104	52,000	0.052	0
24			52,000	0.052	t
25	53532	79	79,000	0.079	0
26	53611	33	33,000	0.033	0.04
27	53644	38	38,000	0.038	0.03
28	53682	50	50,000	0.050	1.15
29	53732	27	27,000	0.027	0.04
30	53759	37	37,000	0.037	0.02
31	53796	43	43,000	0.043	0
Average				**0.057**	**0.080**
Max				0.079	1.150
Min				0.027	0.000

Month: **June** **2009**

Day	Reading	delta	x1000 gal	MGD	Rainfall
1	53839	45	45,000	0.045	t
2	53884	36	36,000	0.036	0.12
3	53920	117	39,000	0.039	t
4			39,000	0.039	0
5			39,000	0.039	0
6	54037	71	35,500	0.036	0
7			35,500	0.036	0.19
8	54108	39	39,000	0.039	0.03
9	54147	36	36,000	0.036	t
10	54183	77	38,500	0.039	t
11			38,500	0.039	0.08
12	54260	29	29,000	0.029	t
13	54289	41	41,000	0.041	0
14	54330	40	40,000	0.040	0
15	54370	42	42,000	0.042	0
16	54412	20	20,000	0.020	0
17	54432	57	57,000	0.057	0.53
18	54489	44	44,000	0.044	0.14
19	54533	53	53,000	0.053	t
20	54586	51.67	51,667	0.052	2.0
21			51,667	0.052	0
22			51,667	0.052	0
23	54741	42	42,000	0.042	0
24			42,000	0.042	0
25	54825	63	63,000	0.063	t
26			63,000	0.063	0
27			63,000	0.063	0
28			63,000	0.063	0.24
29			63,000	0.063	0
30			63,000	0.063	2.26
Average				**0.045**	**0.243**
Max				0.063	2.260
Min				0.020	0.000

Month: **July** **2009**

Day	Reading	delta	x1000 gal	MGD	Rainfall
1	55140	68	68,000	0.068	0.27
2	55208	80	80,000	0.080	0.15
3	55288	57.25	57,250	0.057	0.23
4			57,250	0.057	0
5			57,250	0.057	t
6			57,250	0.057	0
7	55517	45	45,000	0.045	0
8			45,000	0.045	0
9			45,000	0.045	0
10	55652	47.7	47,667	0.048	0
11			47,667	0.048	0.98
12			47,667	0.048	0
13	55795	42.7	42,714	0.043	0
14			42,714	0.043	0
15			42,714	0.043	0
16			42,714	0.043	0
17			42,714	0.043	0.29
18			42,714	0.043	1.06
19			42,714	0.043	0
20	56094	45	45,000	0.045	0
21	56139	58	58,000	0.058	0.18
22			58,000	0.058	0.34
23			58,000	0.058	0.7
24			58,000	0.058	0.19
25			58,000	0.058	t
26			58,000	0.058	0.7
27			58,000	0.058	0
28	56545	45	45,000	0.045	0
29	56590		-	0.000	0.33
30			-	0.000	0
31			-	0.000	0.02
Average				**0.047**	**0.188**
Max				0.080	1.060
Min				0.000	0.000

Table 12: Middleboro Flow Data t = trace Rainfall data from www.wunderground.com

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Attachment G—Equipment Deployed

Digital, Continuously Monitoring Probes:

1 – Laptop computer with 485 to 232 signal converter
2 – SC1000s
2 – LDO probes
2 – pH probe
2 – ORP probe
2 – NH_4D probe
2 – Nitratax probes
2 – Solitax probes

4- SC100s
1- Amtax
1- Phosphax
1- UVAS probe

Laboratory Equipment On-loan:

1 – Hach HQ40d handheld pH and LDO meter
1 – LBOD probe
1 – DR2800 spectrophotometer
1 – Raven centrifuge
1 – Raven Core Taker sampler
2 – Raven settleometers
1 – COD Heater Block
1 – Microscope with photographic/video capability

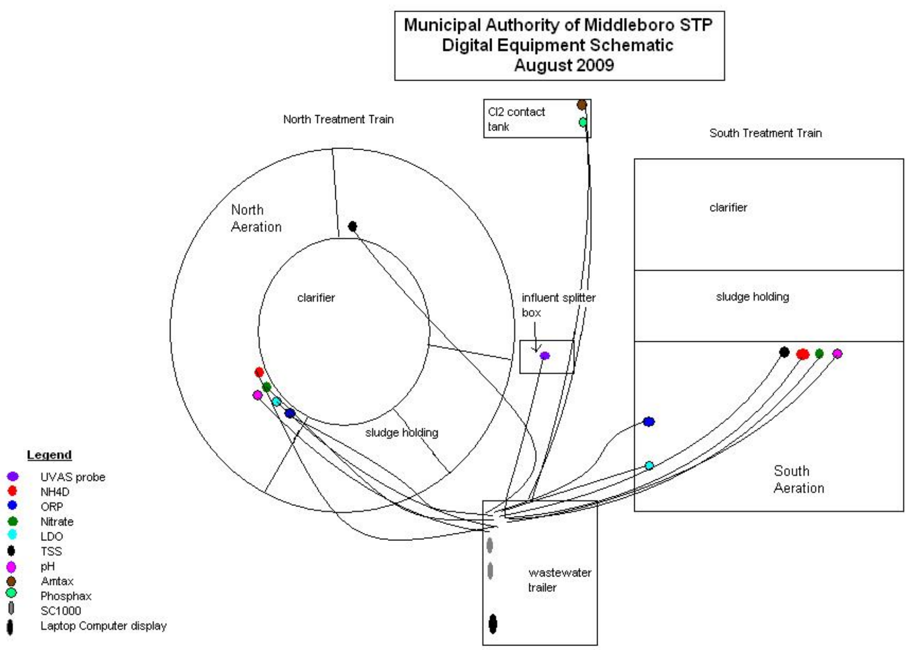

Figure 25: Locations of online process monitoring equipment

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Attachment H— Process Control Test Results

