Nutrient and Energy Optimization Study
Town of Centerville WWTP
Centerville, Tennessee

June 2024

Tennessee Association of Utility Districts

with funding from the **Tennessee Department of Environmental Conservation, State Revolving Fund Loan Program** and support from **Grant Tech, Inc.,** and the **Town of Centerville.**

Introduction

Tennessee Plant Optimization Program (TNPOP) assists water and wastewater utilities in achieving energy efficiency and nutrient optimization through low-and-no-cost measures. TNPOP is a free program operated by the Tennessee Department of Environment and Conservation (TDEC), Division of Water Resources (DWR). The program provides resources to support water and wastewater operators in achieving optimization in energy use and nutrient removal for their facilities through low-and-no-cost measures.

Acknowledgements

The following study was made possible through funding from the Department of Environment and Conservation (TDEC), Tennessee Division of Water Resources (DWR) State Revolving Fund Loan Program with a TDEC/SRF/TAUD contract. The lead technician for this study was TAUD Senior Wastewater Specialist Dewayne Culpepper. Special ***Thank You*** to the Town of Centerville Wastewater Manager Chad Dotson, Grant Weaver of Grant Tech, Inc., and TDEC's Karina Bynum.

Summary of Findings

Preceding the optimization effort described in this report, the Centerville WWTP staff in 2017 (after attending TDEC's seminars on nutrient removal with Grant Weaver) implemented strategies to optimize treatment plant performance. With BOD and TSS concentrations typically below 5 mg/L, Centerville's effluent quality has consistently been high. Nitrogen removal has similarly been historically excellent. Effluent total-Nitrogen concentrations of 5 mg/L or less are the norm. Phosphorus removal is – at times – quite good with effluent concentrations of less than 0.5 mg/L while at other times concentrations rise to 2, 3, and 5 mg/L. Effluent pH values below 6.8, the minimum that supports biological Phosphorus removal, are common. No doubt contributing to the periodic effluent spikes.

As the optimization effort proceeded, two significant "mechanical" issues were identified. Neither of which were addressed, hampering the optimization effort. The unresolved issues were (a) a significantly oversized collection system pumping station which settled solids and created unusually septic conditions that contribute to the low pH and (b) the location of the influent piping with flow short circuiting to the clarifier which makes optimization difficult. Notwithstanding the best intentions of plant staff, at no time during the optimization effort was staff provided with the administrative support / infrastructure funding / authorization necessary to correct these issues. As a result, nutrient optimization strategies were developed but not fully implemented. Once the noted deficiencies are corrected and the optimization strategies implemented, Centerville should realize even better treatment performance.

Electrical data was not made available, so this report does not contain an assessment of energy costs.

Recommendations

The following shortcomings merit attention.

- An on-going investment in identifying and correcting Centerville's collection system Inflow and Infiltration.
- Improvements with the oversized industrial lift station and the installation of chemical treatment injection system on the force main for the control of hydrogen sulfide formation in the force main.
- Modifications to both Aeration Tanks to prevent flow short circuiting to the clarifier.
- In-line instrumentation and computer-based controls.

Centerville WWTP –Conventional Activated Sludge Plant - Design Capacity of 0.9 MGD

Utility Information

Town of Centerville Water, Sewer & Gas
Mayor: Mr. Gary Jacobs
mayor@centervilletn.org
City Recorder: Ms. June Horner
jhorner@centervilletn.org
(931) 729-4246

Centerville City Hall
102 East Swan Street, P.O. Box 238
Centerville, TN 37033

WWTP Operator Information:
Chad Dotson - Wastewater Treatment Plant Superintendent
Grade IV WWTP Certification, Sewer Collection II, Water Treatment III, and Distribution II
wwtp@centervilletn.org
931-994-9849

WWTP Plant Information

NPDES Permit - TN0024937
978 Wastewater Customers
40 miles of Sewer collection lines: 29 miles gravity sewer and 20 miles of force main
I/I = 41%
EMOR – Yes

The City of Centerville is authorized to discharge Treated domestic wastewater from Outfall 001 to the Duck River at mile 71.5. Discharge 001 consists of municipal wastewater from a treatment facility with a design capacity of 0.9 MGD. Tennessee Water Resources Permit information site:

https://dataviewers.tdec.tn.gov/dataviewers/f?p=2005:34308:14044306084165:::RIR:IREQ_PERMIT_NUMBER,IREQ_FILE_TYPE:TN0024937,Permit

The WWTP plant's physical address is:

110 Lawson St
Centerville, TN 37033
35.783945, -87.472069

Wastewater Treatment Plant characteristics
Conventional Activated Sludge Plant with a design capacity of .9 MGD.
Equalization Basin has a volume of 1.0 MG.
Aeration Basins (2) - each has a volume of 0.25MG

Each aeration basin's effluent flows to its own clarifier.
Each Clarifier has a volume of 0.14 MG.
Average Year-round Influent flow: 0.31 MGD
WAS 25,000 gallons each cycle, 2/week in summer and 1/week in winter - based on the desired MLSS

Average 2020-2022 Influent/Effluent parameters:

Average Influent Flow: 0.31 MGD ; Max flow: 1.2 MGD
Influent BOD: 280.00 mg/L; Effluent BOD: 3.1 mg/L
Influent TSS : 167 mg/L ; Effluent TSS : 3.88 mg/L
Influent PH ; 6.32 s.u.; Effluent PH ; 6.61 s.u.
Influent Ammonia NH^3: 35.0 mg/L ; Effluent Ammonia NH^3: < 0.2 mg/L
Effluent TN : 1.6 (This data is the current average since January 2020 through August 2022) - (EFF. TN Avg. for 2022 is 2.6 mg/L)
Effluent TP : 1.0 (This data is the current average since January 2020 through August 2022) - (EFF. TP Avg. for 2022 is 1.85 mg/l)

Influent Alkalinity: 60 mg/L
Effluent Alkalinity: 50 mg/L

Operating Process Control Parameters:

Average MLSS: Summer 5500 mg/L & Winter 6500 mg/L
Volatile Solids Content : > 80%
Average F/M: 0.04 (Summer)/ 0.03 (Winter)
Average SVI 150
MCRT ?

Centerville WWTP Current Process Control

The Centerville Wastewater Treatment Plant is a conventional activated sludge plant with excellent headworks utilizing fine drum screening and grit removal. The influent characteristic is influenced by a yogurt manufacture industry with a heavy BOD and Total Suspended Solids loading. An approved pretreatment program is enforced. A known problem exists with a city owned and operated dedicated oversized pumpstation for the yogurt industry allowing SEVER septic conditions creating hydrogen sulfide resulting in extremely low influent PH(down to 4.8) to the treatment plant.

The wastewater treatment plant has a main lift station that pumps an average flow of 0.31 MGD to the headworks for preliminary treatment. The flow can be routed to a 1.0 MGD aerated equalization tank and/or straight to an influent splitter box. The plant is set up to bypass the EQ Tank until needed, sending the flow to the influent splitter box. The splitter box also includes all returned activated sludge (RAS) from each clarifier. The spitter box splits the flow to (2) convention activated sludge tanks that have their own clarifiers located in the center of the tanks. The aeration system is set up with SCADA controls. The aerators are positive displacement type with soft starts. The aeration utilizes fine air diffusers. There are no mixers in the aeration basins.

Current Biological Process Set-Up

Chad Dotson has been exploring and implementing optimization of the process since 2016 on his own without a mandate. The current on/off aeration cycles for both aeration reactors are SCADA controlled with 1 hour on and 1 hour off. Both aeration reactors, number (1) & (2), and the digestor are on the same aeration cycle. RAS is continuous hydraulically flowing to the influent splitter box mixing with the influent flow which is then split back to the aeration reactors. Wasting is accomplished by manually turning a valve to divert sludge to the digestor. The plant has a 3-meter belt press for sludge dewatering. The wastewater plant operates with a high MLSS averaging 5500 mg/l in the summer and 6500 mg/L in the winter to meet the high influent BOD and TSS, at times high as 700 mg/l (BOD) and 300 mg/L (TSS) from the yogurt industry. The average FM ratio is 0.18 and SVI is 150. For the calendar year 2022, the average effluent TN was 2.6 and the average TP is 1.85.