Middleboro STP
Bench Sheet

Date: 7/16/2009 **Time:** 8:00

Lab Tech: DiGilarmo

Raw Wastewater (INF)		
COD	520.00	**mg/L**
COD	523.00	**mg/L**
Q	0.043	**gpd or MGD**
Solids		% by vol.
Influent TSS	300.00	**mg/L**

BOD	192.00	**mg/L**

GT Flow approx 60% of total flow= 0.03
CT Flow approx 40% of total flow= 0.02

Settleometer Data

Loc	**GT Aerator**	**GT Clarifier**	**GT RAS**	**GT WAS**	**CT Aerator**	**CT Clarifier**	**CT RAS**	**CT WAS**
Spin Solids	5.45				3.00			
Tank vol.	0.062	0.017			0.050	0.024		
SLU								

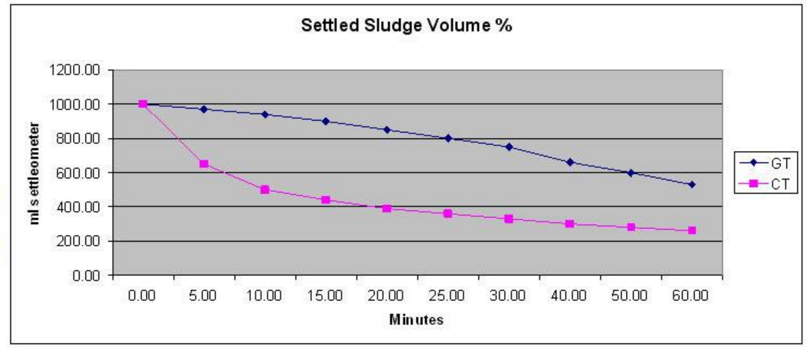
Loc	**GT**	**GT**	**CT**	**CT**
time	**SSV**	**SSC**	**SSV**	**SSC**
0.00	**1000.00**	5.45	**1000.00**	3.00
5.00	970.00	5.62	650.00	4.62
10.00	940.00	5.80	500.00	6.00
15.00	900.00	6.06	440.00	6.82
20.00	850.00	6.41	390.00	7.69
25.00	800.00	6.81	360.00	8.33
30.00	750.00	7.27	330.00	9.09
40.00	660.00	8.26	300.00	10.00
50.00	600.00	9.08	280.00	10.71
60.00	530.00	10.28	260.00	11.54

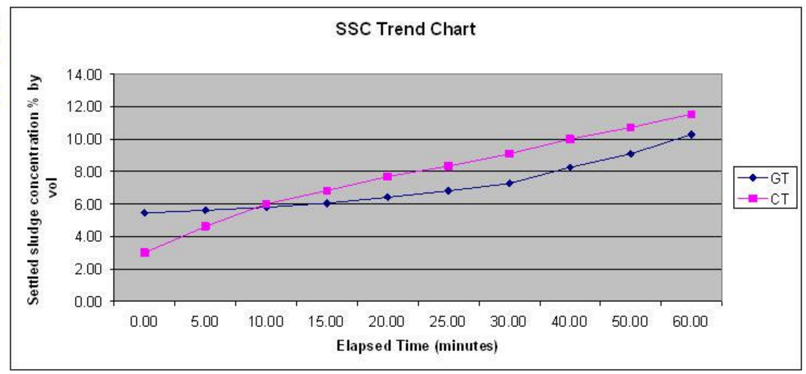
	GT		CT	
SVI	163.90		99.64	
Sludge Age	36.66	days	32.09	days
HRT	57.67	hours	69.77	hours
F/M Ratio	0.03		0.03	

SSC=[(Spin%) x 1000] ÷ SSV

WCR=TSS ÷ Spin%

	GT	**CT**
TSS	4576.00	3312.00
WCR	839.63	1104.00
MLVSS	3028.00	2036.00





RAS & WAS flow calculations:

	GT RAS	**GT WAS**	**CT RAS**	**CT WAS**
Time to fill bucket:				
Volume of Bucket:				
gal/min				
MGD				

Bench Tests	**INF**	**GT Aer**	**CT Aer**	**GT Clar**	**CT Clar**	**EFF**
Nitrate						
Phosphate-P						1.91 / 1.88
Ammonia-N	29.7 / 26.3					.077 / .076
Ammonia-N(1:1)						
Iron						
Chloride						
Ca+ hardness						
Aluminum						
Nitrate (1:1)						
Nitrate		20.0 / 19.4	28.0 / 28.8			
Alkalinity						
Blanket Depth				3.5	5.0	

Notes:

GT clarifier cloudy to 8'
CT clarifier cloudy to 9'