Operations Personnel TNPOP Training

The Wastewater Treatment plant is staffed with two operators. Chad Dotson, Wastewater Treatment Plant Superintendent, is a competent, well-seasoned and highly skilled Grade IV certified operator. All laboratory equipment and reagents for TP, TN, Ammonia as N, Total Alkalinity, Nitrate and Nitrate have been supplied by TAUD. Training to perform all analysis has been completed. The operators were supplied and/or already have portable DO and ORP equipment and trained to complete analysis/sampling. The implementation of TDEC EMOR is active.

Centerville WWTP Influent Preliminary Treatment.

Preliminary Treatment - Drum Screen and Vortex Grit Removal System with Chad Dotson on the walkway.

Influent Splitter Box with RAS.

Aeration Reactor (1) with Center Clarifier Unit.

Aeration Reactor (2) with EQ Basin in background.

Official Centerville WWTP TNPOP Process Review and Initial Process Adjustments

February 9, 2023

The official on-site meeting with Centerville Utilities, TAUD and Grant Weaver was conducted on February 9,2023. Grant Weaver attended the meeting via Microsoft Teams. The current process control, Industrial flow influence, industrial Park lift station problems, toxic influent (H2S & Low Ph),historical & current NPDES compliance data was reviewed. The following was a recap of the meeting Emailed after the meeting from Grant Weaver.

02/09/2023 – Centerville Summary Email from Grant Weaver.
Chad, Dewayne & Karina,

Very interesting.
Thank you for the in-house lab data, repeated below.
Ammonia: variable influent, consistently low effluent.
phosphorus : variable influent, variable effluent.
Nitrate: low influent as would be expected, consistently low effluent.
See below.

Centerville, TN		Ammonia		Ortho-P		Nitrate	
Date	Time	Influent	Effluent	Influent	Effluent	Influent	Effluent
12/22/22	11:45 AM	36.1	0.28				
12/23/22	9:25 AM	39.4	0.31				
1/6/23	8:13 AM	19.5	0.06	4.75	0.21	1.14	0.45
1/12/23	6:55 AM	35.5	0.34	4.40	2.39	0.68	<0.23
1/20/23	8:58 AM	7.5	0.02	8.78	0.20	2.63	0.15
1/25/23	10:30 AM	31.6	0.70	3.77	0.87	0.53	0.16
1/26/23	6:50 AM	14.4	0.57	2.71	1.05		

Thank you for sampling the digester supernate.
At 106 mg/L orthophosphate it likely explains (a) the summertime rise in effluent phosphorus and (b) the variability in the table above ...
The variability possibly being a higher effluent phosphorus when sludge is pressed and the high phosphorus pressate is returned to the waste stream.

After our call, I checked ratios.
According to the literature, microbial growth “consumes” ...
1 mg/L of phosphorus for every 100 mg/L of BOD
5 mg/L of nitrogen for every 100 mg/L of BOD

Given that Centerville’s influent BOD averages 250 mg/L ...

2.5 mg/L of influent phosphorus is removed as waste sludge
12.5 mg/L of influent nitrogen is removed as waste sludge

Once we have a good handle on influent Nitrogen (TKN will provide a close enough answer) and Phosphorus ...
We can approximate how much of the nitrogen and phosphorus is removed as sludge
And
How much is removed through nitrification/denitrification and biological phosphorus removal

... ...

Today we discussed the following.

Industrial lift station
Because it is so big, the flow into it so low, and the force main so long ... flow is septic and very low (4.5) in pH.
Brainstorming ideas for improving conditions:
Increase cycle frequency by changing high and low floats from 2 feet apart to 6-inches apart
Consider options for reducing the volume of the wet well
Consider options for aerating / oxidizing the wet well contents

Seasonal effluent phosphorus (better in winter than summer)
Sludge is dewatered as infrequently as every-other week during winter and as often as daily during summer
We suspect that the high soluble phosphorus concentration of the dewatered sludge during summer months overwhelms the biota's ability to remove the phosphorus, resulting in high effluent P.
Brainstorming ideas for improving conditions:
Establish a bigger population of phosphorus removing bacteria by using the digester as a fermenter and allowing some amount of sludge to return back to the aeration tank by lowering the digester telescopic valve

Decline in treatment when air is cycled off for more than one hour at a time.
We suspect this is due to short-circuiting as in one tank the influent enters the aeration tanks some ten feet from where the effluent flows to the clarifier.
Brainstorming options, we favored the idea of installing lengths of 12-inch PVC pipe on the ground alongside the tanks and over the tank walls at a much further distance from where the wastewater flows into the clarifier.