Table 13: Middleboro bench sheet prepared by PADEP: Q, SSV, SSC, COD, BOD eq., ions

Middleboro STP
Bench Sheet

OUR Testing

Date: 7/16/2009 **Time:** 8:00

Lab Tech: DiGilarmo

Location: GT

OUR = slope x 60

slope = 1.16 / 10

OUR = 1.16 / 10 x 60

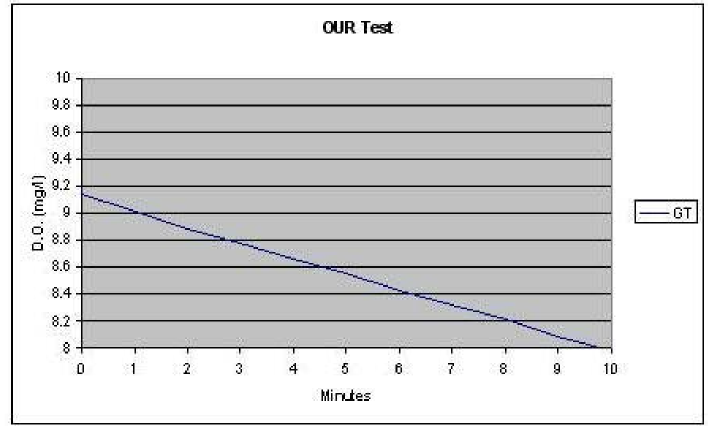
OUR = 6.96

RR= (1000 x OUR) ÷ VSS

= 1000 x 6.96 / 3028.00

RR = 2.30

Time	D.O.
0	9.14
1	9.01
2	8.88
3	8.77
4	8.66
5	8.55
6	8.43
7	8.32
8	8.21
9	8.09
10	7.98



Location: CT

OUR = slope x 60

slope = 0.59 / 10

OUR = 0.59 / 10 x 60

OUR = 3.54

RR= (1000 x OUR) ÷ VSS

= 1000 x 3.54 / 2036.00

RR = 1.74

Time	D.O.
0	9.18
1	9.11
2	9.05
3	8.99
4	8.93
5	8.88
6	8.82
7	8.76
8	8.71
9	8.65
10	8.59

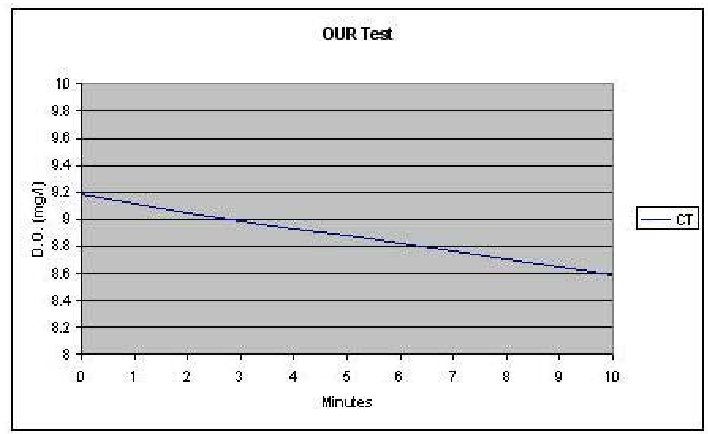


Table 14: Middleboro bench sheet prepared by PADEP: OUR Test

Middleboro STP **Date:** 7/15/2009 Time: 13:00

Test Data:

Lab Tech: DiGilarmo

Loc.	pH	Temp F	DO	
INF	7.19	66	0.15	
EQT 1				
EQT 2				
GT Aer 1	6.95	68.9	0.39	
GT Aer 2	6.95	69.1	1.38	
GT Aer 3	7.04	69.3	3.62	
GT Aer 4				
GT Aer 5				GT Aer. Average DO
GT Aer 6				1.8
GT Clarifier	7.08	69	2.98	
CT Aer 1	6.85	68.6	2.1	
CT Aer 2	6.83	68.6	2.1	
CT Aer 3	6.84	68.6	2.14	
CT Aer 4				
CT Aer 5				CT Aer. Average DO
CT Aer 6				2.1
CT Clarifier	6.84	69.1	1.78	
Wet Well				
Effluent	7.38	69.2	7.62	
Outfall 001				

Table 15: Middleboro bench sheet prepared by PADEP: pH, temperatures, DO

Dissolved Oxygen in the GT was measured starting at the influent end, midway through the tank and at the discharge end near the in-line LDO probe.

Clarifier DO readings were collected to ensure conditions within the units were not conducive to allowing denitrification to occur.

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Attachment I—Graphs: Monthly Monitoring Examples

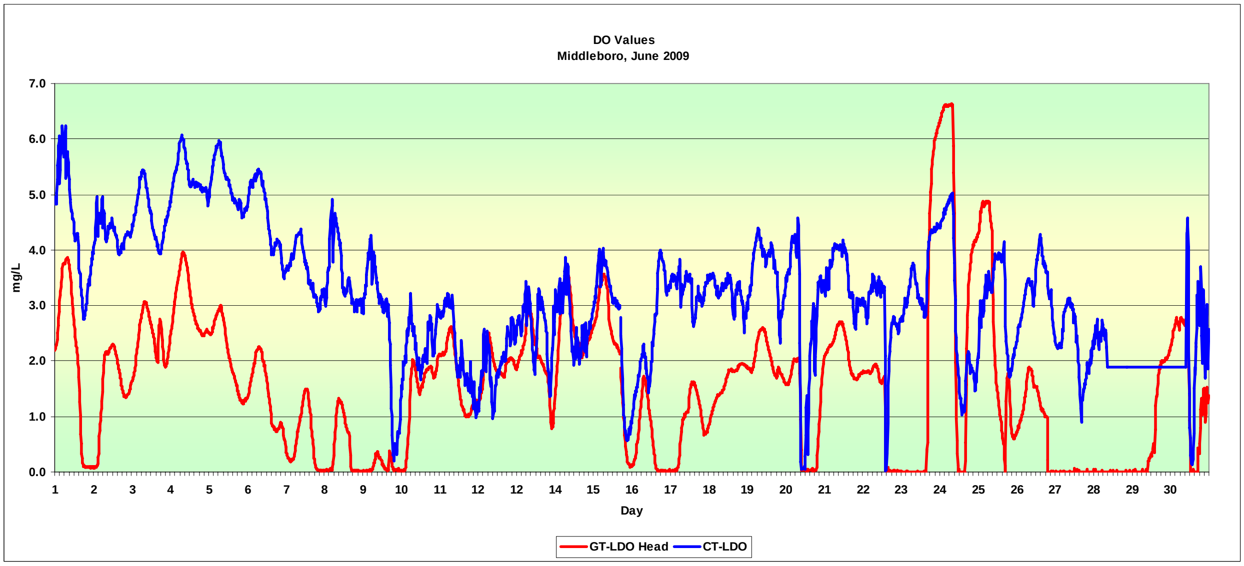

Figure 26: DO values during the month of June 2009

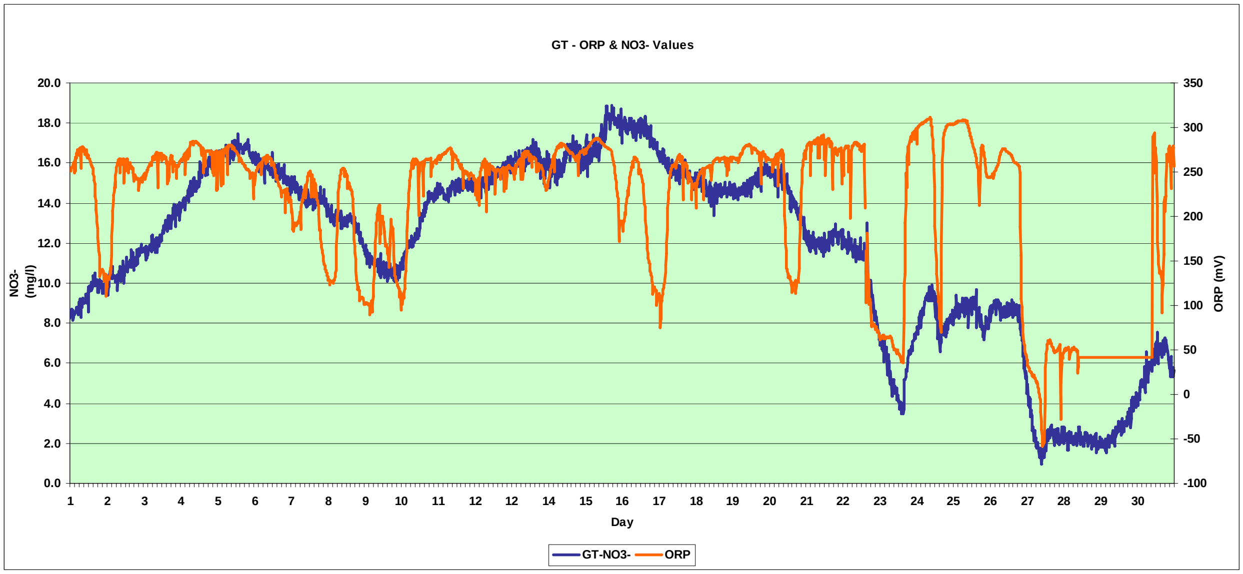

Figure 27: Steel Tank ORP & Nitrate values during the month of June 2009

Figure 28: Influent Total Organic Carbon & Aeration Total Suspended Solids during the month of June 2009