That is a lot for a first visit.
And I'm sure I missed some important things.
Please let me know what I did miss.

Thanks, excellent discussion!

Grant.

02/17/2023 – Centerville Update Email from Dewayne Culpepper.

Good afternoon, Grant,
Just dropping a line on the progress at Centerville. Chad and I have discussed the f/m and MLSS. The f/m number of 0.18 in the data document was correct when he gave it to me. Chad explained that he did not use annual averages or even monthly averages (flow or BOD). He calculates the f/m with weekly data since his BOD range could be from 200 to 800 on any given day. Also, with the toxicity of influent Hydrogen Sulfide and Low PH, the higher MLSS seems to handle the shock load. This week's f/m was right at 0.1, with a maintained MLSS of 6000 – 6500 range.

Currently, Chad has been in process of getting materials and a city crew organized to move the influent lines to the aeration basins. He also has met with the mayor on the oversized industrial lift station to work on remedy. I think once these two items are corrected, Chad will have more control with the influent and the process allowing for adjustments and a healthier optimized process.

Well, Hope everyone is has a great weekend. Dewayne T. Culpepper

Centerville WWTP TNPOP Process Review and Follow Up Process Adjustments March 20, 2023

The follow up on-site meeting with Centerville Utilities Wastewater Superintendent Chad Dotson, TAUD and Grant Weaver was conducted on March 20, 2023. Grant Weaver attended the meeting via Microsoft Teams. The current process control, current NPDES compliance data was reviewed. Chad has been in process of getting materials and a city crew organized to move the influent lines to the aeration basins. Weather related events have delayed planned improvements to the plant. He also has met with the mayor on the oversized industrial lift station to work on remedy. I think once these two items are corrected, Chad will have more control with the influent and the process allowing for adjustments and a healthier optimized process. A follow up meeting is planned on April 20th, 2023, to review process updates.

Centerville WWTP TNPOP Process Review and Follow Up Process Adjustments April 20, 2023

The follow up on-site meeting with Centerville Utilities Wastewater Superintendent Chad Dotson , TAUD, Karina Bynum and Grant Weaver was conducted on April 20,2023. Karina Bynum and Grant Weaver attended the meeting via Microsoft Teams. Chad continues the process of getting materials and a city crew organized to move the influent lines to the aeration basins new locations. The oversized industrial lift station problem, resulting in influent hydrogen sulfide production and low Ph's to the treatment plant, is being addressed with planning and budgeting to fund a rehab project to correct the problem.

During the meeting, process control optimization measures for total phosphorus (TP) removal were discussed. Summer / Winter schedule for aeration rates adjustments were discussed and Grant recommended cutting the air on and air off cycles from 1 hour on / 1 hour off to a shorter on / off schedule, such as 45 minutes on / 45 to 30 off. This is due to high BOD, warmer temperatures and high MLSS. Simultaneous process control sampling of effluent TP and MLSS Ph was discussed and implemented.

This concluded the meeting, and the next meeting is tentatively scheduled on June 13, 2023, at 9:00 am central time.

Centerville WWTP TNPOP Process Review
June 07, 2023

A follow up on-site meeting with Centerville Utilities Wastewater Superintendent Chad Dotson and Dewayne Culpepper was conducted on June 7, 2023. Chad continues the process of getting materials and a city crew organized to move the influent lines to the aeration basin's new locations. During the meeting, process control optimization measures for total phosphorus (TP) removal were discussed. The scheduled virtual TEAMS meeting on June 13, 2023, at 9:00 am was cancelled until construction of the new influent lines is completed.