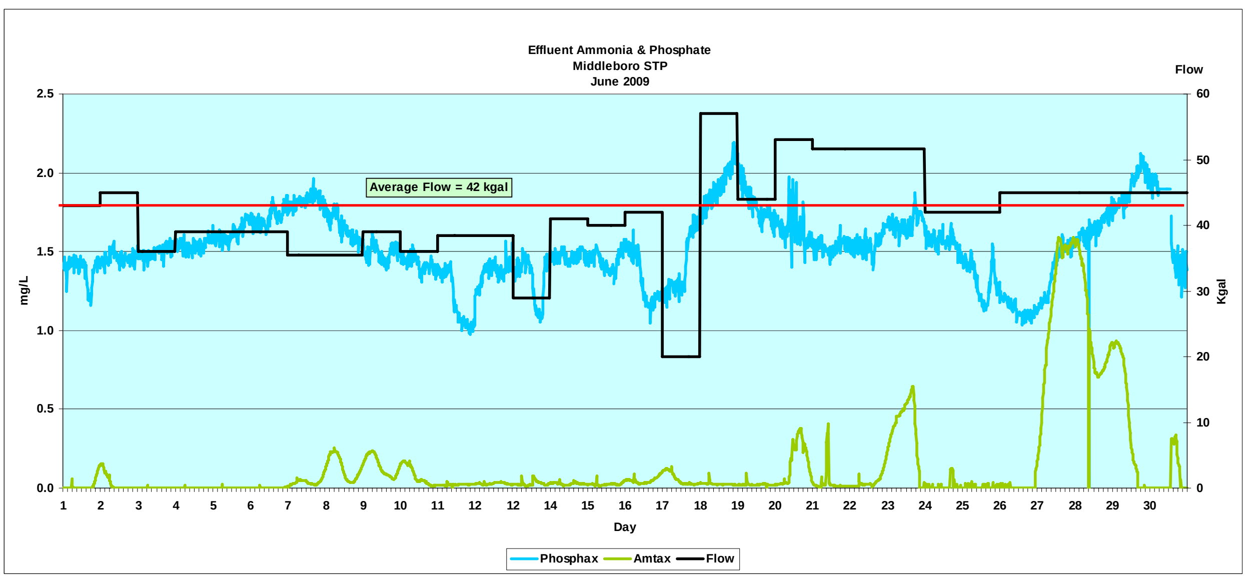

Figure 29: Effluent NH_3-N and PO_4^{3-}, with flow values, during the month of June 2009

Attachment J—Graphs: Daily Monitoring Examples

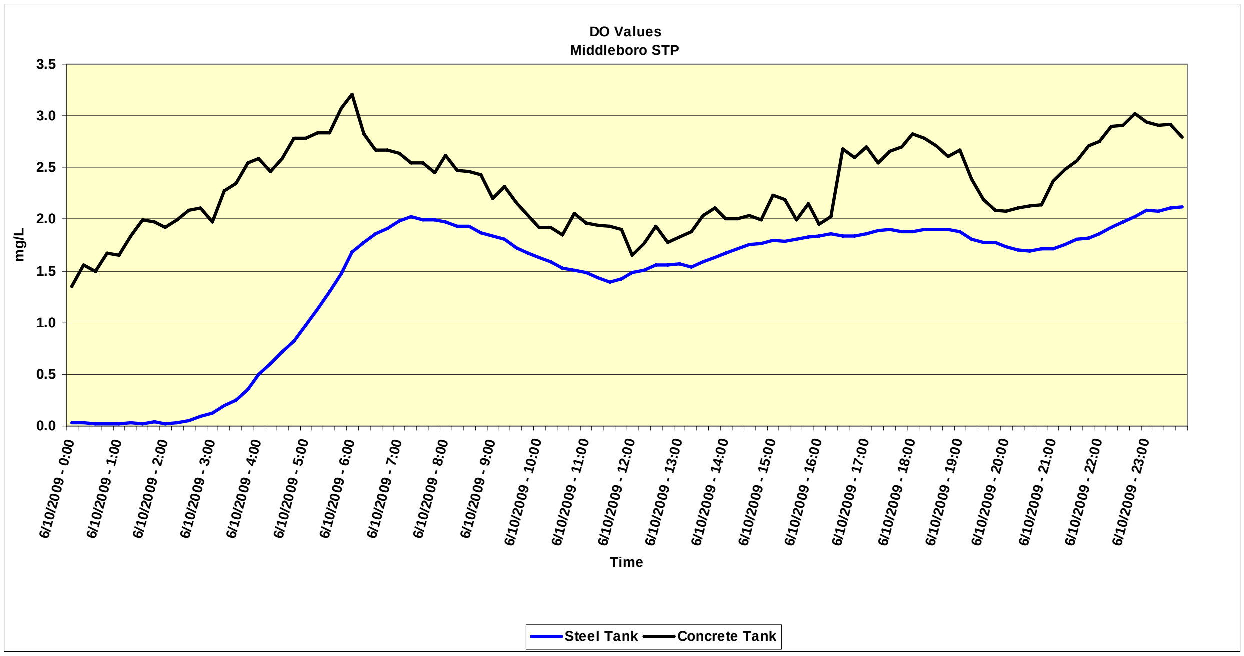

Figure 30: Middleboro DO values on August 10, 2009, for Steel Tank and Concrete Tank

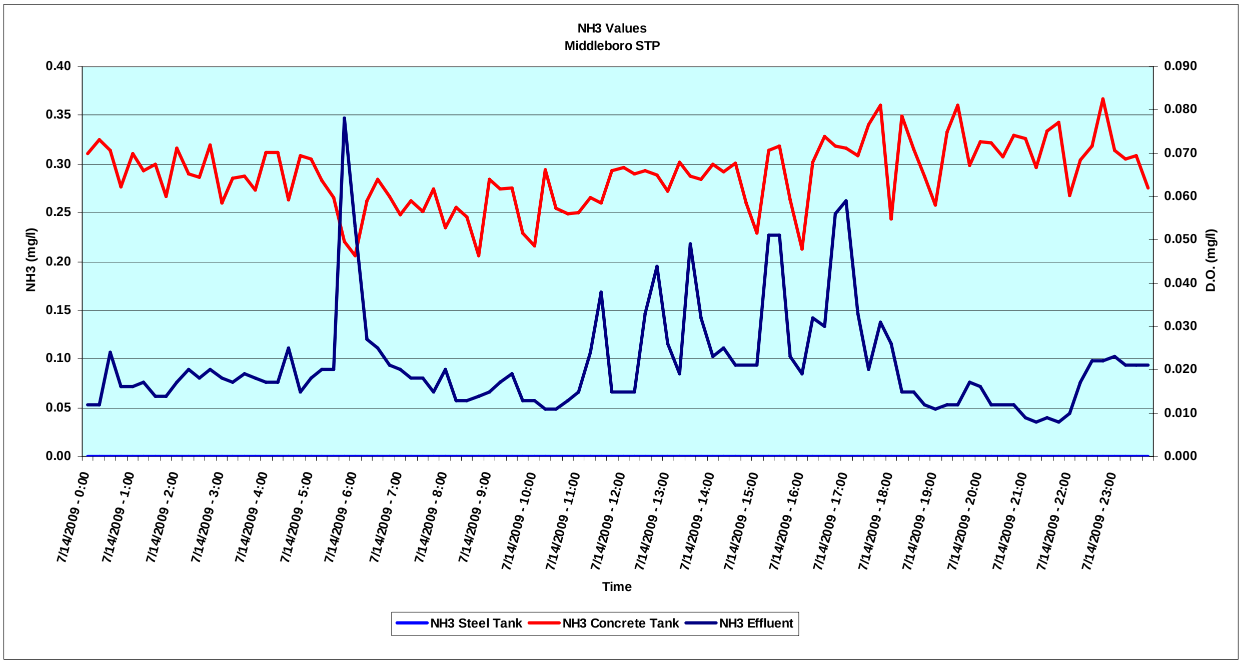

Figure 31: July 14, 2009, Histogram of Ammonia Nitrogen values, process tanks & effluent