Centerville WWTP TNPOP Process Review
July 25, 2023

A follow up on-site meeting with Centerville Utilities Wastewater Superintendent Chad Dotson and Dewayne Culpepper was conducted on July 25, 2023. No progress has happened to move the influent lines to the aeration basin's new locations or modifications to the industrial pump station. During the meeting, process control optimization measures for total phosphorus (TP) removal were discussed. The on-off aeration cycle has been adjusted to 45 minutes on and 45 minutes off. Since the change in the aeration cycle, TN is 2.1 mg/L and TP is 1.9. Before the aeration cycle change the effluent TP had increased to 3.73 mg/l. The MLSS has been reduced to 5000 mg/L. With a septic influent wastewater entering the wastewater plant several times per day (4 to 6 cycles at 15,000 gallons/cycle) from the industrial pump station force main resulting in Ph's of 5 or less entering the plant has affected the TP removal process of the plant. This is 25% of the daily influent flow. The flow from the city's pumpstation entering the main pumpstation at the plant has normal Ph's of 7.0 and higher. Ph of the aeration basin MLSS is in the 6.7 to 6.8 range. We discussed a pH adjustment monitoring and adjustment system using caustic at the main pumpstation and/or using the EQ Basin to stabilize the plant influent.

Centerville WWTP TNPOP Process Review

August 18, 2023

By phone call, Chad gave an update on the process control and effluent laboratory analysis. No progress has happened to move the influent lines to the aeration basin's new locations or modifications to the industrial pump station. The effluent analysis for TP is 2.0 mg/L and TN is 2.0 mg/L

Centerville WWTP TNPOP Process Review

September 5 & October 20, 2023

Follow up on-site meetings with Centerville Utilities Wastewater Superintendent Chad Dotson and Dewayne Culpepper was conducted on both September 5 & October 20, 2023. No progress has happened to move the influent lines to the aeration basin's new locations or modifications to the industrial pump station. During the meeting, process control optimization measures for total phosphorus (TP) removal were discussed. Chad said that he would increase the frequency of analysis for TN & TP.

Centerville WWTP TNPOP Process Review

December 20, 2023

A follow up on-site visit with Centerville Utilities Wastewater operator Greg Edwards and Dewayne Culpepper was conducted on December 20, 2023. No progress has happened to move the influent lines to the aeration basin's new locations or modifications to the industrial pump station. Chad has been on annual leave for most of December.

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Centerville WWTP TNPOP Onsite Process Review with TDEC

February 13,2024

State of Tennessee TNPOP Official, Jordan Fey, and Fleming Training Center Director, John Lawrence, met with Chad Dotson and Dewayne Culpepper onsite at the Centerville WWTP to review the Centerville's TNPOP program, system deficiencies and process control was conducted. After a review and discussion of the past years TNPOP efforts, a walk thorough of the plant reviewing the plant process and deficiencies was conducted. After the overview of the process, all agreed that until the deficiencies were eliminated the plant optimization is complete at this stage. Centerville wastewater system deficiencies effects TP removal at times but TN removal is adequate.

Centerville, TN		Ammonia		Orttho:-P		Nitrate	
Date	Time	Influent	Effluent	Influent	Effluent	influent	Effluent
10/19/23	8:15 AM	15.4	0.25	10.2	1.73		0.52
10/25/23	8:20 AM	9.34	0.014	9.76	4.06		0.376
12/7/23	8:40 AM	3.54	0.11	6.22	1.96		0.448
1/5/24	9:00 AM	20.5	0.241	9.68	3.72		0.10
1/17/24	9:11 AM	50.0	0.247	6.39	2.61		0.15
1/25/24	12:10 AM	3.26	0.090	1.84	1.71		0.16
2/7/24	6:50 AM	10.0	0.622	3.2	0.218		

TNPOP Summary to Date, May 31, 2024

As Summer approaches with warmer temperatures, Centerville will continue with the current process control and monitoring plan, adjusting if necessary to achieve the best optimization of nutrient removal possible. Preceding the optimization effort described in this report, the Centerville staff in 2016 (after attending TDEC's seminars on nutrient removal with Grant Weaver) implemented strategies to optimize treatment plant performance. As a result of the initial optimization efforts, Centerville's WWTP was already providing a high-quality effluent but with inconsistencies due to design and influent loading factors. By utilizing the State of Tennessee's TNPOP program allowed the Centerville WWTP personnel to adjust the process control in several configurations regarding aeration on-off cycles and optimization efforts are now documented with the State of Tennessee Water Resources. Unfortunately, optimization efforts were thwarted due to the collection design flaws creating problems of extremely septic

influent with low influent ph and along with influent flow to the aeration basin short circuiting to the clarifier. In the past year, all parties involved learned the limitations of the process, equipment, and design flaws of the plant and at the same time learned what adjustments optimized the biological process control to achieve lower TN and TP.