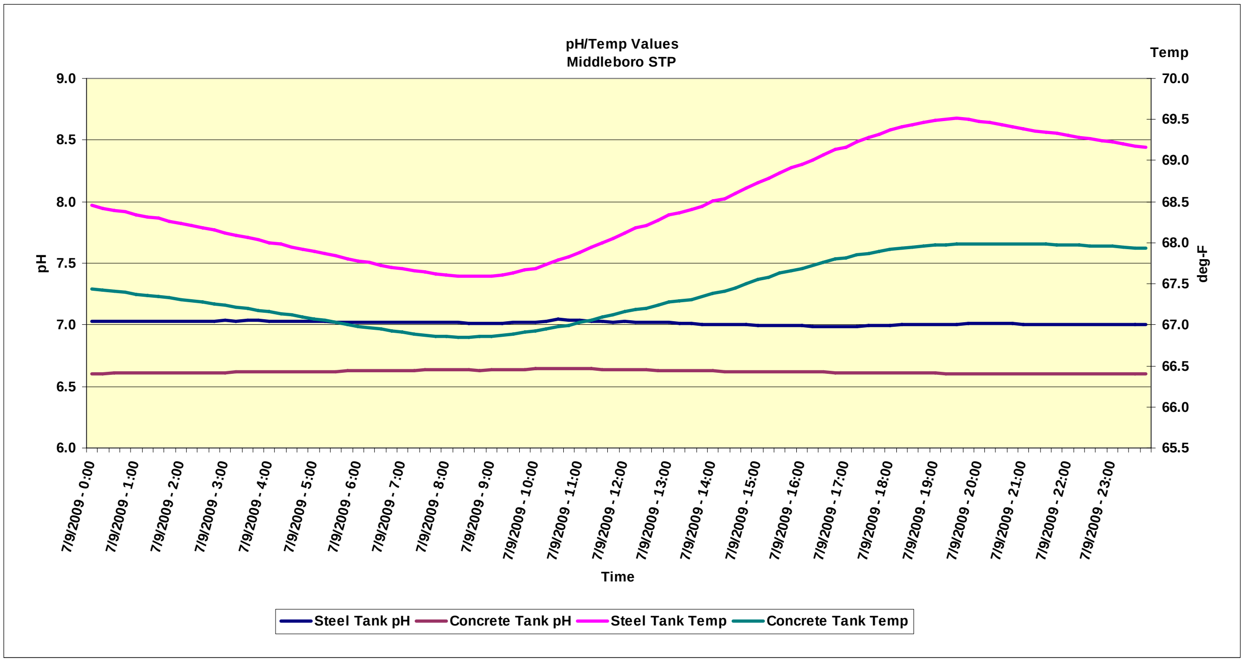

Figure 32: Histogram of pH and Temperature for July 9, 2009

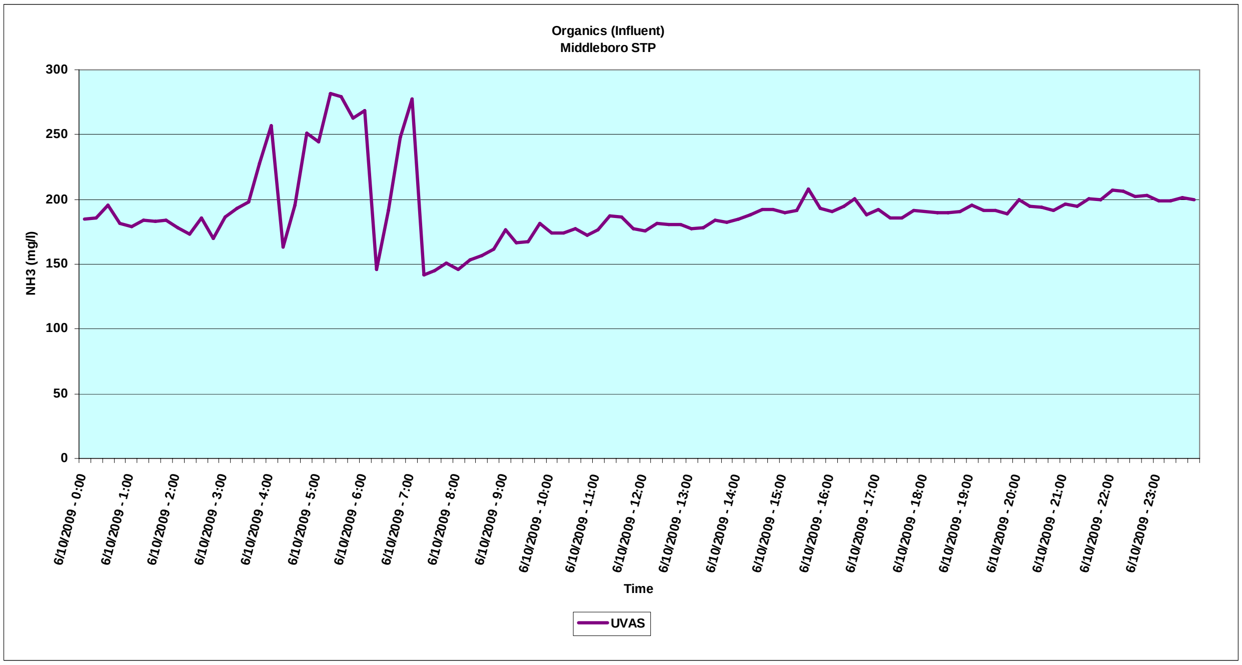

Figure 33: Raw Wastewater Total Organic Carbon (TOC), August 10, 2009

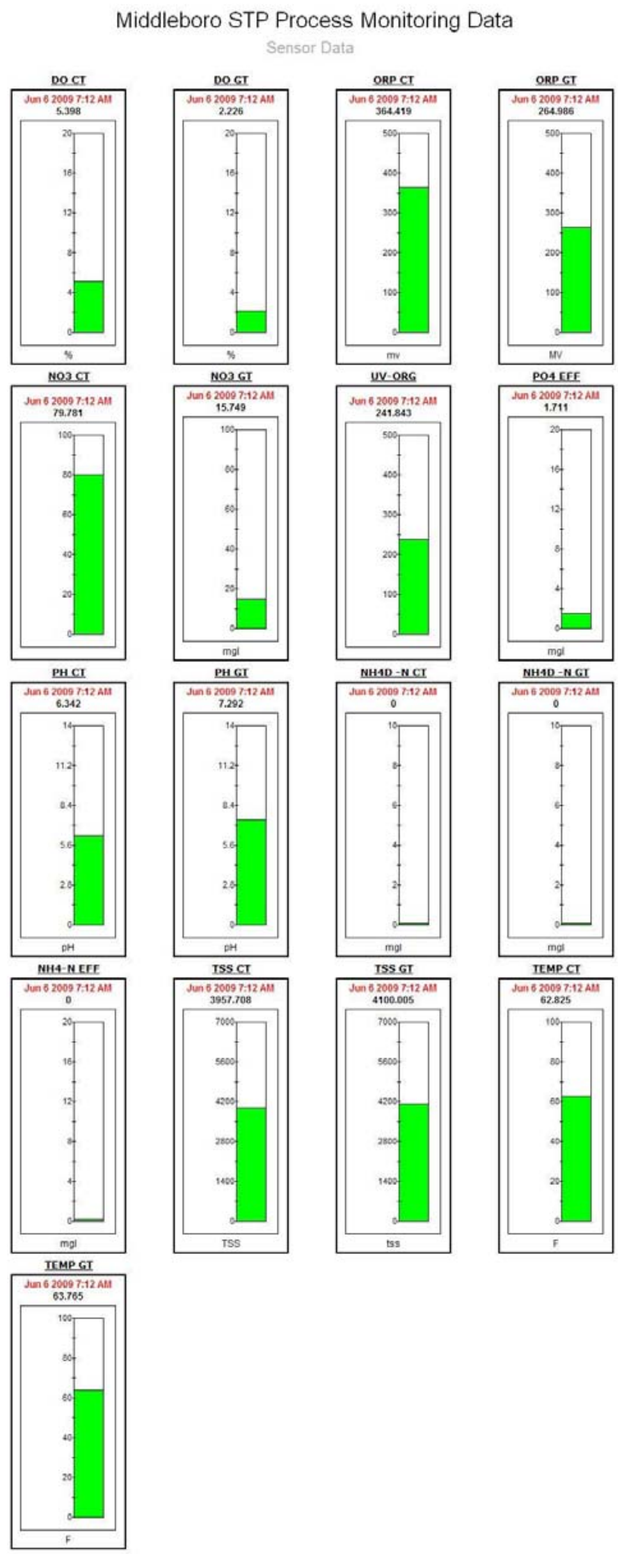

Figure 34: Water Eye System Snapshot for June 6, 2009, 7:12 AM

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Attachment K— Power usage

Power consumption estimate utilizing both blowers and EQ tank motor

Motor Description	Motor HP*	Motor kw	Efficiency*	Virtual kW	Duty cycle* (hours/day)	Electricity charge* (¢/kwh)	Demand charge* ($/kw)
Blower motor	15	11	91.0%	12	24	5.4	4.99
EQ tank	3	2	87.5%	3	24	5.4	4.99

	# of motors*	Annual kwh Cost	Annual Demand Cost	Daily Electricity Cost	Annual Electricity Cost
Blower motor	2	**$11,698**	**$1,473**	$36	**$13,171**
EQ tank	1	**$1,217**	**$153**	$4	**$1,370**
				DAILY	ANNUALLY
			Total Costs	*$40*	*$14,541*

Electricity Charge and Demand Charge are estimates from the previous WPPE performed in February through April
This example shows costs of running the motor for the EQ tank and 2 motors for the aeration tanks

Table 16: Middleboro power consumption estimate: 2 Aeration PD Blowers & 1 EQT PD Blower

Power consumption estimate utilizing one blower and EQ tank motor

Motor Description	Motor HP*	Motor kw	Efficiency*	Virtual kW	Duty cycle* (hours/day)	Electricity charge* (¢/kwh)	Demand charge* ($/kw)
Blower motor	15	11	91.0%	12	24	5.4	4.99
EQ tank	3	2	87.5%	3	24	5.4	4.99

	# of motors*	Annual kwh Cost	Annual Demand Cost	Daily Electricity Cost	Annual Electricity Cost
Blower motor	1	**$5,849**	**$736**	$18	**$6,585**
EQ tank	1	**$1,217**	**$153**	$4	**$1,370**

	DAILY	ANNUALLY
Total Costs	*$22*	*$7,955*

Electricity Charge and Demand Charge are estimates from the previous WPPE performed in February through April
This example shows costs of running the motor for the EQ tank and 1 motor for the aeration tanks

Cost savings by having to run only 1 blower estimated to be $6,586.00/year ($550/month)

Table 17: Middleboro power consumption estimate: 1 Aeration PD Blower & 1 EQT PD Blower

Attachment L—Equipment Placement Photographs

WPPE at Municipal Authority of Middleboro

Figure 35: Nitrate, Ammonium, TSS and pH probes installed in South aeration tank

Figure 36: LDO and ORP probes installed in South aeration tank

Figure 37: Nitrate, Ammonium, pH, LDO, and ORP probes installed in North aeration tank

Figure 38: TSS probe mounted in North aeration tank

Figure 39: UVAS probe mounted at influent splitter box

Figure 40: Amtax and Phosphax probes mounted at the chlorine contact

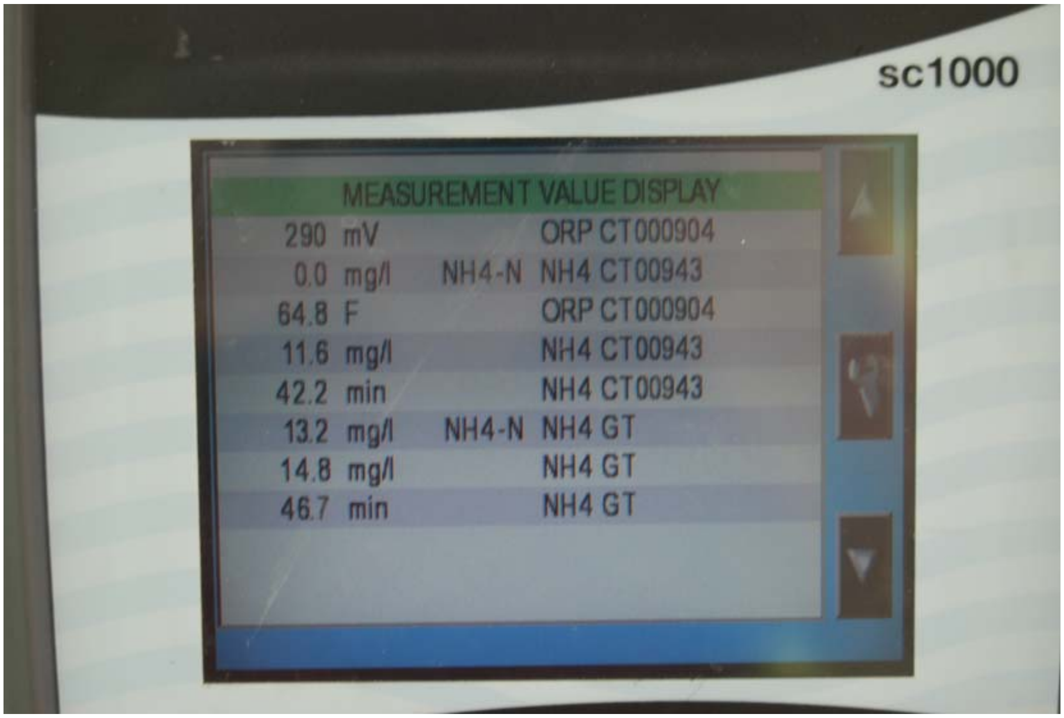

Figure 41: SC-1000 Base Unit Display of Various Readings Taken by Digital Probes

Figure 42: Portable Wastewater Lab Equipment Lent for Duration of WPPE Study